Cranfield University *Université Paris 1 Panthéon-Sorbonne*

School of Management *École Doctorale d'Économie*

Laurent ZIBELL

Outcome predictors of co-operative R&D in Europe: organisational capabilities and cultures

Prédiction des resultats de la R&D coopérative en Europe : compétences collectives et cultures

PhD Thesis — *Thèse de Doctorat*

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Abstract in English

This research investigates organisational capabilities and cultures of both partners as potential explanatory factors of co-operative R&D projects outcomes.

Contributions to theory are (1) a justification for the existence of organisational capabilities and 'world views', (2) a parsimonious typology of 'world views' and (3) a method to measure organisational capabilities.

The survey covers 514 projects in the electronics industry, in Germany, France, the United Kingdom and Finland. It obtains 120 full answers, each of which coupling responses from a matched pair of project managers having co-operated on the same R&D project. The survey refers to the organisation's capabilities, to those of the partner, to its 'world view', and to project outcomes.

None of the traditional explanatory factors (geographic distance, difference in nationality, size or legal status, strategic compatibility) has any significant influence on any of the outcomes being studied (save one).

The explanatory factors introduced by the research (organisational capabilities and 'world views') have a significant influence on almost all outcomes being considered of the co-operative R&D projects: attainment of concrete results, compliance with budget and schedule, creation and transfer of knowledge, learning (modification of capabilities). Cultural diversity, 'absorptive capacity', and teaching effects, selective according to the capability in question, are evidenced. Commonalities between partners are shown to be more important than distance. These results validate empirically organisational capabilities and 'world views' as descriptors of inter-organisational capabilities, and their operationalisation.

Key words in English

Cognitive distance, Collective competence, Cooperation, Dyad, Electronics industry, Europe, Finland, France, Germany, Innovation, Organizational capability, Organizational culture, Project, R&D, United Kingdom, World view

Résumé en Français

Cette recherche porte sur l'influence des compétences collectives et cultures des 2 partenaires sur les résultats de projets coopératifs de R&D.

Les contributions théoriques sont (1) une justification de l'existence de compétences collectives et de 'visions du monde', (2) une typologie parcimonieuse des 'visions du monde' et (3) une méthode de mesure des compétences collectives.

L'enquête porte sur 514 projets dans l'industrie électronique, en Allemagne, France, Finlance et au Royaume-Uni. Elle recueille 120 réponses complètes, correspondant chacune aux réponses de 2 chefs de projets appariés ayant coopéré sur un même projet. Elle porte sur les compétences collectives de l'organisme, sur celles de son partenaire, sur sa 'vision du monde' et sur les résultats du projet.

Aucun des facteurs explicatifs traditionnels (distance géographique, différence de nationalité, de taille, de statut juridique, compatibilité stratégique) n'a d'influence significative, sur aucun des résultat considérés (sauf un).

Les facteurs explicatifs introduits (compétences collectives et 'vision du monde') ont une influence significative sur la quasi-totalité des résultats considérés des projets coopératifs de R&D : atteinte de résultats concrets, conformité avec le budget et le calendrier, création et transfert de connaissances, apprentissage (modification des compétences). Des effets de diversité culturelle, de 'capacité absorptive', d'enseignement, sélectifs selon les compétences concernées, sont mis en évidence. Ces résultats valident empiriquement la compétence collective et la 'vision du monde' comme descripteurs de l'hétérogénéité entre organismes, ainsi que leur méthode de mesure.

Mots-clefs en Français

Allemagne, Compétence collective, Coopération, Culture collective, Culture d'entreprise, Distance cognitive, Dyade, Électronique (industrie), Europe, Finlande, France, Innovation, Projet, R&D, Recherche & Développement, Royaume-Uni, Vision du monde

Résumé substantiel en Français

*Le Résumé substantiel de cette thèse fait l'objet de l'Annexe E ("*Appendix E*") du présent document.*

Host research centres / *Laboratoires d'accueil*

Complex Systems Research Centre Cranfield University - School of Management College Road Cranfield MK43 0AL United Kingdom	Centre d'Économie de la Sorbonne - UMR 8174 Maison des Sciences Économiques 106/112 Boulevard de l'Hôpital 75647 Paris Cedex 13 France

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None of the empirical part of this research would have been done without the goodwill and patience of the 326 respondents to the survey, across Europe (and even further away). They preferred to remain anonymous, for confidentiality reasons, with one exception: Astrium and the ACM-Modem project.

Cranfield University - School of Management hosted my research and set it in a full, structured doctoral programme that accompanied my work throughout. The periodic Reviews of progress, at important milestones, provided essential intermediate goals and feedback. The team of the Doctoral Research Programme at Cranfield University, School of Management, Dr. Colin Pilbeam and Wendy Habgood were the key figures in this process. The University had the generosity to support my work financially, covering not only my tuition fees, but also a significant maintenance grant. I am also very grateful to the Cranfield University Library team, and specifically to Heather Woodfield and Anita Beal, who supported my information research work with untiring kindness.

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Finally, my deepest thanks go to my friends and family, for their understanding and support, and to my fiancée Caroline, who has been so present, kind and supportive over these years.

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1 General introduction

1.1 Explicit co-operation of actors in Economics

When he founded Economics as a scientific discipline, Smith (1776) placed trade and market relations at the centre of human economic interactions:

> *"Whoever offers to another a bargain of any kind, proposes to do this. Give me that which I want, and you shall have this which you want, is the meaning of every such offer; and it is in this manner that we obtain from one another the far greater part of those good offices which we stand in need of."* (Book 1, chap. 2).

In such a society, the locus of interaction between suppliers and customers of a specific good, ie. the market, is the best (and only) means for humans to satisfy their needs. Society is the juxtaposition of many such parallel and independent markets, where each individual is a customer in all but one, and a supplier in the last, which is where s/he exerts his/her main occupation. No explicit co-ordination is supposed to be present, either among suppliers, among customers, or between customers and suppliers: on the opposite, blind competition between suppliers and between customers ensures that the price and quantity exchanged maximise public welfare. Explicit co-ordination between suppliers or between customers would lead to monopolies (resp. monopsonies), and to distortions from the market optimal equilibrium. Explicit co-ordination between suppliers and customers is (if at all existent) centralised and brokered by a neutral, automatic "*auctioneer*" (Walras, 1926).

The general paradigm is therefore that of independent, autonomous and identical agents, that are isolated and separated from one another. This initial view has long prevailed in Economics. One of the reasons may be ideological, because Economics were developed in an intellectual environment that I call the 'polity of Liberty' (§ 4.4.4.2). Another, better grounded, reason may be that the collective behaviour of such independent agents, being easier to model, deserves being treated first in a sound research strategy that starts with simple phenomena before engaging more complicated ones. This strategy was successfully followed in the branch of Physics called Statistical Mechanics, where the first object to be studied were perfect gases, made of independent, identical molecules, before crystals and other materials, in which atoms and molecules are connected to one another, were modelled.

However, this approach of economic agents as being essentially autonomous and independent was contested early, specifically by List (1856), for whom the source of economic prosperity does not lie essentially in the division of labour, but in the co-operation of agents:

> *[T]he augmentation of the powers of production in consequence of the separation of occupations and the **co-operation** of the powers of individuals begins in the separate manufactory and extends to the united nation. The manufactory prospers so much the more in proportion as the commercial operations are divided, the more closely the workmen are **united**, and the more the **co-operation** of each person is insured for the whole. The*

> *productive powers of every separate manufactory are also increased in proportion as the whole manufacturing power of the country is developed in all its branches, and the more intimately it is* ***united*** *with all other branches of industry.* (chap. 13, emphasis added)

In List's views, it is the co-operation of the workers around a common objective within the factory, and the explicit co-operation of firms along the value chain that build the foundation of economic activity and prosperity. His positions, despite their historical importance in the economic development of late nineteenth-century Germany (Webb, 1980), remained marginal.

1.2 Contemporary inter-organisational co-operation

1.2.1 The renewal of academic interest in inter-organisational co-operation since the 1980s

It is not until the very end of the twentieth century that explicit **inter-organisational co-operation** gained again the attention of scholars, specifically in the fields of Industrial Organisation and of Strategic Management. They showed that co-operation exists between economic actors, and can be beneficial. The benefit occurs not only to those engaged in the co-operation (which critics of collusions and cartels already had emphasised), but also to general welfare. Perroux (1955) discussed the leadership role of large firms in the industrial education of their suppliers in "*growth poles*". Aoki (1988) studied the rich supplier-customer relationships present in the supply chains of the Japanese automotive industry, and its benefits in terms of adaptation, innovation and quality. Hamel et al. (1989) investigated strategic alliances in Europe, Japan and the United States of America, and evidenced the learning benefits arising from the joint technical work.

The concept of "*strategic alliance*" was defined as "*voluntary arrangements between firms involving exchange, sharing, or co-development of products, technologies or services*" (Gulati, 1998, p.293) or as "*arrangements between two or more independent companies that choose to carry out a project or co-operate in a specific business area by co-ordinating the necessary skills and resources jointly rather than either operating on their own or merging their operations*" (Dussauge et al., 2000, p.99). These co-operative arrangements have generally been described according to their legal or contractual status, along various typologies involving mainly the presence or absence of equity participation (1988). Das and Teng (2000a) identify 4 legal forms: *"(1) joint ventures; (2) minority equity alliances; (3) bilateral contract-based alliances; and (4) unilateral contract-based alliances*" (p.43), while Hagedoorn (2002) simply sees "*two categories, i.e. contractual partnerships, such as joint R&D pacts and joint development agreements, and equity-based joint ventures*" (p.478). Whatever their legal form, they all rely upon the pooling of financial, material or intellectual resources of the partnering firms, with an agreed-upon sharing of both duties and rewards.

The reason for this renewed interest in the last decades of the twentieth century for inter-organisational co-operation is not purely academic and intellectual though. It is rooted in the growth of inter-organisational co-operations that was empirically experienced during this period.

1.2.2 The empirical phenomenon of inter-organisational co-operation

Indeed, since the late 1970s, firms have massively engaged in co-operative activities with either suppliers, customers, competitors or non-profit organisations such as universities or public research institutes (Depret and Hamdouch, 2004). This surge in the number of inter-organisational co-operations was supported by "*the changes in the US antitrust policy [...that] reduced the post-war hostility of the US federal competition authorities toward R&D collaborations among established firms*" (Hagedoorn, 2002, p.490), resulting in the "*National Cooperation Research*" Act of 1984 and the "*National Cooperation Research and Production*" Act of 1993.

The number of inter-firm R&D partnerships recorded in the highly comprehensive, longitudinal, Merit-Cati database of Maastricht University has grown steadily from a few units per year in the 1960s and 1970s to ca. 160 in 1980 and to figures persistently above 300 since 1985, with a peak at almost 700 in 1996 (Hagedoorn, 2002, Figure 1, p.480). These figures are coherent with those obtained earlier by Hagedoorn and Schakenraad (1992) and by Narula and Hagedoorn (1999) using data from the same Merit-Cati database, and later by Paulré *et al.* (2003) using the Thomson Financial database on alliances, whose results are reproduced hereafter in Figure 1.2.1.

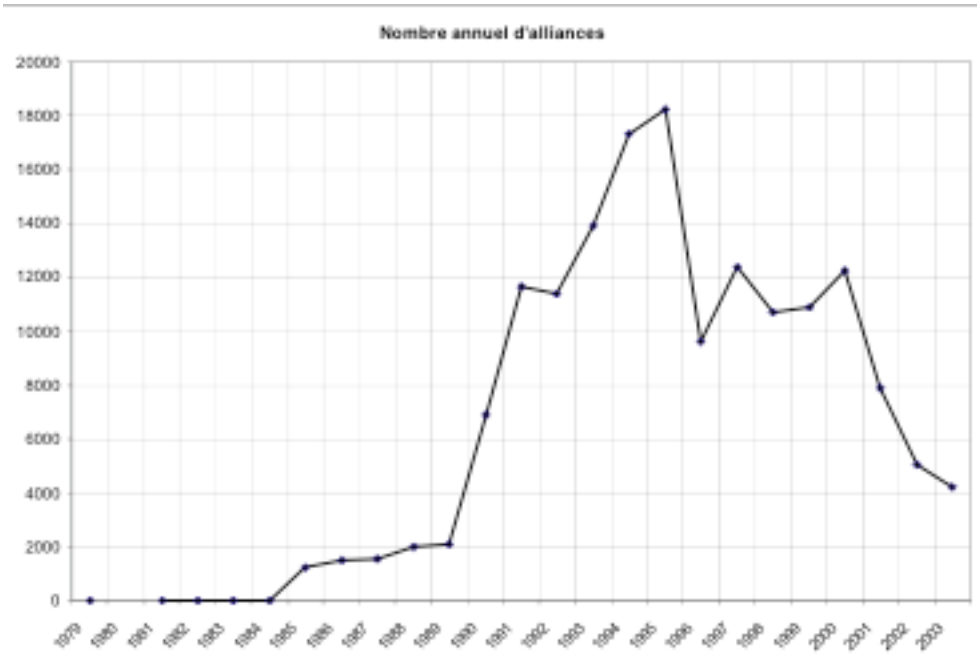

Figure 1.2.1: Annual number of alliances recorded in the Thomson Financial database on alliances (1985 - 2003), reproduced from (Paulré et al., 2003)

The decline observed in the number of reported alliances after 1995 may be attributed to two factors: (1) a saturation effect, in which the available partners in an alliance are progressively all engaged, and leave no more opportunities for new alliances, or (2) a banalisation effect, where alliances become so common that they don't deserve being reported. The latter interpretation, whose consequence would be that the observed decline in the number of alliances actually is a measurement artefact, is confirmed by observations by Kremp and Mairesse (2002) and by Corbel (2005), based on massive surveys of French industrial firms in the early 2000s, that an average of 23% of all

industrial firms co-operate to acquire knowledge, with proportions rising above 40% in technology-intensive sectors. These observations, that have no reason to be specific to the French environment, as evidenced by surveys in other European countries (Becker and Dietz, 2004; Tether, 2002; Bayona et al., 2001; Fritsch and Lukas, 2001; Kleinknecht and Reijnen, 1992), would mean that inter-organisational co-operation is a common, widespread fact of industrial life in contemporary economies.

Simultaneously, the Framework Programmes of the European Commission, that specifically foster inter-organisational R&D co-operation, have increased their annual budget from an average of 817 M€ in the First Programme (1984-1987) to 7 800 M€ in the Seventh (2007-2013), an almost ten-fold increase in 25 years.

1.2.3 Rationales for co-operation

Beyond these legal issues, the motivations of these co-operative activities have been early identified by Dodgson (1993) as being:

> *"1. Improving the development process [...] of new knowledge, products and processes [...]. 2. Enhancing efficiency in the production chain [...]. 3. Merging previously discrete technologies and disciplines [...]. 4. Learning through information exchange [...]. 5. Corporate strategies [...] concerned with reducing the cost, risk and uncertainty of technological innovation [...] 6. Public policies"* (pp.10-11).

He also mentioned the need for "*speed to market*" (p.29), the aim of "*creating technological standards*" (p.30), of "*competitor exclusion*" (p.31) from unique sources of knowledge, of "*positioning, watching and waiting*" (p.33) in times of great uncertainties in technical outcomes, and that alliances may be a tool for "*pre-merger exploration*" (p.33) between partners.

Doz and Hamel (1998) have classified the strategic aims of alliances into three "*value-creating logics*", namely "*co-option*", "*co-specialisation*" and "*learning*". Co-option is a strategy in environments with strong positive feedbacks to size, or increasing scale yields (Arthur, 1988) such as network externalities or technological races for standards. The purpose is to be the stronger coalition as fast as possible, in order to belong to the team that will effectively monopolise the market, since the positive feedback leads to a 'winner takes all' end situation. This strategy is applied in competition around technical standards with strong interoperability issues, such as telecommunications and information technology. This strategy may (and often does) involve firms that work in the same industry, even direct competitors. Co-specialisation is the association of firms with different, non-substitutable skills and capabilities. Learning is an unilateral move, in which the 'student' firm pays a 'tuition' (in form of various economic advantages) to learn from the 'teacher' firm. In general, each 'value creating logic' is relevant to a specific stage of industry maturity (figure 4.5, p.115).

Other authors motivate co-operative R&D as "*sharing risks and costs in the face of uncertain technological developments, shortening innovation cycles, the pursuit of efficiency gains such as economies of scope and scale or synergistic effects through efficient pooling of the firms' resources, learning through monitoring technology and market developments, dealing with regulations and industry standards, and responding*

to government subsidy policies" (Belderbos et al., 2004, p.1479), as a means to pre-empt rare resources, such as competencies or strategic partners, and to increase robustness and adaptability towards industrial uncertainty, keeping strategic options open (Depret and Hamdouch, 2004; Joly and Richard, 1999).

In summary, the motivations may be distinguished as (1) financial, such as sharing risks and costs, (2) strategic, such as the access to rare resources (and denying this access to competitors) or pre-empting a market with strong positive feedback effects, or (3) marketing, such as providing an early or combined offering.

My interpretation of the reason why inter-organistional co-operation experienced such a robust growth specifically in the late twentieth century is related to the Schumpeterian (1939) theory of technical innovations appearing in "*chains*". In a period where coherent technical progress makes a change in the dominant "*technical system*" (Gille, 1978), as was the case with the digital Information and Communication Technologies that blossomed in the 1980s and 1990s, the exploitation of the breakthrough in technical possibilities must be made fast, because the new, virgin market is open for colonisation by the first mover. In addition, this exploitation requires resources that often are not all immediately at hand within the organisation. A fast alternative to growing these resources internally (a slow process) is to mobilise them externally. To that end, the conclusion of formal co-operations with third-party organisations is a convenient means.

1.2.4 Inter-organisational co-operation experiences high failure rates

Despite the apparently convincing rationale to establish them, inter-oganisational cooperations are reported to encounter **high failure rates**. Das and Teng (2000b) report that their literature survey, comprised of 16 empirical studies covering several hundreds of cases (table 1, pp.79-80), leads to the conclusion that "*less than half of the alliances studied can be said to have performed satisfactorily*" (p.78). Similarly, failure rates of 50 to 70% are cited (Brouthers et al., 1995, p.18; Sivadas and Dwyer, 2000, p.32). These results are highly consistent across the literature, whatever the empirical setting.

This poor level of performance of inter-organisational co-operation therefore deserves being investigated, and reliable predictors of their outcomes to be developed. This is the **general intention of my thesis**.

1.3 Main findings of previous research in Management and Economics on co-operative R&D

In order to better understand the determinants of co-operative R&D, and of these poor success rates, I searched the main findings of previous research in Management on the subject.

1.3.1 Search methodology

I performed a search on the ISI - Web of Science database, using the following keywords: cooperat* AND R&D. I then restricted the results to Scientific Articles as "Document Type", and to Management OR Business as "Subject area", in order to focus on those journal articles referring explicitly to Management. This search yielded 266 results, that I then sorted by the number of times each reference was cited in the ISI

- Web of Science database. This procedure led me to identify a list of 22 articles that were cited 23 times or more, and that referred to inter-organisational co-operation. They were published in the leading scientific journals in the field: Research Policy (12 articles), Strategic Management Journal (5 articles), Academy of Management Journal, Journal of Product Innovation Management, Technovation, Management Science and R&D Management (1 article each). This list of articles may thus be considered as those containing the main and most influential findings of research in Management about co-operative R&D, published in the key journals of the field.

(The space below is deliberately left blank)

The list of the articles that I considered, and that appeared following this search, is displayed in Table 1.3.1 below.

Rank	**Reference**	**Journal**	**Number of citations in ISI Web of Science**
1	(Hagedoorn, 2002)	Research Policy	152
2	(Robertson and Gatignon, 1998)	Strategic Management Journal	87
3	(Bouty, 2000)	Academy of Management Journal	84
4	(Tether, 2002)	Research Policy	79
5	(Sakakibara, 1997)	Strategic Management Journal	71
6	(Kleinknecht and Reijnen, 1992)	Research Policy	67
7	(Hagedoorn and Schakenraad, 1992)	Research Policy	66
8	(Doz et al., 2000)	Strategic Management Journal	65
9	(Oxley and Sampson, 2004)	Strategic Management Journal	55
10	(Fritsch and Lukas, 2001)	Research Policy	52
11	(Miotti and Sachwald, 2003)	Research Policy	52
12	(Petersen et al., 2003)	Journal of Product Innovation Management	49
13	(Narula and Hagedoorn, 1999)	Technovation	42
14	(Belderbos et al., 2004)	Research Policy	40
15	(Bayona et al., 2001)	Research Policy	33
16	(Brockhoff, 1992)	Management Science	32
17	(Mathews, 2002)	Research Policy	28
18	(Becker and Dietz, 2004)	Research Policy	27
18	(Colombo and Garrone, 1996)	Research Policy	27
20	(Hakanson, 1993)	R & D Management	25
21	(Ham and Mowery, 1998)	Research Policy	24
22	(Olk and Young, 1997)	Strategic Management Journal	23

Table 1.3.1: List of 22 most-cited journal articles in Management referring to inter-organisational co-operative R&D

Many of these articles rely upon data gathered during the Community Innovation Surveys (CIS), organised by the European Commission, in Germany(Becker and Dietz, 2004), France (Miotti and Sachwald, 2003), the United Kingdom (Tether, 2002) the Netherlands (Belderbos et al., 2004) and Spain (Bayona et al., 2001).

I have referred to the articles by Hagedoorn and Schakenraad (1992), Narula and Hagedoorn (1999) and by Hagedoorn (2002) earlier in the section on the quantitative assessment of the phenomenon of co-operative R&D (§ 1.2.2).

The issues being considered in the 19 remaining research articles are the following, and cover the whole cycle of co-operative R&D, from the decision whether to engage at all in co-operation to the governance issues involved in the success of such a venture. They are coherent with those identified by Bayona *et al.* (2001):

- whether co-operation has an effect on the R&D performance of firms, and if so, in what direction (Becker and Dietz, 2004; Belderbos et al., 2004; Miotti and Sachwald, 2003). These articles are considered in greater detail in § 1.3.2 hereafter.
- the factors that influence the propensity of firms to engage in co-operative R&D, or in other words the factors that motivate a firm to engage in such ventures (Becker and Dietz, 2004; Tether, 2002; Bayona et al., 2001; Fritsch and Lukas, 2001; Kleinknecht and Reijnen, 1992; Robertson and Gatignon, 1998; Sakakibara, 1997; Miotti and Sachwald, 2003; Brockhoff, 1992; Colombo and Garrone, 1996). This issue is addressed in § 1.3.3 below.
- the criteria for partner selection in the co-operative R&D project (Fritsch and Lukas, 2001; Miotti and Sachwald, 2003), which is the purpose of § 1.3.4.
- the process of partnership formation in co-operative R&D (Doz et al., 2000; Petersen et al., 2003; Mathews, 2002), to be examined in § 1.3.5.
- the factors that affect the performance of co-operative R&D itself (Hakanson, 1993; Ham and Mowery, 1998; Olk and Young, 1997), which will be investigated in § 1.3.6.
- the control and governance rules that foster the achievement of the firm's objectives in the alliance, in front of potentially harmful behaviours by the partner (Bouty, 2000; Oxley and Sampson, 2004; Hakanson, 1993). The articles adressing this question will be described in § 1.3.7 hereafter.

I will provide a summary of the findings of existing literature on co-operative R&D in the final § 1.3.8 of this section.

1.3.2 Effect of co-operation on R&D performance of firms and on general social welfare

Bolderbos *et al.* (2004) state the purpose of their research as follows:

> *"analyse the impact of R&D cooperation on firm performance differentiating between four types of R&D partners (competitors, suppliers, customers, and universities and research institutes), and considering two*

> *performance measures: labour productivity and productivity in innovative (new to the market) sales".*

They use data from two waves (1996 and 1998) of the Dutch version of the European Commission's CIS survey, on a sample of 2056 firms. Their results "*strongly confirm the contribution of R&D cooperation [both with competitors and with suppliers] to [labour] productivity growth*" (p.1486). For "*firms' productivity in generating sales of innovative products new to the market per employee*" (p.1486), "*university cooperation [...] has a significant impact on productivity growth and competitor cooperation gets a marginally significant impact for persistent collaborators*" (p.1486). In both cases, lagged productivity has a significant and negative impact: those firms that were productive in 1996 have lost 52% of their labour productivity (resp. 72% of their sales of innovative products) advantage in 1998.

Becker and Dietz (2004) argue that although the effect of co-operation on the R&D intensity of firms (i.e. on the innovative input of the firm) was studied in the past, the research on the effect of co-operation on the realisation of new products (i.e. on the innovative output) needs to be considered. The empirical study relies upon the German version of the Community Innovation Survey, called the Mannheim Innovation Panel of 1993, and covers 2048 firms.

The authors report a highly significant positive effect of inter-organisational co-operation and of the number of co-operating organisations in the consortium on the intensity of R&D effort (the amount of R&D expenditures divided by sales). In addition, they observe the expected effect of control variables: firm size (negative effect), international operations, diversification, appropriability, technology level of industry (positive effects). They also report a highly significant positive effect of the existence of co-operation on innovative output (i.e. on the creation of new products), alongside more traditional positive effects of R&D intensity, firm size, international markets, appropriability conditions, and diversification. The size of the co-operative consortium displays a positive, but unsignificant effect on innovative output.

Miotti and Sachwald (2003) mobilise the empirical results of the CIS-2 survey in France, that yielded 4215 answers, with an amazing response rate of 85 %. They investigate the effect of partnering on two outputs of the R&D effort, namely the probability to apply at least one patent in the period being investigated and the share of innovative products in turnover. "*Size, market share, permanent R&D and public funding increase the probability to patent*" (p.1493), and "*R&D co-operation exhibits a significant positive impact on the propensity to innovate*" (p.1493). They conclude that "*R&D co-operation is efficient*".

In addition to these articles retrieved from the systematic review described above (§ 1.3.1) and that refer to the effect of co-operation on the private welfare of firms, a significant stream of literature in the field of Economics considered the broader effects of co-operation in R&D on public welfare.

The seminal article on this issue was published by d'Aspremont and Jacquemin (1988). The article analyses the effects of co-operation in R&D and in manufacturing on the level of R&D expenses, on the quantities being produced, and on the overall welfare of

both consumers and producers, in a duopoly situation. The inverse demand function and the effect of R&D on costs are assumed to be linear.

Three scenarios are considered: (1) non-co-operative behaviours at both stages; (2) co-operation in pre-competitive R&D but not in manufacturing (i.e. the firms maximise the joint profits by agreeing on their R&D effort level, but not on their quantitative outputs) and (3) co-operation at both stages of R&D and of manufacturing (i.e. joint determination of R&D effort and of output level). The models consider that R&D only modifies production costs. A key parameter is the spill-over effect, that "*implies that some benefits of each firm's R&D flow without payment to other firms*" (p.1133). In both co-operative scenarios, only the symmetric case is considered, in which both firms share identical levels of R&D expenditure (and of quantitative output, where appropriate). In each scenario, the Cournot-Nash equilibrium is computed, and is compared to the overall optimal welfare situation, for consumers and for producers.

The key variable is the spill-over level. In the second scenario, "*for large spill-overs [...], the level of R&D increases when firms co-operate in R&D [...]. In the same perspective [...], the amount of production is also higher with co-operation in R&D, than in the non-co-operative situation*" (p.1135). In the third scenario, the output level is lower than without collusion on output quantities, but "*the amount of R&D in the case of collusion in both output and R&D is higher than on in the case of pure R&D co-operation. This stems from the fact that less competition on the product market allows the firms to capture more of the surplus created by their research and induce more R&D expenditures*" (p.1135). When comparing with social welfare, "*the clearest conclusion is that co-operation in R&D (but not in production) increases both expenditures in R&D and quantities of production, with respect to the non- co-operative solution [...] whenever the spillover effect is large enough; otherwise it is the reverse*" (p.1136).

The authors conclude that:

> *"for large spillovers, [...] the amount of research which is the closest to the social optimum is the one achieved by firms co-operating in both output and research, and the most distant, the one obtained by non co-operative behaviour [...]. Concerning the quantity of production, the closest to the social optimum is what is produced by firms co-operating at the pre-competitive stage, that is, in research [...]. For small spill-overs, [...] the classifications are different, but the second best for R&D is still obtained by a co-operative behaviour at all stages"* (pp.1136-1137)

This article raised a considerable interest in the research community, since it reversed much of the previous doctrine on co-operation between firms. In particular, it was a (somewhat *post-hoc*) theoretical justification for the reversal of anti-trust regulations that until the 1980s prevented firms from co-operating in any field. It is however limited by some of its assumptions. Specifically, the effect of R&D is restricted to reducing the production costs of existing products, but has no influence on the development of new products. Another simplification is that the co-operation is restricted to the joint definition of the R&D expenditure level (and of the output level, when appropriate), but not on the nature of the R&D activities being undertaken. The firms are considered as

being identical, with no functional specialisation of any sort: the co-operation being considered is restricted to that between direct competitors, and not between organisations in different stages of the supply chain, or between organisations of different nature (such as private firms and non-profit research organisations). Another issue is that the effects of co-operation crucially depend on the spill-over level, which is summarised by a parameter designated as β in the article, with no means to actually measure it. Whether the spillover level is sufficient in any concrete situation to justify the co-operation in R&D therefore remains unknown.

Despite these limitations, the article by d'Aspremont and Jacquemin (1988) was followed by others, that generalised its findings. The most notable among these were those by Suzumura (1992), Yi (1996) and Hinloopen (2003).

Suzumura (1992) generalises d'Aspremont and Jacquemin's results to cases where the number of firms is superior to two, and where the inverse demand function and the function describing the cost reduction when R&D efforts are undertaken (by the focal firm and by its competitors) are non-linear. It also extends the criterion for the evaluation of social welfare to more realistic "*second best*" criteria. Taking into account these mathematical refinements, the original results hold.

Yi (1996) shows that

> *"(i) co-operative R&D reduces both equilibrium R&D and social welfare for "intermediate" spill-overs; (ii) co-operative R&D reduces R&D investments but has ambiguous effects on social welfare for "low" spill-overs [...]; and (iii) as the elasticity of the slope of the inverse demand function increases, co-operative R&D raises social welfare for a larger set of spill-over rates and, in the limit, co-operative R&D is socially benefitial for all spill-over rates" (p.682).*

Yi's main improvement to d'Aspremont and Jacquemin's article is to consider the effects of benefit sharing between producers and consumers in the computation of social welfare. The last result in the list above stems from the fact that, at the limit being described, the benefits of increased R&D are fully appropriated by the firms, and not by the consumers, so that any cost reduction (due to R&D effort) fully is translated into corporate profits (and therefore in social welfare), whatever the spill-over rate.

Finally, Hinloopen (2003) introduces the interesting argument that, when considering the social desirability of co-operation in R&D, the spill-over to be considered is not the one existing *ex ante*, but the one following the co-operative project. Indeed, a co-operative R&D project, by causing scientists and engineers from distinct organisations to work in close relationship, increases the opportunity for knowledge and know-how to flow between them (the spill-over effect). Since this spill-over is socially desirable, the increase in the spill-over due to the existence of a co-operative R&D project deserves being considered.

As a conclusion of this section, it may be seen that, both from a private, corporate point of view rooted in the Management literature, as well as from a public welfare point of

view expressed in the Economics literature, co-operation in R&D is considered as having positive effects, provided some validity conditions are met.

1.3.3 Factors influencing the propensity of firms to engage in co-operative R&D

Many articles study the factors that influence the probability for an organisation to engage in a co-operative R&D project.

Kleinknecht and Reijnen (1992) investigated a sample of 1929 Dutch firms in manufacturing and services, which perform R&D, with the aim to "*identify those factors which have a systematic influence on the probability that a firm engage in one or the other form of co-operation*" (p.349). Their findings tend to contradict many of the other articles that I identified: neither organisation size, nor R&D intensity, nor market concentration, nor activity in high-tech industries have any influence on co-operation in R&D. On the other hand, having used the services of a government R&D agency is related to co-operation, as is the fact of hosting an in-house R&D department.

Brockhoff (1992) wishes to determine "*what factors lead to perceptions that negotiating and transaction costs are high when co-operative R&D is carried out*" (p.514), by focusing on "*the technical characteristics of the products under development*" (p.514) and on "*the contractual arrangements within which the development takes place*" (p.514). He relies on data gathered through a questionnaire, to which 253 firms among the "*385 largest industrial establishments in the Federal Republic of Germany*" (p.516) answered. The issues when engaging in co-operative R&D are reminded as being mainly the dependency on the partners and the high costs of negotiations and transactions (Table 1, p.516), which justifies the reasons for adopting this transaction cost perspective. The author concludes that the following factors enhance the perception of transaction costs: "*a lack of experience with co-operation, formality of agreements and [...] early stages of a technological life-cycle*" (p.522) increase the perception of uncertainty, while international, later-stage developments involving functional areas such as production or marketing in addition to R&D would "*lead to a high specificity of resource commitments*" (p.522). Both phenomena contribute to the perception of high transaction costs in the co-operation, and thus tend to reduce the propensity to engage in a partnership.

Colombo and Garrone (1996) investigate with improved statistical tools the Granger-type (1969) causal relationship between R&D intensity and inter-firms co-operative agreements. While previous (and subsequent) research tended to consider that R&D intensiy could cause an increased propensity to engage in co-operative R&D, as is illustrated in the present section, the authors consider also the reverse relationship. They study a sample of "*95 major US, European and Japanese firms in the semiconductor, data processing and telecommunications industries, observed during the period 1980-1986*" (p.924), from the Arpa database from Politecnico di Milano containing 2014 agreements, using "*an extension of bivariate vector autoregressions*" (p.924). *À la* Granger causality is detected in both directions: R&D intensity causes the propensity to engage in co-operative agreements, and reciprocally (p.929). They should therefore be modelled jointly. Despite this early methodological warning, the articles surveyed in

this section show that its recommendations were not followed with significant effect by later research.

Sakakibara (1997) considers "*two competing motives for participating in co-operative R&D [...] cost-sharing vs. skill-sharing*" (p.143), by examining "*the differences in the fims' capabilities, as well as differences in the structure of the underlying competition*" (p.143). Her sample comprises 86 Japanese State-sponsored R&D consortia, in which 67 companies participated, for which 398 company-project pairs provided useable responses. She finds that "*firms perceive gaining access to complementary knowledge as the most important objective of the project*" (p.151), while "*sharing fixed costs is one of the least important objectives*" (p.151). By splitting respondents between homogenous and heterogeneous consortia as regards industries (and, implicitly, skills), she supports empirically her hypothesis that skill-sharing motivation is more important for consortia with heterogeneous skills bases (p.154). Regression models confirm her hypothesis that the motivation by cost sharing increases with project size (p.156). These effects are not modified by the level of government subsidies.

Robertson and Gatignon (1998) investigate the motivations for "*the formation of technology alliances*" and base their reflection"*on transaction cost analysis*" (p.516), with the idea that alliances are an intermediate between markets and hierarchy. The three dimensions relevant for deciding which mode of R&D should be chosen are: "*(1) asset specificity, (2) external uncertainty [about demand and technology], and (3) behavioral (internal) uncertainty*" (p.517). They obtained survey answers from 264 R&D directors in the United States of America, over several industries. The factors favouring co-operative compared to internal R&D are a low level of product-category specific assets, technological uncertainty, the ability to measure innovation performance, previous successful experience with alliances and slow market growth.

Bayona *et al.* (2001) "*analyze the reasons which motivate Spanish industrial firms to enter into cooperative R&D agreements*" (p.1290), in a context of less technologically advanced environments. They conclude that the factors that support the existence of co-operation in R&D are the existence of a permanent R&D activity in the organisation, the organisation size, the technological intensity of the sector, the perception of risk in the innovation process, the perception that lack of financing restricts innovation. These conclusions are tested for three classes of firm sizes, and are reasonably robust to variations along this parameter, with small firms being more sensitive to perceived obstacles to innovation and less ambitious.

Fritsch and Lukas (2001) studied the propensity to co-operate in a sample of 1800 German manufacturing firms located in three regions, Bade, Hanover-Brunswick-Göttingen and Saxony, and being rather specific as regards the depth of the co-operative relationship. They consider the factors that support the establishment of at least one co-operative R&D agreement, and identify them as being firm size, R&D intensity, the presence of a Gatekeeper function and the objective of developping a fully new product (rather than of improving an existing one).

Tether (2002) considers the factors that foster the existence of a co-operation in R&D in the United Kingdom. He identifies the engagement in R&D, the intensity of R&D effort (per employee), the financial effort to acquire external technologies, the fact of

engaging in more radical ("new to the market") innovations, the existence of barriers to innovation (information on markets, availability of financing, cost and risk of innovative activities), firm size, activity in the high tech sector (although with a different pattern of partners for services and manufacturing) as being factors supporting the existence of inter-organisational co-operation.

The empirical setting of Miotti and Sachwald's (2003) study were considered above (§ 1.3.2). They consider the determinants of co-operative propensity in France, and conclude on the favourable effect of firm size, public funding, existence of a permanent R&D department in the firm, and of the sector being R&D intensive.

Becker and Dietz (2004) also report on the probability of engaging in co-operative R&D effort in Germany, and identify a positive influence of R&D intensity of firms, of innovation barriers (cost and risk of innovation, financial restrictions).

(The space below is deliberately left blank)

The findings of these ten articles on the factors affecting the propensity of firms to engage in R&D may be summarised in the Table 1.3.2 below.

Sign of influence	**Variable**	**Significance level**	**Source**
Positive	Firm size	***	(Tether, 2002; Bayona et al., 2001; Fritsch and Lukas, 2001; Miotti and Sachwald, 2003)
	Public funding	***	(Miotti and Sachwald, 2003)
	Skills-sharing	***	(Sakakibara, 1997)
	Permanent R&D	**	(Tether, 2002; Bayona et al., 2001; Kleinknecht and Reijnen, 1992; Miotti and Sachwald, 2003)
	Innovation barriers	**	(Becker and Dietz, 2004; Tether, 2002; Bayona et al., 2001)
	Radical innovation	**	(Tether, 2002; Fritsch and Lukas, 2001)
	Diversification	**	(Becker and Dietz, 2004)
	Firm size	**	(Becker and Dietz, 2004)
	Previous successful experience with alliances	**	(Robertson and Gatignon, 1998)
	External sources of knowledge	**	(Becker and Dietz, 2004)
	R&D Intensity	**	(Becker and Dietz, 2004; Tether, 2002; Fritsch and Lukas, 2001)
	Technological uncertainty	*	(Robertson and Gatignon, 1998)
	Ability to measure innovation performance	*	(Robertson and Gatignon, 1998)
	High-tech sector	*	(Tether, 2002; Bayona et al., 2001; Miotti and Sachwald, 2003)
	Gatekeeper	*	(Fritsch and Lukas, 2001)
	Medium-tech sector	°	(Miotti and Sachwald, 2003)
Negative	International sales	**	(Becker and Dietz, 2004)
	Market growth	**	(Robertson and Gatignon, 1998)
	Asset specificiy	*	(Robertson and Gatignon, 1998)

Table 1.3.2: Variables influencing the propensity to engage in co-operative R&D
Significance levels: °: p-value <10%; *: p-value <5%; **: p-value <1%; ***: p-value < 0.1%

1.3.4 Criteria for partner selection

Miotti and Sachwald (2003) answer "*three major questions: why co-operate, who does and with whom?*" (p.1482). The empirical setting of their study were considered above (§ 1.3.2).

They identify that the propensity to co-operate with competitors is low, but is higher with clients, suppliers and public academic institutions. They also detect that French

firms, specifically SMEs, tend to co-operate within the same country and within Europe.

The authors' main focus of research is to investigate the propensity to co-operate with each of the four categories of possible partners: competitors, clients, suppliers and academic institutions. Co-operation with competitors is more frequent in high-tech sectors, and in cases where cost is considered as being the main obstacle to innovation: it would be the case when firms team up to share R&D costs in fast-evolving markets. On the other side, firms co-operating with public academic institutions do not consider costs, but the lack of information on the market, as being the main obstacle: this would mean that they are engaged in more advanced R&D, in more radical innovations, about which market knowledge is reduced. Co-operation with suppliers and customers is more frequent in lower-tech sectors, and is related to the fact that market information is scarcely available: co-operating with a customer may be a means to alleviate this issue. The determinants of co-operation with firms in the United States of America are firm size and operations in high-tech sectors in which the United States have a technological lead.

The effectiveness of innovation output in patenting is fostered by partnership with academic partners only, while the achievement of new products is more probable when partnering with clients or suppliers. The other forms of partnerships, i.e. with competitors, have no effect. Co-operation of French firms with partners located in the United States of America also tends to foster the application of patents and the share of new products in turnover, more than co-operation with French or European partners only.

Fritsch and Lukas (2001) dedicated their research also to the issue of determining the number of co-operation partners of the firm, once the decision was taken to actually engage in a co-operative R&D project. The empirical setting of their study were considered above (§ 1.3.2). They observe that once the firm has engaged in co-operative R&D, its size plays no role on the number of co-operation partners. However, the R&D intensity keeps its positive influence, while the objective to engage in the development of a new product takes a negative sign, which would indicate that firms engaging in high-stake innovation would concentrate their co-operation on a reduced number of partners.

1.3.5 Process of partnership formation

Doz *et al.* (2000) focus on "*the evolutionary processes of network formation*" (p.239), and examine in detail "*the formation of a particular type of network, an R&D consortium*" (p.240). They study 84 R&D consortia that filed "*with the U.S. Justice Department under the National Cooperative Research Act of 1984 between years 1984 and 1989*" (p.243), and received answers from 41 consortium managers and from 207 individual member organisations. The authors "*created a model with nine elements, represented by 47 factors, derived from 135 variables*" (p.245 and Table 2, p.246) using a Partial Least Squares (PLS) structural equation modelling software. They develop a model linking these nine elements together, along a complex, non-sequential graph (Figure 1, p. 248), that may be simplified into two main processes: "*Emergent*" and "*Engineered*" (p.249).

'Emergent' consortium formation processes, are triggered by "*responses to common threats or a perceived need to gain access to similar resources*" (p.250). In such processes, "*no one single entity creates the collaboration and there is an open solicitation in which any interested party may join. Thus, a consortium's membership is likely to come from a process of self-selection*" (p.250). The structure tends to have a weak central node, among organisations that know each other rather well, and often are competitors, with the purpose of exploiting a visible opportunity.

'Engineered' consortium formation processes, on the other hand, require "*the intervention of a triggering entity as a necessary condition for consortia formation*" (p.251). These 'Triggering entities' may act as "*champions, convincing potential member organisations [...] that an opportunity or a problem exists*" (p.251), and build a 'hub and spoke' network structure. The champion may be an individual rather than an organisation, and in this case, s/he tends to be well-connected, but from a weaker organisation, in order not to elicit skepticism among potential partners. If the consortium works well, the central, triggering node tends to reinforce over time. Since the consortium was purposely built by assembling entities that did not know one another before being set in contact upon its creation, this form is more related to explorative ventures.

Mathews (2002) investigates the specific case of Taiwanese R&D consortia, that, in contrast to those in more established industrial regions, are driven by "*technological learning, upgrading and catch-up industry creation*" (p.634), and have therefore led to specific management practices, specifically in public-private co-operations.

> *"The basic model of the Taiwanese alliances is the construction of a process in which R&D costs can be shared, and risks reduced, through bringing many small firms into a collaborative alliance with each other and with Taiwan's Industrial Technology Research Institute - ITRI. [...T]hey differ from their counterparts in the Triad countries in that their goal is rapid adoption of new technological standards, products or processes developed elsewhere, and their rapid diffusion to as many firms as possible—rather than extending the envelope of R&D"* (p.635).

He bases his research on 20 case studies of such consortia, that operated between 1983 and 1997, mainly in the electronics industry, but also in telecommunications, mechanical engineering and software (Table 1, p.636).

The general pattern is one in which the ITRI secures access to foreign advanced technologies on behalf of all participating Taiwanese firms, and then gathers these (often small) firms around a common project. Initially, the government's involvement was extensive, but tended to let more space for industry leadership later. The ITRI however plays a critical role by being considered as a "*neutral party*" (p.648), that allows "*the firms being able to work cooperatively and productively on a specific project while remaining competitors elsewhere*" (p.648). The main task of the consortium is to develop a well-targeted product, or more precisely a set of standardised components and interfaces (and a list of those standards, while deliberately and strategically maitaining other elements of the products open for competition and differentiation) that allow the participating firms to negotiate high-volume low-cost

deals with their suppliers, and therefore to reach mass production that would otherwise been inaccessible to these small actors (p.648). Once this product is developed, which generally is done after a short period of time (typically less than two years), the consortium is disbanded. They are very explicitely skills-sharing agreements (Sakakibara, 1997), and very much engineered (Doz et al., 2000), while keeping in mind that "*participation by firms is entirely voluntary*" (p.649).

Petersen *et al.* (2003) consider the effort symmetrical to co-operation with customers in the R&D process, namely the co-operation with suppliers. They base their conclusions on "*case studies with 17 Japanese and American manufacturing organizations and validate the model using data from a survey of 84 purchasing executives in global corporations with at least one supplier integration experience*" (p.285). The case studies were based on "*companies considered ''best in class'' in the areas of supplier integration into N[ew] P[roduct] D[evelopment]*" (p.286), in the "*automotive, electronics, computer, chemical, consumer products, and semiconductor industries*" (p.286). The four salient variables that were considered as potentially explanatory of success in the integration of suppliers in the NPD process were "*(a) Customer Knowledge of Supplier; (b) Technology and Cost Information Sharing; (c) Supplier Involvement in Decision-Making; and (d) Technology Uncertainty*" (p.287), in a multi-level structural model (Figure 1, p.286). The confirmation survey asked questions about the business unit's "*''most successful'' and ''least successful'' cases of supplier integration*" (p.290), and yielded 44 complete answers (i.e. paired responses from the same firm). The relationship between variables were computed using the "*EQS 5.6 structural equation modeling software package*" (p.292), and the relations anticipated by the structural model are confirmed and significant, with one exception (Figure 2, p.293).

1.3.6 Factors affecting the performance of co-operative R&D projects

Hakanson (1993) observes in a study over 49 projects among Nordic firms that "*prior contacts with prospective partners improve the chances that a cooperation will succeed*".

Olk and Young (1997) study specifically the "*members' decision to stay in or to leave*" a co-operative R&D consortium (p.855). The assumptions are that this decision is "*more than just the reversal of establishing a relationship*" (p.855) and that co-operations, in contrast to organisations, do not necessarily have survival as their long-term goal. The authors test two explanations for staying or leaving: (1) "*membership reflects satisfaction with the joint venture's performance*" (p.856) and (2) "*membership conditions*", i.e. the degree of dependency of the organisation on the venture itself. They study "*research and development consortia registered with the U.S. Department of Justice under the National Cooperative Research Act of 1984, listed in the Federal Register during the period January 1985 through January 1992*" (pp.861-862), and obtain 184 useable answers from 81 consortia.

The authors use the structural equation method of Partial Least Squares (p.863). Results (pp.866-867) show a positive and significant relationship between continuity of participation and (1) satisfaction with the consortium, (2) the fact of having fewer

alternatives to the consortium, (3) knowledge-related involvement in the venture and (4) the presence of more than one network relation within the consortium.

Ham and Mowery (1998) performed five case studies of Co-operative Research and Development Agreements between the Lawrence Livermore Laboratory, a large State-run weapons laboratory belonging to the Department of Energy in the United States of America, and one private firm (therefore considering dyads). The general conclusion is that these contracts are "*most effective for projects that draw on the historic missions and capabilities of the laboratories*" (p.662), and that successful projects "*require budgetary and management flexibility, a high degree of commitment form all parties, continuous interaction between the research teams familiarity with user needs and sufficient internal R&D and technical expertise within the firm to absorb and apply the results of collaboration*" (p.672).

The case studies examined, among others "*(1) management factors in the L[awrence] L[ivermore] N[ational] L[aboratory] and participating firms that affected the successful completion of the [agreement]; (2) the nature of the benefits realised by LLNL and private firms from these projects and (3) the feasibility of quantifying the economic benefits of recently completed [agreements]*" (p.664), and covered various sizes and durations of project, sizes of contracting firms and mix of process and product technology.

The areas for improvement in the co-operative R&D agreement process that were identified in the case studies were the following: (1) the process of formal approval for the contract should be shortened, specifically for those firms for which time to market is an essential competitiveness issue; (2) more attention should be given to smaller projects from senior researchers in the laboratory, which would imply changing the accounting rules for project overhead; (3) the private firm should have sufficient in-house technical and scientific expertise in order to be able to 'absorb' (Cohen and Levinthal, 1990) the knowledge from the agreement; (4) differences in R&D "*styles*" (p.667) between public R&D scientists keen on performance and understanding of the underlying scientific phenomena, rather than cost or compliance with schedule, and private firms eager to bring products to the market fast and to answer user needs, should be onvercome; (5) direct, personal contacts should be established between the LLNL scientists and potential users of the technology, in order for these scientists to better understand their needs and finally (6) more flexibility should be introduced in the financial management of the contract, in order to account for the inevitable uncertainties inherent to early-stage, advanced R&D.

The benefits of co-operative R&D agreements proved to be difficult to evaluate simply using economic criteria, such as "*jobs created, technological advances or increased exports*" (p.669). Most of the benefits were described as "*generic*" (p.669), in terms of technical & scientific knowledge for the firm, such as "*design principles, engineering techniques and testing methods*" (p.674), and of knowledge of practical civilian applications for the LLNL. A very simple metric of the agreement effect was that the participants considered simply that the project would have been infeasible without it - so that measuring benefits in terms of reduction in development cost or duration made little sense. In addition, estimations made of sales or of financial benefits in the

immediate aftermath of project completion, when significant technical fine-tuning remains to be done, proved to be extremely error-prone and to lack robustness.

Finally, the authors conclude on the "*influence of historical factors and intra-organisational incentives on the behaviour of researchers in Livermore and other facilities is so strong that reorientation of the activities of these research installations will require considerable time [and] far-reaching changes in their internal management*" (p.673).

1.3.7 Control and governance rules

Hakanson (1993) also argues that "*detailed specifications of the procedures to be followed during implementation*" should be avoided in co-operative R&D contractts, in order to maintain the level of flexibility and autonomy of operational actors compatible with uncertain ventures. The empirical setting of his study were considered above (§ 1.3.6).

Bouty (2000) studies the direct, interpersonal communications between scientists across firm boundaries, that generate up to 40 % of innovative ideas, but that could "*represent critical breaches of confidentiality*" (p.50). These information flows are "*ad hoc and independent of any organisational structure, policy and fomal collaborations*" (p.50), and make apparent the well-known "*tension between fostering innovation and retaining intellectual capital*" (p.50). She uses grounded theory methods (Glaser and Strauss, 1967) over interviews with 38 scientists working in France, in 13 organisations from 6 industries, during which 128 significant events were reported. She concludes that:

> *"Each individual decision is viewed as a three-step, filtering-down process. First, among potential exchanges, the only ones that are possible are those that encompass resources that the scientist [...] considers as not confidential and at hand. Second, the resources a scientist is ready to exchange depend on the extent of her or his acquaintance, mutual trust and competition with the partner. Third [...t]he interaction logic (profitable or equitable) is the last step in making the final decision"* (p.62).

When people barely know each other, or are "*satellites*" in each other's networks, they will exchange "*quasi-public information [...] on a published paper or a marketed product [or...] non-committing services, such as giving names or addresses*" (p.56). On the other hand, exchanges with people at the "*heart*" of each other's networks will involve "*strategic resources [such as] making measures on product samples with sophisticated equipment, prereviewing a paper, or exchanging ideas about a project in progress*" (p.56). The short-term "*profitable*" (p.57) exchange logic is about receiving immediate payback on non-strategic resources, while the longer-term "*equitable*" exchange logic is "*simply about helping a partner when he or she requires it an receiving help in return when you need it*" (p.57) on either strategic or non-strategic resources, with 'heart' partners being involved in 'equitable' exchanges only. Paradoxically, strategic resources are exchanged in an 'equitable' mode, where no direct, immediate and specific payback is planned (p.59) - in contradiction with the standard behaviour expected from the *homo œconomicus* in such high-stake issues. Development of a trusted relationship is a self-reinforcing process, where stakes initially are low, and the satisfaction of initial expectations leads to deeper and deeper involvement and the

transformation of 'profitable' to 'equitable' exchange logics, in a "*virtuous cycle leading from profitable exchanges between satellites to equitable exchange between heart partners*" (p.61), that can however be interrupted at any time (although with a form of inertia) when opportunistic behaviour is detected.

Oxley and Sampson (2004) consider methods to "*find the right balance between maintaining open knowledge exchange to further the technological development goals of the alliance, and controlling knowledge flows to avoid unintended leakage of valuable technology*" in R&D alliances (p.723), in addition to determining the "*appropriate governance structure or organisational form*" (p.723), as suggested by earlier literature on transaction costs economics. They investigate the method of defining the correct alliance "*scope, as an alternative to control the threat of knowledge leakage and protect R&D assets in an alliance*" (pp.723-724). Indeed, by reducing the alliance scope, the risks of potential leakage of knowledge are also minimised.

Alliance scope is operationalised in this study in a simple way, vertically, by distinguishing "*alliances that involve R&D activities alone against those that combine R&D with other activities, specifically manufacturing and / or marketing*" (p.726), where the former allow a much better isolation from external insight than the latter, although they are predicted to be performing worse in markets evolving at high speed. The empirical data covers 208 R&D alliances reported in the Securities Data Company database involving firms in telecommunications equipment or electronics, from 1996 to 2004.

The authors observe that overlap in markets, and specifically in geographic markets, tends to reduce the scope of alliances because of competition concerns, while the participation of industry "laggards" and technological overlap would increase it, because they have less to protect and more to gain from co-operation to catch up with leaders, and because of absorptive capacity effects, respectively. When considering jointly governance mechanisms, such as the choice of equity joint venture vs. contractual arrangements, and decision on scope, the authors observe that

> *"firms decide whether or not to engage in joint manufacturing based on the needs of the project and the capabilities of the partners, and then mitigate the hazards posed by joint manufacturing through choice of an appropriate governance structure. On the other hand, potential hazards raised by joint marketing are primarily mitigated by a reduction of alliance scope — i.e., partners simply avoid joint marketing when they foresee problems — and this decision is essentially independent of the choice of governance structure"* (pp.742-743).

1.3.8 Conclusion on the main findings of research in Management and Economics on co-operative R&D

As may be seen from this review of the most meaningful articles in Management journals on co-operative R&D, research has been fast to establish that co-operation has a positive effect on R&D outcomes (Becker and Dietz, 2004; Belderbos et al., 2004; Miotti and Sachwald, 2003) and on general welfare (D'Aspremont and Jacquemin, 1988; Suzumura, 1992; Yi, 1996; Hinloopen, 2003). The main purpose of the research has been on the prediction of propensity to co-operate, with reasonably convergent

results summarised in Table 1.3.2. Processes during the partnership formation, and during the operational phase of the co-operative R&D project were also studied, and led to operational recommendations (Oxley and Sampson, 2004; Petersen et al., 2003) and typologies (Bouty, 2000; Sakakibara, 1997; Doz et al., 2000) that were empirically confirmed (Mathews, 2002).

The factors that affect the performance of the co-operative R&D during partner selection were limited by the available data to the nature of the partner, to be differentiated between the following broad categories: competitor, academic institution, supplier or customer (Fritsch and Lukas, 2001; Miotti and Sachwald, 2003). Beyond this simple means to consider partner selection, the issues considered by these most cited articles in Management to predict the success of co-operative R&D projects were procedural, and affected the governance of the project itself (Hakanson, 1993; Ham and Mowery, 1998; Olk and Young, 1997).

(The space below is deliberately left blank)

These results of existing literature in Management and Economics on co-operative R&D may be summarised in the Figure 1.3.1 below.

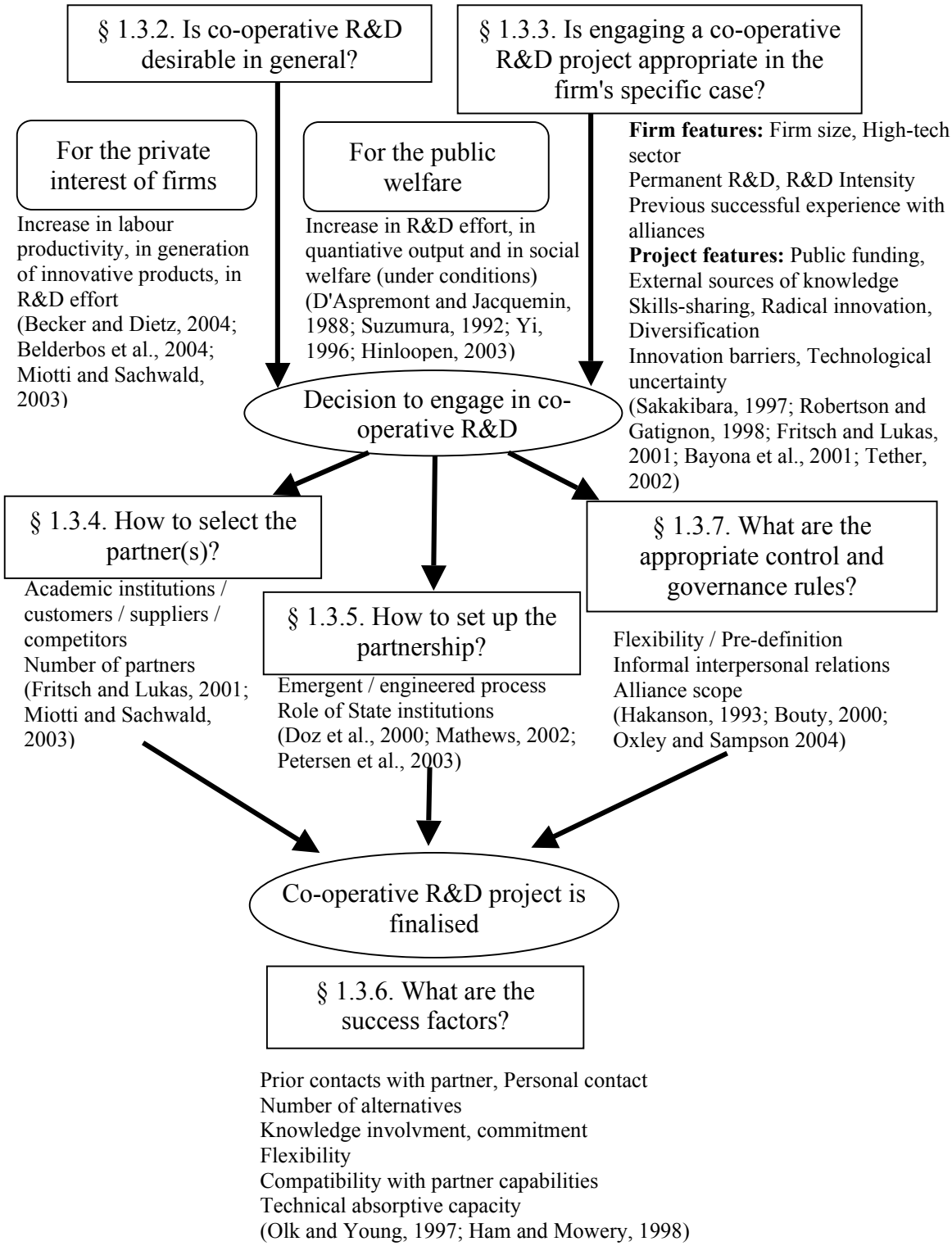

Figure 1.3.1: Results of existing literature in Management and Economics on co-operative R&D

I need therefore to be more specific in my literature review, and consider, beyond those influential articles that shaped the study of co-operative R&D in Management research, to consider in greater depth those articles that consider more specifically the prediction of co-operative outcomes. This is the purpose of my next section.

1.4 Predictors of co-operation outcomes

Scholars have been early at identifying this high failure rate of inter-organisational co-operation, and proposed interpretations, as well as remedies. In order to do so, one important issue is to identify the most influential factor on co-operation, or the most reliable predictor of co-operation outcomes.

In a first stream of research, influenced by Transaction Costs Economics and game theory, the main issue is that of the governance of the co-operation, and of its legal framework (§ 1.4.1). A Strategic Management perspective focuses on the *ex ante* assurance of goal compatibility (§ 1.4.2). Another direction of investigation considered geographic distance as a key factor for co-operation (§ 1.4.3), and was further refined in a broader concept of "*cognitive distance*" (§ 1.4.4). However, I do not consider these explanations as satisfactory, and will, in my thesis, pursue the practitioner-originated idea that determinants of co-operation outcomes lie in "*cultural fit*" and "*complementary capabilities*" between partners (§ 1.4.5). This will lead me to my research question in the next section (§ 1.5).

1.4.1 Legal governance of co-operation

In terms of Transaction Costs Economics (Coase, 1937; Williamson, 1979; Williamson, 1991), markets are a preferred mode of economic organisation when the specificity of the assets used to provide the goods is low. Reciprocally, hierarchies are preferred when assets are highly specific, and there would be a risk of 'hold-up' of the party having invested sunk costs in them. In this framework, co-operative partnerships and contracts (should they involve R&D or not) are considered as an 'hybrid', intermediate governance form between integrated hierarchies and markets, that would be valid when the specific nature of the assets involved in the transaction is moderate (Baudry, 1995). In this respect, it may be considered that identifying and implementing the right governance system, at the correct place along this continuum between hierarchies and markets, that would minimise the transaction costs of the interaction between the contracting firms, is a skill in itself, and a source of competitive advantage (Dyer and Singh, 1998).

Game theory was also mobilised to understand inter-organisational co-operation. It was mainly involved with un-co-operative games, such as the archetypal 'prisoners' dilemma', that foster opportunistic, and mutually destructive, behaviours, because each party has an incentive to be the first one to cheat. Scholars have then modelled the tools necessary to deter opportunism, using "*both ex ante contracts and ex post monitoring*" (Das and Teng, 2000b, p.98), or by relying on the fact that alliances "*are likely to resemble infinitely repeated games*" (p.80), in which a tit-for-tat strategy ensures co-operation (Axelrod, 1984).

This view of co-operative ventures as a form of zero-sum game, in which the gains from one side are necessarily the losses of the other, is highly prevalent among academic

researchers of the field. It leads to the recommendation of an opportunistic, predatory behaviour aiming at stealing as much as possible from the other party's knowledge is both to be pursued as a strategy, and to be feared from the other side. For Hamel et al. (1989), "*collaboration is competition in a different form*", and alliances are an opportunity to "*absorb the skills of the other*" (p.134). For Das and Teng (2000a) the purpose of the alliance lies in "*being able to procure valuable resources from the other party without losing control of one's own resources*" (p.44). They recommend using equity participations as an "*hostage*" to deter the stealing of valuable resources, and anticipate "*learning races*" in bilateral contract-based alliances that are to be terminated as soon as one firm has finished learning what it needed. For Dussauge et al. (2000), "*[t]he underlying interpretation of alliances [...] is that of a Trojan horse or the kiss of death*" (p.121).

These reflections, centred around the governance of the inter-firm R&D co-operation, have led to recommendations that appear as very standard, promoting the development of dedicated tools and staff. For Bamford and Gomes-Casseres (2002) firms should develop "*tools, systems, staff and organisational structures that institutionalise alliance excellence*" (p.321), that "*include a streamlined corporate alliance unit, an alliance mapping system, a deep and extensive database*" (p.323). Similarly, Anslinger and Jenk (2004) describe management institutions required for a joint venture to work that share many features with a standard shareholder agreement.

1.4.2 Strategic compatibility between partners' goals

In Doz and Hamel's (1998) strategic management perspective, the partners in an alliance must agree beforehand (1) which of the three "*value-creating logics*" is their motivation for entering an alliance, (2) what is the "*scope*" of the alliance, in its "*three dimensions: areas of interest, net benefits and joint operations*" (p.72) in order for the alliance to be successful. "*Strategic compatibility*" must also be ensured between potential partners, depending upon their respective "*competitive industry position*" among the following categories: "*leaders*", "*followers*" (which are further split between "*challengers*" and "*laggards*"), "*newcomers*".

> *"The commonly observed alliance configurations [are]: leaders collaborating with newcomers to limit new competition and weaken other coalitions; followers or newcomers joining forces to challenge leaders; newcomers using laggards for market entry and learning or wrestling advantages from leaders in exchange for markets"* (pp.116-117).

Once this strategic compatibility between partners' goals is assured by a preliminary check of the issues listed, then the co-operation is believed by the authors to proceed smoothly.

1.4.3 Geographic distance

In a very different perspective, economic geographers noticed that inter-firm co-operation appears to be particularly frequent and efficient in areas of high geographic concentration of R&D activities, known as 'high-tech clusters'. In these areas, such as the archetypal 'Silicon Valley' in California (United States of America), the local firms tend to co-operate very openly and intensely (Saxenian, 2000). The most important reasons why networks promote innovation have been identified as: better access of

firms to information, knowledge, skills and experience; more intense linkage and co-operation; higher response capacity; reduction of risks, moral hazard, information and transaction costs; and better trust and social cohesion (Hotz-Hart, 2000, p.434).

Research on high-tech clusters has focused on geographic proximity as a predictor of co-operative success, considering that the co-location of R&D activities strongly fosters co-operation. The local transmission of information between co-located organisations has been assumed to be somewhat automatic, following Marshall's (1890) often-cited observation that "*industrial secrets*" in clusters are "*in the air*". This automatic (and generally unplanned) transfer of knowledge from one organisation to the next over a short distance is being referred to in the literature as "*local knowledge spill-overs*". Scholars detect them macroscopically by geographically correlating the presence of knowledge sources (such as universities) with innovations (Feldman, 1994; Feldman, 2000; Audretsch and Feldman, 2004; Gallié, 2004). This research has focused on purely geographic proximity, as if it considered that the co-location of R&D activities was a sufficient condition for co-operation to take place. Its conclusions have led to very active public policies promoting short-distance co-operation, for example in France with the "*competitiveness poles*"[1] (Blanc, 2004; Darmon, 2004), in the European Union (Gustavsen et al., 2007) and by international public policy organisations (OECD - Organisation for Economic Co-operation and Development, 1999). The 'knowledge spillover' concept was also severely criticised as ignoring the effective transmission processes of high-value, proprietary knowledge between organisations, that generally involve elaborate partnership contracts and Intellectual Property clauses (Breschi and Lissoni, 2001).

The detailed study of innovative networks requires to investigate the actual existence of inter-organisational formal links, and not to presume their existence from the mere co-location of organisations. This work has been undertaken at a very local level, in a set of qualitative case studies (De Bernardy and Thivin, 1993; Decoster et al., 1993; Maillat et al., 1993; Lourimi and Torre, 2006).

A more sophisticated view on the inter-organisational information transmission was proposed by Bathelt et al. (2004) that introduce the distinction between local "*buzz*" and established "*pipelines*".

"*Buzz*" is defined as the free, continuous flow of information, gossip, rumours that happen in a socially rich environment, "*in negotiations with local suppliers, in phone calls during office hours, while talking to neighbours in the garden or when having lunch with other employees*" (p.41) but also in trade fairs that act as "*temporary clusters*" (Maskell et al., 2006). It provides ideas, confrontations with new opportunities, on a highly unstructured way. It may thus be argued that this local 'buzz' mainly refers to the 'know-who' information (Blondel, 2002): "*who knows what and where [s/he] is employed*" (Breschi and Lissoni, 2001, p.993).

"*Pipelines*" of information on the other hand are considered to be long-range communication channels, established at a rather high cost, aimed at obtaining pre-

[1] "*pôles de compétitivité*"

defined information from distant organisations. The cost of establishing such channels of information is related to the confidence-building process:

> *"This process of building up trust takes time and involves costs [It involves] sequential transactions and interactions wherein small risks are followed by larger ones and commitments progressively increase"* (Bathelt et al., 2004, p.43).

Despite its increased sophistication, the idea that simple geographic distance be sufficient to account for the quality of inter-organisational co-operation in R&D has been subject to several proposals for improvement, the most relevant of which being the idea that, in addition to geographic distance, a form of "cognitive distance" would need to be considered.

1.4.4 "Cognitive distance"

As a reaction to the limitations of pure geographic distance as an explanatory variable to co-operation outcomes, the notions of "*cognitive distance*" (Nooteboom, 2000) and of "*organised proximity*" (Torre and Rallet, 2005; Pecqueur and Zimmermann, 2004) were developed. They are based upon the intuition that

> *"People perceive, interpret and evaluate the world according to mental categories […] In order to achieve a specific joint goal the categories of thought of the people involved must be co-ordinated to some extent. Different people have a greater or lesser 'cognitive distance' between them. […] A trade-off needs to be made between cognitive distance, for the sake of novelty, and cognitive proximity, for the sake of efficient absorption. Information is useless if it is not new, but it is also useless if it is so new that it cannot be understood."* (Nooteboom, 2000, pp.71-72)

Concepts of these enriched forms of 'distance' (or, reciprocally, of 'proximity') are highly diverse (Knoben and Oerlemans, 2006). Many descriptions of these result from in-depth qualitative case studies (Filippi and Torre, 2003; Gill and Butler, 2003; Lam, 1997; Wilkof et al., 1995; Zeller, 2004).

In quantitative studies, operationalisation of 'cognitive distance' is generally limited to two methods: (1) cultural differences are represented by a variable for the nationality (Coenen et al., 2004; Gertler, 1995; Schamp et al., 2004), and (2) capabilities are restricted to technological capabilities, themselves represented by a technical specialisation index obtained from patent data (Branstetter and Sakakibara, 2002; Colombo, 2003; Greunz, 2003; Nooteboom et al., 2007; Nooteboom et al., 2005; Wuyts et al., 2005; Cantner and Meder, 2007). These methods suffer from various limitations. First, regarding nationality as a proxy for cultural differences between organisations overlooks the fact that regional diversity within nations may be larger than among nations, and that organisations themselves develop cultural features that may contradict, enhance or supplement national characteristics. Second, patent data, although easily available, is classified by application, not by underlying technology (World Intellectual Property Organization (WIPO), 2009): two patents belong to the same class if they solve the same problem, even by using different technical means. Therefore, the fact that organisations share the same patent classes means that they are involved with the

same applications – inferring that they use the same technological knowledge to do so goes beyond the actual information present in the patent class data. In addition, the pairwise nature of co-operation is lost in patent data, as noted by Nooteboom himself (2005, p.4): "*patent data are only available by firm per year, and cannot be attributed to individual alliance partners of the firm, so that the model has to be tested on the basis of average distance to the firm's alliance partners*".

The concept of 'organised proximity' (Torre and Rallet, 2005) encompasses two distinct phenomena: a "*logic of belonging*" where people belonging to the same organisation, or to the same R&D network interact easily because they have done it before and share the same communication routines, and a "*logic of similarity*", where people interact easily because they share the same representations. The authors however do not specify any further the means to operationalise this type of similarity.

1.4.5 Need for further explanations: influence of organisational capabilities and cultures

All of the parameters identified above may indeed influence the outcome of inter-organisational co-operation, and extensive earlier research has tended to support that the appropriate governance mechanisms, a sound strategic compatibility, geographic or 'cogntive' proximity all contribute to predicting the outcomes of inter-organisational co-operation, and that the correct choice in this space should ensure success.

However, it also appears that a strong motivation for inter-organisational co-operation is that the **capabilities** of partners are **complementary** (Richardson, 1972), a situation described as "*co-specialisation*" (Doz and Hamel, 1998). When this occurs, the reunion of the partner organisations becomes able to perform tasks, to reach goals, that neither of them would have been able to achieve separately. This is particularly important in Research & Development activities, that often requires the novel assembly of scientific & technical skills that originally are separated (Schumpeter, 1934). However, one difficulty to be overcome is to find the adequate **fit** (or compatibility) between organisational "***cultures***" (Mason, 1993; Bailey et al., 1998).

This assembly of different, complementary capabilities has been deemed possible by pure market mechanisms, where capabilities and knowledge are assimilated to mere information, and this information is considered as a "*commodity*" (Arrow, 1962), to be traded (albeit imperfectly) on a market. Another option would be to consider that all capabilities are embedded in individuals, and these may be reached and assembled by recruiting them from the open labour market (Tyson, 2006).

Another, and in my opinion more fruitful, path is to consider that **capabilities** are **collective**, embedded in the organisation itself (Penrose, 1995; Barney, 1991; Prahalad and Hamel, 1990; Teece et al., 1997; Teece and Pisano, 1994; Eisenhardt and Martin, 2000; Winter, 2003; Helfat et al., 2007). Members of the organisation bring into it their individual skills, but the seamless coordination of their actions requires the learning of specific inter-personal capacities, that convey global capabilities to the organisation as a whole. If indeed organisational capabilities exist, then explicit co-operation between organisations is a form of division of labour at this scale, that complements the internal division of labour within the firm (Fritsch and Lukas, 2001; Young, 1928).

Inter-organisational co-operation, specifically in Research & Development, and collective, organisational capabilities are therefore closely inter-related. Co-operation is (among other reasons) motivated by complementarity of organisational capabilities, and its success depends (among other causes) upon cultural compatibility between partners. Reciprocally, organisational capabilities, specifically scientific & technical capabilities, are modified and transformed by the co-operation with external partners (among other antecedents).

I will, in this thesis, explore in greater detail the influence of 'cultural fit' and 'complementary capabilities' on co-operative R&D. Before I proceed further however, I need to examine the state of the art in this field, in order to identify the gaps and weaknesses that I may contribute to remedy. This is the purpose of the next section (§ 1.5).

1.5 Review of the literature on the influence of organisational capabilities on co-operative R&D

I wish now to consider the state of the art in the research on the influence of organisational capabilities on co-operative R&D, in order to identify the areas in which my own research could be most productive. In order to do so, I performed a small-scale Systematic Review of the literature to identify the articles that relate the outcome of inter-firms co-operative activities with their capabilities.

1.5.1 Method of the Review of literature

I first relied upon a very recent literature review on the issue of R&D co-operation (Faems, 2006) that yielded 8 articles and 4 books.

I further performed an additional database search, using the following research string:

Concept	**Keyword string**
Co-operation	alliance OR cooperat* OR collaborat*
Outcomes	success OR failure OR outcome*
Capabilities	competenc* OR abilit* OR capabilit* OR skill* OR capacit*

Table 1.5.1: Research strings used for the small-scale Systematic Review on capability-based predictors of co-operative R&D outcomes

Since I was looking for articles treating the issue of the outcomes of co-operative activities, the first two concepts were linked by the WITHIN3 operator, which means that the words must be within 3 words of one another for the article to be selected. The search was performed on the ABI-Inform database, the only management database that includes the WITHIN3 operator. The search yielded 97 articles, of which 20 were relevant following the reading of the title and abstract.

Finally, I was made aware of one additional book (Saad, 1998) on this subject by one respondent in my survey, and of two references by anonymous referees of an article containing the main results of my research.

The final list of relevant and high-quality references that I have used in this small-scale Systematic Review is the following.

N°	**Reference** (in alphabetical order of main author)	**Journal name or Editor of the book**
1	(Arya and Lin, 2007)	Journal of Management
2	(Bailey et al., 1998)	International Journal of Technology Management
3	(Bizan, 2003)	Research Policy
4	(Branstetter and Sakakibara, 2002)	American Economic Review
5	(Brouthers et al., 1995)	Long range planning
6	(Das and Teng, 2000a)	Journal of Management
7	(Dodgson, 1993)	Routledge, London (United Kingdom)
8	(Doz and Hamel, 1998)	Harvard Business School Press, Boston, Mass. (United States of America)
9	(Gulati, 1998)	Strategic Management Journal
10	(Kale et al., 2002)	Strategic Management Journal
11	(Koza and Lewin, 1998)	Organization Science
12	(Lambe et al., 2002)	Academy of Marketing Science Journal
13	(Mason, 1993)	Management Review
14	(Rothaermel and Deeds, 2006)	Journal of Business Venturing
15	(Saad, 1998)	Peter Lang GmbH, Frankfurt am Main (Germany)
16	(Sampson, 2005)	Strategic Management Journal
17	(Sivadas and Dwyer, 2000)	Journal of Marketing
18	(Taylor, 2005)	International Journal of Operations & Production Management
19	(Wilkof et al., 1995)	The Journal of Applied Behavioral Science
20	(Yuan and Wang, 1995, p.785)	International Journal of Technology Management
21	(Zajac, 1998)	Strategic Management Journal
22	(Zollo et al., 2002)	Organization Science

Table 1.5.2: List of articles and books being considered in the small-scale Systematic Review

1.5.2 The re-use of practitioner-originated notions

One route pursued by extant literature on organisational capabilities and co-operation has been to rely upon practitioners themselves, and to re-use their concepts and notions in surveys. Mason (1993) uses the metaphor of "*marriage*" (p.11) to describe an alliance. She states that "*chemistry is […] extremely important, because personalities as well as business ideologies have to blend for the partnership to work*" (p.11). Her notion of "*chemistry*" is typical of the sort of vague and unspecified, yet very frequent, notion found in the literature on alliances. It translates the personality fit between the managers in charge of the co-operation, and more broadly that between the organisations.

Brouthers et al. (1995) define *"[t]he four Cs of strategic alliances: [...] alliances should be utilised when: complementary skills are offered by the partners; co-operative cultures exist between the firms; the firms have compatible goals; and commensurate risks are involved*" (p.18). Again, the notions of 'complementary skills' and 'co-operative cultures', although considered as fundamental by the authors, are not further defined in the article. Bailey et al. (1998) use the concepts provided by their respondents to identify the main selection criteria for co-operative R&D partners: "*technical capability; matching aims; cultural compatibility; [...] management ability; collaborative record; business strength*" (in descending order of importance, table 6, p.131). These notions are considered as self-evident by the respondents, and are not further developed by the authors.

Koza and Lewin (1998) appear as very conscious of the existence of a gap in the understanding of co-operative inter-firm activities. They underscore that *"[w]hile many idiosyncratic factors have been attributed to explain alliance success, failure and stability,* ***trust*** *seems to have emerged as the* ***magic ingredient*** *necessary for alliances to succeed*" (p.259, emphasis added). They do not consider this invocation as satisfactory, though: "*First, [...] trust is treated as a residual term for the complex social-psychological processes for social action to occur [...] Typically, trust is attributed ex post. For trust to be a useful concept, its principle components must be identified, operationalised and measured*" (p.259). They conclude that "*[r]esearch on trust must evolve beyond a catch-it-all residual in the unexplained random error*" (p.261), but provide no route in this research programme towards an operationalisation of this concept.

In his early book on alliances, Dodgson (1993) underlines that the "*reasons for the success of the collaboration [were]* ***complementary technology*** *and* ***trust****, respect and good communication between partners*" (p.152, emphasis added) and compatible business aims. He also stresses the importance of cultural compatibility: "*Successful collaboration depends critically on a* ***shared culture*** *between scientists and engineers*" (p.159, emphasis added), and illustrates this by anecdotal evidence involving dress codes at IBM and Apple, but does not go any further in making explicit the criteria along which this 'compatibility' should be sought.

In their reference book on alliances, Doz and Hamel (Doz and Hamel, 1998) notice that "*each partner in the alliance projects onto the alliance its 'way of doing things', a set of tacit and accepted behaviours, norms, procedures and routines*" (p.143), and that therefore "*differences in styles, values, beliefs, and approaches to decision-making likewise set allied firms apart*" (p.146). They observe that "*compatibility does not usually stem from similarity in strategic position and/or other contributions but from* ***complementarity****, implying differentiated rather than similar positions and contributions*" (p.99). However, and again, they do not develop the nature of this complementarity, nor of the dimensions along which it should be considered, except for an example of the differences between a "*bigger, more bureaucratic, partner*" and "*smaller, more entrepreneurial partner*" (Table 6.2, p.152), that would suggest that organisation size is relevant.

Taylor (2005) performed an empirical investigation on 'link' alliances (i.e. implying firms contributing dissimilar inputs) in the software industry. "*Trust*" is identified as the

most influential factor. "*The second most influential factor [...] emphasises the need for personal rapport and chemistry among the individuals tasked with making the alliance work*" (p.481). The author also stresses "*the almost palpable need for **compatible capabilities and cultures***" (pp.482-483, emphasis added). However, neither of these notions of 'trust', 'personal chemistry' or 'compatible culture' is defined any further than by its name.

In a much more theoretical article, Das and Teng (2000a) also consider that, for an alliance to be successful, complementarity must be present, and that "*complementary alignment exists under two conditions: the resources have to be [...] complementary [...and] to be compatible*" (p.50). They do not, however, explicit any further what is meant by these adjectives.

Following the same route, Wilkof et al. (1995) evidence in a detailed case study how "*corporate culture mismatches*", interpreted along the framework provided by Harrison (1972), impact the life of an inter-organisational relationship in the computer industry.

It may thus be seen that scholars do consider these practitioner-originated notions as being important, but that they have the greatest difficulties in operationalising them, and in transforming them into variables that have a predictive capability. As underscored by Koza and Lewin (1998), the claimed explanation appears often as a *post-hoc* justification, be it that of 'trust', or the contentions that "*the company is very supportive towards the alliance*" or that "*effective communication channels exist between the company and its alliance members*" (Yuan and Wang, 1995, p.785).

This difficulty in moving beyond a mere re-use of the practitioners-originated notions may be rooted in the fact that the measurement of collective competencies remains a very nascent and immature field of academic investigation, as I have shown earlier (Zibell, 2007, reproduced in Appendix A, and summarised in § 5.2).

1.5.3 The hypothesis of a generic "alliance management capability"

Another route considered by the extant literature is to investigate the existence of an 'alliance management capability', growing with prior experience of involvement in alliances, that describes the appearance of a new corporate function dedicated to its legal and procedural aspects, in the wake of the transaction costs economics approach described above (§ 1.4.1). The existence of such a generic capability was first suggested by Zajac (1998), building upon an observation by Gulati (1998) that "*alliance management*" capability encompasses: "*identifying valuable alliance opportunities and good partners, using appropriate governance mechanisms, developing inter-firm knowledge-sharing routines, making requisite relationship-specific investments, and initiating necessary changes to the partnerships as it evolves while also managing partner's expectations*" (p.308). This generic 'alliance management capability' was successfully supported empirically (Kale et al., 2002; Lambe et al., 2002; Sampson, 2005; Hoang and Rothaermel, 2005). Rothaermel and Deeds (2006) define "*a high-technology venture's alliance management capability*" in a quantitative fashion as "*a firm's ability to effectively manage multiple alliances*" (p.430). They measure it by "*the point of diminishing total returns in the relationship between a firm's alliances and its new product development*" (p.433), under the hypothesis that each firm is only able to manage a limited number of alliances simultaneously. They investigate it with a sample

of "*2 226 R&D alliances entered into by 325 global biotechnology firms in the 25-year period between 1973 and 1997*" (p.430). They positively correlate this 'alliance management capability' to a biotechnology firm's "*alliance experience*", proxied by "*its alliance years, which is the cumulative sum of the alliance duration for each of the firm's alliances*" (p.443).

However, the contention that 'alliance management capability' be generic, i.e. that the knowledge and practice learnt during the interactions with one partner organisation are re-usable with any other one, has been debated.

Sampson (2005), studied the effects of alliance experience, measured simply by "*a count of alliances that a firm has been involved in[...]. These alliances can be of any type, such as marketing, manufacturing, or supply*". She justifies her choice contradicting that of Rothaermel and Deeds (2006) by arguing that:

> *"firms learn to manage the coordination difficulties inherent in R&D alliances with any type of prior alliance experience, rather than just prior R&D alliance experience. With any type of alliance, firms learn how to coordinate across organizational boundaries, select appropriate contract structures, evaluate performance and manage differences in corporate cultures. Coordination across firm boundaries is always challenging and, therefore, skills gained in improving this coordination likely are gained from any type of alliance"* (pp.1016-1017).

When she examines whether the alliance experience is generic or specific to a given partner, she draws mixed conclusions: "*prior experience with a specific partner improves collaborative outcomes; the estimate of prior links is positive and significant. [...] However, this effect does not remove the effect of prior experience generally. Non-specific prior alliance experience still has a positive and significant effect on alliance outcomes*" (p.1023).

Hoang and Rothaermel (2005), in a study of 158 co-operative projects between established pharmaceutical and start-up biotechnology firms in the United States of America between 1980 and 1998, whose outcomes are unequivocally successes (i.e. FDA or EMEA approval) or failures (i.e. discontinued), observe an effect of the generic alliance capability of the biotechnology firm (but not of that of the pharmaceutical firm), and no effect of the dyad-specific alliance capability.

In the opposite direction, a strong argument that a firm's co-operation ability is specific to each given partner is given by Zollo et al. (2002). They argue that generic alliance competency may be problematic, because "*alliances are typically less frequent and more heterogeneous than many manufacturing or R&D processes*" (p.703), which makes lessons learnt in one case easier to forget and more difficult to transpose to another setting or to accumulate. The "*paucity of metrics*" (p.703) on the success of alliance is also a source of difficulties to learn, since if there is no base to appreciate success or failure, it is difficult to provide input to the learning feedback process. However, they posit that "*[o]ne [...] key body of knowledge accumulated during alliance activity concerns the partnering firms themselves [...] both partners develop a[n...] understanding of each other's cultures, management systems, capabilities,*

weaknesses" (p.703). This knowledge can be described as inter-organisational routines. The empirical investigation was made in the biotechnology sector. Three types of prior alliance experience were investigated, by asking respondents to report "*the number of prior agreements with any partner on any subject (i.e. general collaborative experience), the number of prior agreements with any partner in product areas similar to the one of the focal agreement (i.e. technology-specific experience) and the number of prior agreements with the same partner (i.e. partner-specific experience)*" (p.707). The linear regression model (Table 2, p.708) shows no support for the hypotheses that previous general collaborative experience and technology-specific experience should positively influence the success of alliances. However, it shows that "*partner-specific experience fosters better alliance performance*" (p.707). The authors conclude:

> *"We […] suggest that partner-specific experience facilitates the development of inter-organisational routines, or stable patterns of behaviour aimed at the interaction and co-operation across the two organisations. These routines may contribute to the performance of the alliance by facilitating the information gathering, communication, decision-making, conflict resolution and the overall governance of the collaborative process" (p.709).*

However, even this conclusion is questioned by Dyer et al. (2007) in a later empirical investigation on 397 companies involved in 142 R&D alliances funded by Advanced Technology Project (ATP) within the National Institute of Standards and Technology in the United States of America that covers a large variety of explanatory variables, gathered in three categories: "*alliance formation factors*", "*alliance execution factors*" and control variables. For them, neither "*general alliance experience*" nor "*partner-specific alliance experience*" has any influence on project outcomes.

1.5.4 Studies investigating capabilities-based predictors of co-operative R&D outcomes

I have only identified a handful of studies that investigate deeper into the capabilities-based predictors of co-operative R&D success, in addition to those that mobilise the concept of "cognitive distance" (§ 1.4.4).

Sivadas and Dwyer (2000) introduce and operationalise a construct called "*cooperative competency*" (p.32). "*We use the term cooperative competency to refer to [...] trust, communication and coordination. Cooperative competency is a property of the relationship among the organisational entities participating in N[ew] P[roduct] D[evelopment]*" (p.33). The need for cooperative competency is present in both intra- and inter-firm NPD: "*whether or not NPD is undertaken jointly with another organisation, it is a cooperative enterprise with other functional units- R&D, marketing and manufacturing*" (p.33). This construct is very close to that of 'deftness' that was defined by McGrath et al. (1995) in an intra-organisational setting as "*how well group processes are operating*" (p.267), or "*a quality in a group which permits [mutually] heedful interactions to be conducted at minimal cost*" (p.256).

This 'co-operative competency' is considered by the authors as crucial for the success of the New Product Development:

> *"Cooperative competency manifests itself through the effective exchange of information (communication), and the negotiation and design of activities and roles (coordination). Without trust, there can be little sharing of information, only minimal regards for system requirements, weak follow-through and low goal attainment. Cooperative competency is the ability of interacting units (within or across firms) to adjust mutually"* (p.33).

They validated their construct in an empirical research on New Product Development in the semiconductor industry (that represent 400 firms in the United States of America, and had reportedly formed 130 alliances in 1993). Their main study was performed on 350 firms, controlling to have all major (i.e. publicly listed) firms in the sample. In addition to 'co-operative competency' that was the purpose of a full section of the questionnaire, the "*[c]omplementarity of partner competencies was measured using a two-item, five-point scale. The items measured the extent of synergy in the objectives and capabilities of the partners*" (p.38).

The empirical results show that 'cooperative competency' and complementarity of partner competencies both have a significant and positive influence on NPD success. Cooperative competency itself is enhanced by "*clan*" governance features, i.e. when interactions are "*governed by shared values and norms*" (p.34).

> *"High partnering capability [...](selecting the right kind of partner, using appropriate administrative mechanisms and providing appropriate institutional support) [...] alone will not ensure high levels of cooperative competency and NPD success"* (p.45).

Despite the rather crude mode of measurement of 'complementarity of partner competencies', this study is one of the only ones to introduce a conceptually developed dyadic organisational capability, in which the heart of co-operative activity is addressed. However, despite the acknowledgement that the dyad is the locus of this "co-operative competency", it is measured unilaterally, by only asking one of the partners in the co-operation, which limits the validity of the findings.

Arya and Lin (2007) have contributed the second example I have identified of a research in which the dyad is investigated as the unit of analysis. Their conceptual contribution lies in the fact that the activities (and also, implicitly, the abilities) of both partners are compared by means of overlap or of difference between data obtained independently from each.

The article empirically considers the effects of networking between organisations in the not-for-profit sector, in the empirical setting of "*HIV/AIDS service delivery network in Dallas, Texas [in the United States of America]*" (p.709).

The survey asked for features at organisation level (pp.701-703): "*service generalism*" (i.e. the scope of the organisation's services from a list of 29 possible services), "*funding generalism*" (i.e. the diversity of the organisation's funding, from a list of 6 potential funding sources) and " *status*" (i.e. the recognition of the organisation by its peers). For each identified 'collaborative relation', i.e. at dyad level, the researchers computed the "*service overlap*" (p.704) and the "*funding overlap*" (p.705) by counting the number of

services or funding sources the partners have in common, and the "*status difference*" (p.706). The empirical study identifies the "*strategic benefits that accrue to the focal organisation from collaboration*" (p.712), and validates that 'service generalism' is positively and significantly correlated to them, while 'funding overlap' exerts a negative and significant influence.

Bizan (2003), in the third study that I identified, attempts to predict the technical and commercial success of co-operative US-Israeli R&D projects, supported by the State-sponsored BIRD Foundation. His data, at dyad level, contains the work sharing between both partner firms during the project in five functional areas: (1) R&D activity, development of prototypes, and software modules; (2) product definition, specification and requirements, and protocol writing; (3) product and interface design, integration, alpha and beta-site tests, quality assurance, documentation and packaging; (4) manufacturing; (5) sales, services and customer support. Complementarity between partners is assumed when only one firm participates in the task, and substitution when they both participate in the task. This work-sharing is not, however, strictly equivalent to the presence or absence of capabilities in each of the partners, and Bizan does not make the claim that it would be. The prediction of technical and commercial success is made difficult by the very high success rate (94.36 % and 79.85 % respectively). The main findings are that project size and integration between partners favour both natures of success, while complementarity only affects technical success.

Branstetter and Sakakibara (2002) study "*almost all company - to - company cooperative R&D projects formed with a degree of government involvment from 1980 to 1992*" in Japan (p.145), and measure their outcomes as the variation in the number of patents applied for by participating firms "*in the targeted technologies before, during and after participation*" in the consortium (p.144). The measurement of outcome is made at the level of the firm, and the issue is to detect the influence of participation in the consortium on the overall corporate patenting activity. The explanatory variables explored are: (1) the technological proximity of participants, i.e. the normalised correlation between patent portfolios of partners, as in other studies of "cognitive distance" (§ 1.4.4); (2) the market proximity of participants, i.e. the relative weight of markets where commercial activities overlap to the whole activity; (3) the basic nature of the research; (4) the centralisation of consortium organisation; (5) the diversity of the industry mix in the consortium. The results show: (1) a positive and significant effect of technological proximity; (2) a negative (but statistically not very robust) effect of market proximity and (3) a positive effect of "basic research orientation".

The research presents the limitation that it uses patent data (§ 1.4.4), despite their limits as descriptors of technical knowledge. However, it is a highly integrative piece of research, that covers a very diverse field of potential explanatory variables.

Saad (1998) wrote the fifth and final study relevant to my investigation. He performed a very thorough and early empirical investigation of the relations between the initiation phase of a European (Esprit) co-operative R&D project and its overall success, and of the predictors of the initiation phase success. The study relies upon a multi-lingual questionnaire sent to 676 project managers in 12 European countries, and that received 339 responses from organisations that had participated in a total of 193 projects (response rate of 50.1%).

The constructs being used as potential predictors of the success of the initiation phase and of the overall project are the following: (1) consortium confidence[2]: free flow of information, relevance, reliability of commitments, heeding of confidentiality; (2) consortium solidarity[3]: resources invested for the project, readiness to fulfil commitments, importance of long-term relationship; (3) goal clarity[4]: clear definition of prototype performance & functionalities and of partner contributions & roles; (4) goal conflicts[5]: differences in technical objectives, applicability appreciation, valorisation of inputs; (5) consortium competence[6]: qualified employees, relevant infrastructure, technical references; (6) complementarity[7]: mutual complement, synergies, goals reached through co-operation. He also considers metrics of success of the initiation phase and of the overall project: (1) project "effectivity" = concrete results and satisfaction with the prototype; (2) project "efficiency" = compliance with time and resource budgets; (3) success in terms of co-operation; (4) success in terms of learning. (Table 4.7, p.139, Tables 6.2 to 6.9, pp.173-181 and Tables 7.1 to 7.4, pp. 208-213)

The constructs result from the consolidation of (2 to 7) questionnaire items, the validity and reliability of the construct are checked using factor analysis, Cronbach's Alpha coefficient and Items-to-Total correlation (Tables 6.2 to 6.9, pp.173-181 and Tables 7.1 to 7.4, pp. 208-213). The relations between potentially explanatory constructs and those describing the success of the initiation phase or of the overall project are established using correlation analysis and linear regressions (Tables 6.14 to 6.19, pp.191-200 and Tables 7.6 to 7.9, pp. 215-219). The main results are: (1) the initiation phase is positively and significantly related to the overall success, however, the model only explains 6 % of the variance; (2) the relation between initiation phase and overall success grows meaningfully for short (≤ 24 months) and small (≤ 6 partners) projects; (3) "consortium confidence" and "complementarity" are the significant independent variables in the linear regressions that explain the overall project success and its sub-components, with models explaining between 8.5 % and 20.8 % of variance.

However, although Saad's unit of analysis is the project, and although he collects information from several organisations participating in the same project, he does not exploit the differences and similarities between the answers provided by the partners: answers from different organisations having participated in the same project are simply averaged, with weights according to their share of the project budget. He therefore loses the opportunity that his very rich set of data could have given him to investigate deeper into the notions of "complementarity". In addition, his mode of investigation relies upon very general appreciations made by his respondent on the objects being considered (such as "complementarity", "confidence" or "competence"), and he does not move any further in the actual measurement of these.

[2] Konsortialvertrauen
[3] Konsortialverbundenheit
[4] Zielklarheit
[5] Zielkonflikte
[6] Konsortialkompetenz
[7] Komplementarität

1.5.5 Conclusions on the literature related to the effects of organisational capabilities on co-operative R&D

As a conclusion, it may be seen that the literature on the effects of organisational capabilities on co-operative R&D remains very limited. Although the practitioners insist that they look for '**complementary capabilities**' as a key motivation for engaging in co-operation and believe that '**compatible cultures**' are determinants of success, scholars have mainly either re-used these vague notions without critical appraisal nor deeper investigation or have reduced the concept to the single dimension of 'alliance management capability' that fitted well with earlier reflections on governance. Neither of these approaches appears as satisfactory, since none considers the variety of organisational capabilities and cultures that may be involved in the success of a co-operative R&D activity, nor do they operationalise them.

The very few studies that dwell deeper in the investigation of the relation between organisational capabilities and co-operative R&D provide interesting insights, but remain limited. Sivadas and Dwyer (2000) and Saad (1998) both evidence the importance of 'complementarity' for co-operative R&D project success, and stress the relevance of 'co-operative competence' or of 'consortium confidence'. However, their operationalisation of these constructs relies on the general answers of isolated respondents, although these authors recognise that co-operation is dyadic in nature. Bizan (2003) uses data from both partners, but it covers work-sharing in the project, not capabilities. Arya and Lin (2007) and Branstetter and Sakakibara (2002) provide the only studies that I have encountered that draw conclusions on the compatibility and complementarity of organisational capabilities by comparing the answers obtained independently from the two participating organisations.

The very limited existing research on the subject justifies that I dedicate time and effort to investigate it. I will specify the precise purpose of this proposed work hereafter (§ 1.6).

1.6 Research question and scope of the research

I am now in a position to specify my research question and thus the purpose of this doctoral thesis. I will first state my research question (§1.6.1), then justify the scope of my investigation (§1.6.2).

1.6.1 Formulation of the research question

I focus on two predictors of the outcomes of co-operative Research & Development projects that have so far received little attention in the literature, although they are widely recognised by practitioners as being relevant both in the selection of partners and in the prediction of outcomes: 'cultural fit' and 'complementarity of capabilities' (Brouthers et al., 1995; Mason, 1993; Bailey et al., 1998; Taylor, 2005).

More precisely, my research questions are the following:

(1) what combinations, at the dyad level, of the 'organisational capabilities' and 'world views' of the partner organisations, are reliable predictors of the **concrete** outcomes of co-operative R&D projects?

(2) what combinations, at the dyad level, of the 'organisational capabilities' and 'world views' of the partner organisations, are reliable predictors of the **learning** outcomes of co-operative R&D projects?

In this research question, several concepts need to be defined with greater accuracy. I will define "Research & Development" and "co-operative R&D projects" immediately hereafter (§ 1.6.2). However, the precise meaning that I give to two key concepts of my research, namely "**organisational capabilities**" and "**world views**" is the purpose of the first part of my thesis, and will only be provided significantly later (§ 3.2 and 4.3).

'Learning' in this specification of the research question includes the following three components:

1. the modification of the organisation's capabilities
2. the common creation of knowledge by the co-operative R&D project and
3. the (unilateral) transfer of knowledge from one organisation to its partner during the co-operative R&D project.

The learning is the feedback effect of the co-operative R&D project on the capabilities of the partner organisations.

1.6.2 Scope of the research and justification

The scope of my research is that of formal, time-limited R&D projects, mobilising two partners based in Europe, and in the industrial field of the electronics and telecommunications equipment. I will justify this scope in the following sections.

1.6.2.1 Research & Development as a privileged observation point for inter-organisational co-operation

I define **Research & Development** (subsequently abbreviated as R&D) as a cognitive activity mobilising scientific and technical knowledge with the ultimate purpose of designing an new artefact that will be used concretely. This artefact may be any combination of material and immaterial components, from a pure material "product" to a purely immaterial "service" or "process". The fact of the artefact to be "new" means that at least one of its features or characteristics is different from any of those previously existing or known to perform the same function, or that it performs at least one function that previous artefacts were unable to. As such, R&D is a powerful engine of **innovation**.

This definition specifies in some greater detail the one given by the OECD (2003): "*Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society and the use of this stock of knowledge to devise new applications*" (§ 57).

I exclude from the scope of Research & Development that I consider in this thesis those innovations in marketing or business models: I concentrate solely on science and technology.

The perspective of designing an usable artefact may be in the long term, and the R&D activity may be far away from the concrete application, but this perspective remains present. In that respect, R&D may be distinguished from (pure) research, where the aim is the creation of knowledge *per se*. R&D activity may therefore range from the creation of scientific or technical knowledge (that still keep in mind potentially long-term applications) to the design and mass production of a fully industrialised artefact.

The users of the artefact being developed by an R&D activity may be customers on a market, but it is not necessarily so. The nature of R&D does not require a specific mode of making its outcome available to users: free availability (as in the "*libre*" software environment), or provision by a State-run organisation (as was the case in the armament industry and arsenals until recently, or in the technically innovative Soviet Union) are fully legitimate options.

I choose to study specifically **co-operation** in the field of **Research & Development** because these operations mobilise a high level of motivation from the participants, if they are to succeed. By definition, innovation cannot be a mere repetition of what exists already. It requires those involved in innovative activities to go beyond known frontiers, to explore, with no other metric for success than those that the innovator sets for him/herself (while in imitation or catch-up settings, the standard is set by the leading firm / organisation in the field).

Therefore, the determinants of co-operation outcomes in R&D should be more demanding than those of co-operation in other fields (such as workload sharing in manufacturing, joint sales forces or common, centralised provisioning). Co-operation in R&D should thus reveal more about co-operation efficiency than other forms of inter-organisational co-operation.

Another justification for my focus on R&D is that, in a "*knowledge-based economy*" (Drucker, 1969), or in the age of "*cognitive capitalism*" (Lebert and Vercellone, 2004), the determinant factor of production and economic prosperity is knowledge. Therefore, the activities that create, transform and lead to the appropriation of knowledge, epitomised by Research & Development, are of paramount importance to understand the evolutions of economic activities.

1.6.2.2 Formal, time-limited projects as instruments to observe outcomes

My intention is to study the effects of collective capabilities and cultures on co-operative R&D. In order to perform a reliable measurement, I need to ascertain the following: (1) I must have reliable evidence that co-operation has indeed taken place; and (2) I must have a metric for the outcome of the R&D process.

Co-operation may indeed take highly informal forms, among people that know each other well, in a form of "*cafeteria effect*" (Massard et al., 2004). However, detecting and characterising such informal relations between people is an extremely difficult task for empirical research: it would require to have a list of all people present in a given

geographic setting, and to be able to ask them about the nature of their relations with all the others. This very concrete difficulty has led me to focus my research on **explicit**, **formal** co-operations between organisations. These co-operations are significantly easier to detect, because they are supported by formal contracts, and because, being often supported by public bodies, they are recorded in publicly available databases.

In order for an outcome to be measured for the R&D process, it is important to have a point in time at which the retrospective evaluation is made of what was achieved during the process. This point in time should be universal enough over all R&D processes being considered in my research to allow comparisons. One easy means to obtain a universal point in time at which project managers have made the effort of the retrospective evaluation of the outcomes of the R&D process is to restrict my research to **time-limited projects**, that have an explicit beginning and end in time. The moment at which the evaluation takes place, and where the outcomes may be measured, is thus the end of the time-limited project. This restriction excludes from my thesis those co-operations that would be permanently ongoing.

To be more explicit, I focus on **co-operative R&D projects**, that I define as a temporary associations of several independent organisations sharing Research & Development activities, in which the partners contribute different skills and capabilities to the common venture. This form of co-operation is being referred to in the literature as 'co-specialisation' (Doz and Hamel, 1998).

The organisations involved may be public or private, and may be firms, non-profit research organisations, universities or laboratories. The co-operative nature of the project is agreed upon beforehand and its key elements, such as the IPR sharing, are defined in contractual agreements.

1.6.2.3 Europe as a locus of cultural diversity

One important purpose of my research is to consider the effect of organisational cultures on co-operative R&D. My hypothesis – that I believe was reasonable in the design phase of my research programme – is that national and regional environments have an influence on organisational cultures.

I have decided to leverage the cultural diversity being present between European regions, and chose to lead my investigation in several European regions and countries, to broaden the scope of cultural diversity potentially present in the organisations being investigated.

I also chose to investigate in several European countries and regions in order to alleviate cultural biases: if I detect a phenomenon in a given cultural environment, it is only by checking that it is also present in other cultural settings that I may potentially claim that it is universal. In this respect, working at European scale provides a significant advantage as compared to the greatest part of economics and management research, that is led in a purely United-States of America environment, and tends (wrongly, in my belief) to consider that what is observed in these circumstances is of universal validity.

1.6.2.4 Electronics and telecommunications equipment as a well-known, innovative industry

Among the organisational capabilities that I consider in my research are those of technical and scientific nature. I need to describe these capabilities in a way that elicits correct responses from my respondents in the empirical part of my research. One major condition for this is that I have the correct, accurate vocabulary to describe these technical and scientific fields of knowledge that I want to investigate.

In addition, interactions with respondents in the empirical part of the research are made easier if they consider me as a competent person, able to understand their issues and concerns, and to ask relevant questions.

I have in my previous career worked 16 years in the electronics and telecommunications industry, first as an R&D engineer, then as an investor in high-tech, early stage start-up firms and ultimately as an innovation strategy consultant. I have thus accumulated a deep knowledge of the technical and scientific vocabulary present in this industry.

In addition, electronics and telecommunications equipment is a highly innovative industry, that concentrates a very significant proportion of the global R&D effort in Europe: the NACE codes DL30 (Manufacture of office machinery and computers), DL32 (Manufacture of radio, television and communication equipment and apparatus), DL33 (Manufacture of medical, precision and optical instruments, watches and clocks); I642 (Telecommunications services) and K72 (Computer and related activities) represent 12.47% of the overall R&D expenses of the European Union in 2006 (Eurostat, 2009).

1.6.2.5 Pairs of partners as a simplification at an early stage of research

I choose to investigate only pairs of partners (ie. dyads), and not to consider co-operation consortia with a number of partners larger than two, although these are very frequent, specifically in the Framework Programmes of the European Commission.

I made this choice for reasons of simplicity, at a stage of research where I am breaking new ground in several aspects of methodology and concepts. Indeed, the notion of 'distance', which I will use extensively later on, is easy to define and to operationalise between two entities, but is much more problematic within a group of more than two: should I consider the distance between one entity and the mean position of all the others, the sum of pairwise distances to all other entities, or still other metrics? These are complex issues that I did not want to enter at this early stage of research. This is why I restricted myself deliberately to the simple dyadic case of R&D projects in which two partners only co-operate.

1.7 Distinctive and original features of this research

The main distinctive and original features of the doctoral research that I performed to answer the questions stated above (§ 1.6) are the following:

- First, I introduce an **operationalisation** of organisational **'capabilities'** and **'cultures'**. I justify this operationalisation theoretically, using novel concepts, such as 'world views'. I also validate its relevance empirically, by proving that

describing organisations with this framework has a predictive capacity, in the specific setting of co-operative R&D projects.

- Second, my unit of analysis in the empirical study is the **co-operative R&D project**, in which I gather data from **matched pairs of respondents** in the partner organisations.
- Third, I consider **feedback** effects of the co-operative R&D project on the organisational capabilities, which opens the path for further studies of the dynamics of capability-building in organisations.

Having stated the content and scope of my research, and its main distinctive features, I can now present my theoretical positioning, that is, the theoretical sources that I will mobilise in my work (§ 1.8).

1.8 Theoretical positioning

I rely in my research upon three theoretical tools: (1) the **relational view of the firm**, in which the dyad is the object of study (Dyer and Singh, 1998), (2) **Proximity Economics**, that insist on the importance of cognitive proximity between organisations (in addition to geographical proximity), in order for them to effectively co-operate (Pecqueur and Zimmermann, 2004) and (3) **Conventions Economics**, for which economic and social actors operate in coherent, but distinct, sets of conventions that shape their actions and motivations (Favereau, 1988; Eymard-Duvernay, 1989; Boltanski and Thévenot, 1987; Eymard-Duvernay et al., 2004). In addition, my general view of the firm is inherited from **Evolutionary Economics** (Nelson and Winter, 1982; Dosi et al., 2000; Witt, 2008), for which stable features within the organisation, such as the routines, maintain persistent differences among firms in the nature and level of their capabilities.

1.8.1 Relational view of the firm

Dyer and Singh (1998) have coined the "*relational view of the firm*" concept, according to which the source of competitive advantage lies in the relationships that it has established with its partners. This concept was later completed by Lavie (2006), for whom "*an interconnected firm can extract value from resources that are not fully owned or controlled by its internal organization*" (p.639).

In contrast with the industry structure view (Porter, 1985) and the Resource Based View of the firm (Barney, 1991) described below (§ 3.1.1), for which the sources of sustained competitive advantage lie in the industrial sector and the interior of the firm, respectively, Dyer and Singh state that "*idiosyncratic inter-firm linkages [...] inter-firm routines and processes*" (p.661) may be sources of quasi-rents and competitive advantage. For them, "*[a] firm's alliance partners are, in many cases, the most important source of new ideas and information that result in performance-enhancing technology and innovation*" (p.665). In complement to generic 'absorptive capacity' defined by Cohen and Levinthal (1990), they define a "*partner-specific absorptive capacity, [that] refers to the [...] ability to recognise and assimilate valuable knowledge from a specific alliance partner*" (p.665), in the same sense as Lane and Lubatkin (1998) and Zollo et al. (2002). This capacity depends on the overlap of technical knowledge between the partners, and on the frequency and quality of personal

interactions. It is enhanced when "*individuals within the alliance partners know each other well enough to know who knows what and where critical expertise resides within each firm*" (p.665). This partner-specific absorptive capacity is essential for alliances to create competitive advantage.

The sustainability and preservation of these advantages rely upon "*causal ambiguity"* (i.e. it is difficult to identify the exact source of the advantage) and "*time compression diseconomies*" (i.e. the process takes a definite time to develop, that cannot be accelerated), that already exist at firm level (Barney, 1991). Additional effects appear in the dyadic relation: (1) inter-organisational asset interconnectedness, i.e. the fact that some investments have already been made increase the economic profitability of making additional ones, in self-reinforcing "*snowball*" effect (Dyer and Singh, 1998 p.672) of increased commitment; (2) partner scarcity, i.e. in a market where potential suitable partners are few, once the good ones are engaged in a stable relationship, it effectively locks out latecomers; (3) resource indivisibility, i.e. once the alliance has evolved, the partners become inseparable because they have developed an activity that is essential to both; (4) institutional environment, i.e. the legal or conventional framework that enforces (or not) the co-operative behaviours and controls opportunism, on a national cultural basis.

(The space below is deliberately left blank)

The relations between the three dominant theoretical explanations of competitive advantage are summarised in the Table 1.8.1 below.

Theoretical standpoint	**Industry structure view**	**Resource-Based View**	**Relational view**
Key authors	(Porter, 1985)	(Barney, 1991)	(Dyer and Singh, 1998)
Unit of analysis	industry	firm	pair or network of firms
Primary sources of supernormal profit returns	relative bargaining power, collusion	scarce physical resources (e.g. land, raw material input), human resources and know-how (e.g. managerial talent), financial resources, intangible resources (e.g. reputation)	relation-specific investments, inter-firm knowledge-sharing routines, complementary resource endowments, effective governance
Mechanisms that preserve profits	industry barriers to entry, government regulations, production economies & sunk costs	firm-level barriers to imitation	resource scarcity & property rights, causal ambiguity, time compression diseconomies, asset stock interconnectedness
Ownership of rent-generating processes & resources	collective (with competitors)	individual firm	collective (with trading partners)

Table 1.8.1, reproducing (Dyer and Singh, 1998, Table 1, p.674): Comparing the industry structure, Resource-Based and Relational views of competitive advantage

The Relational View of competitive advantage considers the dyad (or the network of firms connected by pair-wise co-operative relations) as the unit of analysis, and as the locus of competitive advantage (Sivadas and Dwyer, 2000). It is therefore central in the study of inter-organisational co-operation and specifically of co-operative R&D projects.

1.8.2 Proximity Economics

The "Proximity Economics" theory ("*Économie des proximités*") was introduced by Pecqueur and Zimmermann (2004), as an intersection between the disciplines of industrial organisation and geographical economics. It stresses the importance of local resource **creation** more than that of resource allocation. In its investigation of inter-organisational relations, it considers not only geographic proximities, but also institutional, organisational and cognitive proximity as a source of mutual understanding and potential co-operation. In applying this theory to the specific field of

innovation, Massard (2004) insists on the fact that geographic proximity is not enough for co-operation to appear, and that there may be a form of naïveté in considering that the innovation-promoting effects of geographic proximity are automatic. She reports empirical failures of deliberate attempts to create local networks where none existed (the French *'Réseaux de Diffusion Technologique'*), due to cognitive differences between professional worlds and to the existence of prior links to external (rather than local) actors. She emphasises the need to consider the following factors when attempting to establish an inter-organisational co-operative R&D relation: (1) geographical, organisational and cognitive proximity; (2) the 'absorptive capacity' (Cohen and Levinthal, 1990) of the recipient.

In this theory, cognitive or organisational proximity is not a static, given or permanent feature, although the fact of belonging to the same community may bring a positive *a priori* attitude. It must be built or sustained through a confidence-building process that capitalises on successful interactions, as described by Dupuy and Torre (2004). The process is a rather unstable one, since it is highly self-reinforcing (Arthur, 1988): confidence breeds closer interaction, while defiance encourages the seeking of (legal or game-theoretic) guarantees and fosters opportunism in a self-fulfilling prophecy of pre-emptive action.

1.8.3 Conventions Economics

Convention Economics theory ("*Économie des conventions*") was first introduced by Favereau (1988) and Eymard-Duvernay (1989) following initial intuitions by Boltanski and Thévenot (1987; 1991; 2006), as an ambitious attempt to unite economics, social and political sciences. It was later summarised by Storper (1995) and by Eymard-Duvernay *et al.* (2004). It was also instrumental in the development of the theory of "*worlds of production*" by Salais and Storper (1992).

The central idea of this theory is that the key issue of economics, social and political science is that of the **co-ordination of individual actions**: "*we may recognise a common question to sociology and economics: the problematic co-ordination of human behaviours*[8]" (Eymard-Duvernay et al., 2004, p.4). In other words:

> *"the coordination of individuals is the central problem of economic activity. All productive activity depends upon reciprocal actions, coherently harmonised with others, without which our own actions become inefficient or unproductive […] The issue is to know how actors manage to enter into efficient - that is: successfully co-ordinated - forms of collective action*[9]*"* (Storper, 1995, p.111)

[8] "nous pouvons reconnaître une question commune à la sociologie et à l'économie : la coordination problématique de conduites humaines"

[9] "La coordination des individus est le problème central de l'activité économique. Toute activité productive dépend d'actions réciproques, harmonisées de façon cohérente avec d'autres, à défaut desquelles nos propres actions deviennent inefficaces ou improductives […]La question est de savoir comment les acteurs parviennent à entrer dans des formes d'action collective efficaces, c'est à dire coordonnées avec succès"

However, this co-ordination is made difficult by the radical uncertainty about the behaviour of the other agent(s):

> *"All these situations of action are virtually struck by uncertainty […]. For one part, this uncertainty is 'secondary' in nature, since it may be attributed to the fact that other individuals – upon which we depend – are themselves in a situation of uncertainty […]; for another part, the uncertainty originates in an ill understanding or in an imperfect communication of the intentions of the other actors[10]"* (Storper, 1995, p.111)

In the economic world, and specifically in the field of innovation, "*any co-ordination is uncertain, since it involves heterogeneous actors, unfolds over time and aims at a product (or a service) that never is fully pre-defined[11]*" (Eymard-Duvernay et al., 2004, p.5).

This uncertainty may only be reduced by the intervention of "***conventions***" that stabilise the behaviours and permit reliable anticipations of the other party's expectations and actions: "*Conventions may be defined as mutually coherent expectations and practices, some of which are embodied in formal institutions, and others not[12]*" (Storper, 1995, p.112). These conventions define what portion of the observed phenomena the agent considers as meaningful, and how s/he will hierarchise them. Since the importance and the value being attached to a phenomenon or to an action also depends on the way it is being evaluated by others, this evaluation is also a collective process.

One of the issues upon which conventions apply is the quality of goods. Indeed, uncertainties on quality can have disruptive impacts on the very operation of markets (Akerlof, 1970). The 'Conventions Economics' theory postulates that the means to evaluate the value of a 'good' are pluralistic. The word 'good' was deliberately chosen to underline the pluralism, since it may mean either a material object or anything desirable for moral or political reasons. Eymard-Duvernay (1989) identifies three basic modes of quality assessment: (1) by the market, (2) by reference to technical standards and (3) by reference to a trademark. These are respectively attached to the "*market[13]*", to the "*industrial[14]*", and to the "*domestic[15]*" convention. Each convention evaluates the value of a good in its own environment, using its specific evaluation criteria, and by reference to its specific source of legitimacy.

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[10] "[T]outes ces situations d'action sont virtuellement frappées par l'incertitude […]. Pour partie, l'incertitude est de nature 'secondaire' au sens où elle est imputable à ce que d'autres individus -desquels on dépend-, sont eux-mêmes en situation d'incertitude, […]; pour partie l'incertitude provient de la méconnaissance ou d'une communication imparfaite des intentions des autres acteurs."

[11] "Toute coordination est incertaine dans la mesure où elle met en jeu des acteurs hétérogènes, se déroule dans le temps et vise un produit (ou un service) qui n'est jamais entièrement prédfini"

[12] "Les conventions peuvent être définies comme des attentes et des pratiques tenues pour mutuellement cohérentes, certaines s'incarnant dans des institutions formelles, d'autres pas."

[13] "convention marchande"

[14] "convention industrielle"

[15] "convention domestique"

Along the same tradition, Salais and Storper (1992) identify four coherent "*worlds of production*" ("*industrial*", "*network*", "*Marshallian*" and "*innovation*") with their associated "*conventions of quality and resulting price formation processes*":

> *"the industrial standard and price competition in large, anonymous markets for the Industrial World; the localised industrial standard, and niche prices (which are held in check by the standard and the competition it encourages) for the Network Market World; the satisfaction of buyers is reflected in a price which embodies quasi-rents on quality in the localised, information-rich Marshallian Market World; and scientific-technical rules for product performance in the World of Innovation."* (p.180)

Boltanski and Thévenot (1991) generalised these considerations and posited that conventions are part of broader coherent social, political and economic frameworks of ends deemed desirable, and of rules considered as legitimate, that they call "***polities***". They introduce the hypothesis that these 'polities' are clearly distinct from one another, and exist in finite numbers, because they must respect a set of six stringent "*axioms*" that preserve their capacity to morally justify a legitimate social order (pp.96-99).

Each 'polity' is structured around a "*common superior principle*[16]" (p.86), a common good that is worth being sought, and that is considered as superior, within this specific polity, to potential alternatives. This 'common superior principle' ranks potential actions and agents within that 'polity': those actions and agents that contribute more to the 'common superior principle' are considered as of higher "*worth*", and also as bringing the most valuable contribution to the common social good. This feature justifies that those agents of higher 'worth' receive a greater share of social advantages. By justifying the hierarchy of actions and the distribution of advantages, the 'common superior principle' is the cornerstone of social agreement within a given 'polity'.

Reciprocally, a 'polity' may also be defined by those agents and action of lesser worth, at the lower end of the hierarchy. However, this lower end is perceived with greater confusion, as if it were partially unconscious or undifferentiated (Boltanski and Thévenot, 1987, p.116).

I will come back to this theory, and develop some of its key intuitions, in the later section dedicated to the development of a general model of 'world views' (§ 4.4).

1.8.4 Evolutionary Economics

I will set my investigation in the more general framework of Evolutionary Economics. This theory was first called for by Veblen (1998), and was formalised by Nelson and Winter (1982), alongside with Dosi et al. (2000) as an alternative to neo-classical economics. Its main ambition is to account for historical developments and change in the techno-economic system, in a situation of permanent disequilibrium. It may be related to the general framework of evolutionary theories of systems (Campbell, 1969; Campbell, 1974), that explain historical change through the joint effect of three "*evolutionary processes*": random variation, environmental selection and retention.

[16] "principe supérieur commun"

The micro-foundation of evolutionary economics theory is the fact that individual and collective behaviours contain some **stable elements**, that are subsequently subject to the 'evolutionary processes' described above. These stable elements are an individual's "*skills*", and are called "*routines*" at organisational level.

Nelson and Winter (1982) define an individual's "*skill*" as "*a capability for a smooth sequence of coordinated behaviour that is ordinarily effective relative to its objectives, given the context in which it normally occurs*" (p.73). It may be body movements coordinated with decisions (e.g. driving), or be imprinted in mental process (e.g. calculus).

The authors define the "*routine*" at organisation level. The concept mainly is valid for organisations that provide roughly the same good or service over a given period, with "*criteria for doing well or poorly*" (p. 96), in a Schumpeterian "*circular flow*" (1934) or static situation of absence of change. Routines act as the repository of "*organisational memory*" (p.99) and of memorising by doing. They are defined by the usual set of actions prescribed for a person's job, by the reactions to orders and other forms of "*coordinating messages*", so that every person behaves in a way that is expected by the other members of the organisation (should this behaviour be nominal or not).

In this theory, the 'routines' used by organisations in their daily activities are in no way optimal. They would rather be some temporarily stabilised modes of operation or of solving a technical or organisational problem, considered as "*satisficing*" (March et al., 1958). They are kept alive, "*often well beyond the circumstances which spurred their introduction*" (Cohen et al., 1996, p.660), for cognitive reasons, because of the cost of developing a more efficient procedure, or for political ones, because they embody an "*intraorganisational truce*" between conflicting interests (Nelson and Winter, 1982, p.107) on the rules defining each person's role, on the sharing of workload and benefits, and on the allowances within the unspecified range of accepted action, that would be costly and uncertain to breach.

Since the routines are the stable elements in the organisation that undergo the evolutionary process, the authors introduced an analogy of "*routines as genes*" (p.134) that has exercised great influence on later works.

A more comprehensive definition of routines was later given by Cohen et al. (1996): "*A routine is an executable capability for repeated performance in some context that [has] been learned by an organisation in response to selective pressures*" (p.683). Routines are based upon deeply memorised individual skills of individuals, are semi-automatic, and rely upon "*tacit*" knowledge (Polanyi, 1967). The authors claim that their concept of 'routines' is embedded in scientific knowledge on "*short-tem memory limits, reasoning powers and differentiated forms of long-term memory and learning*". The underlying cognitive theory is the following. People act in an effective way when they are being required to repeat the same behaviour in identical or analogue situations. This set of analogue situation is progressively imprinted "*by doing*" in the actors' memories. When faced again with it, the actors recognise the common pattern and respond semi-automatically, fast and efficiently to it. Cohen et al. (1996) thus consider that their theory of routines relies upon a form of "*cognitive realism*" (p.654).

Following the assumptions that the underlying 'routines' are stable and persistent, organisational performances are heterogeneous from one organisation to the next – because 'routines' differ in their effectiveness to solve the technical or organisational problems they are meant to - , and persistently so, because of the slow evolution speed of the underlying 'routines'. Thus, in contrast to Neo-Classical Economics that mainly manipulates homogeneous 'representative' firms, Evolutionary Economics is populated with organisations that differ significantly and persistently in their capabilities.

However, even if the evolution speed of organisations in the framework of evolutionary economics is slow, it is non-zero. Organisations do evolve over time. In contrast again to Neo-Classical economics (and to voluntaristic desires of many firm managers), Evolutionary Economics postulate that this change is continuous (no quantum leaps between one state and the next) and irreversible (no capacity to revert to a previous state). The evolution is therefore path-dependent, with bifurcations leading to highly different future states according to the branch taken. The evolution of organisational 'routines' may be described with the very general concept of 'learning'.

The co-operative R&D activities that I study may be a privileged opportunity for such learning. One source of learning is the unilateral **transfer** of skills and knowledge from one party to the other, as observed and feared by most students of alliances as a zero-sum game (Hamel et al., 1989; Dussauge et al., 2000; Das and Teng, 2000a; Das and Teng, 2000b; Alvarez and Barney, 2001). A second source of learning is the task itself. By engaging in co-operative R&D, the partner firms learn about the technology, the product and the market that they jointly explore. They identify dead-ends and promising avenues, modify and adapt their project and their own operating modes following the results of theoretical reflection and of empirical testing. This learning from "*exploration*" (March, 1991) is a key knowledge **creation** process, and goes beyond the mere knowledge transfer process described above. It is the very central and explicit purpose of the co-operative R&D, and were identified by Tezuka and Niwa (2004), in their study of the improvement of "*business planning capability*" (which may be interpreted as strategic marketing information on the market being addressed) through the innovative R&D project. Finally, each organisation learns about its partner, on its behaviour, routines and processes, as evidenced by Zollo et al. (2002) and by Ethiraj et al. (2005). This specific, inter-organisational learning may have self-reinforcing, positive feedback effects (Arthur, 1988) in which organisations repeatedly co-operate with the same set of partners that they already know and trust. This may lead to stable constellations or quasi-molecules of co-operating organisations.

In addition to the learning process described above, three other phenomena shape the cognitive evolution of firms, according to the Evolutionary Economics school: (1) the nature and size of technological opportunities lying ahead and laterally, (2) the pre-existence in the firm of complementary assets that could be used in other activities, thereby building path dependencies due to sunk costs, and (3) the intensity of the selective and competitive pressure. These phenomena explain the overall coherence of the firm in a stable portfolio of product-market couples (Teece et al., 1994).

I do not agree with the contention by scholars of Evolutionary Economics that 'routines' are the highly stable, continuously evolving features of organisations. Instead, as I will attempt to show in chap. 2, I would consider that what is stable in an organisation is

both what I call its 'world view' and its 'purposive communication network'. Despite this disagreement, I retain from the Evolutionary Economics school these ideas that organisations are stable, evolve continuously and irreversibly, and display persistently heterogeneous features, and that cognitive evolution (or 'learning') of organisations exists.

1.8.5 Conclusions on theoretical positioning

I will retain the following main ideas from this overview of the theoretical sources that I rely upon: (1) organisations are heterogenous entities, that bear stable, slowly evolving features; (2) organisations differ by their capabilities, but also by cultural aspects, among which conventions influence internal and external co-ordination; (3) when considering inter-organisational co-operation, the dyad is the relevant unit of analysis and (4) in this dyad, the cognitive distance between partners deserves attention.

Having stated this, I may now detail the method I will use to perform my work programme.

1.9 Structure of the thesis

I will follow a simple work structure. In Part 1 of this thesis, I will construct my theoretical concepts. In Part 2, I will present my empirical work and its results, and will conclude in a final Part 3.

Going into greater detail, Part 1 will start with a theoretical justification of the existence and persistence of organisational capabilities and cultures (chap. 2), introducing the key concept of 'world view'. This auxiliary theoretical result is important: it is only after having proven their existence that I can manipulate concepts, specifically when they have proven to be as elusive as 'organisational capabilities' or 'cultures'. Following this justification, I will then review the existing definitions of organisational capabilities to be found in the literature, expose their strengths and limitations, and propose the definition that I will use in the thesis (chap. 3). I will proceed in same way for organisational cultures. I will review the existing definitions and typologies of organisational cultures, and propose to restrict myself to the consideration of 'world views'. I will then introduce my second auxiliary theoretical result, namely a typology of organisational 'world views' (chap. 4).

Having set the theoretical foundations of my research, I will in Part 2 justify and expose my methodology (chap. 5), report on the results of my empirical study of 120 co-operative R&D projects in the electronics industry based in Germany, France, the United Kingdom and Finland (chap. 6), and interpret them (chap. 7). These results are regression models that predict the concrete and learning outcomes of co-operative R&D projects, using as explanatory variables the organisational capabilities and cultures of both partner organisations, measured simultaneously at dyad level, and conventional control variables such as geographic distance, differences in nationality, size and legal status (private firms vs. non-profit organisations).

I will then be able to conclude this work (chap. 8), by summarising my main results, acknowledging limitations, and proposing paths for further research.

Part 1: Construction of theoretical concepts

Although my thesis is empirical in nature, and is based upon survey data, I still need to develop theoretical concepts before I can actually engage into the core of my issue. More specifically, two concepts lie at the heart of my investigation, and need to be explained and justified: (1) organisational capabilities and (2) what I call the 'world view' of an organisation, which is a sub-part of its culture.

I first need to justify the reason why an organisation should, if at all, bear features such as 'organisational capabilities' and 'organisational culture'. This is a logically necessary preliminary step, an auxiliary theoretical lemma that supports the further design of the empirical investigation at the core of my research. This step is the first theoretical contribution of my thesis, and the purpose of chapter 2. I will upon this occasion define an organisational 'world view'.

Once I have justified the very existence of organisational capabilities, I will be able to present the existing definitions of that concept, and to propose the one that I developed, and that I will use in my further empirical research (chap. 3).

In a similar fashion, I will present the existing definitions of organisational cultures, and the typologies that were developed by previous research to describe them in an synthetic way. Focusing on what I have defined as 'world views', I will expose the second theoretical contribution of my thesis, namely a unified model of such 'world views' (chap. 4).

2 Capabilities and cultures as organisational invariants

I will in this chapter attempt to justify the existence of 'organisational capabilities' and of 'organisational culture'. These concepts are indeed central to my research, and I will use them extensively hereafter. This chapter therefore constitutes a preliminary, but important theoretical building block of my work.

In order to make this justification, I will answer two research questions: (1) what are the basic structures of an organisation? and (2) what processes make these structures stable? If indeed I justify that organisational capabilities and culture belong to the basic structure of an organisation, and if they are stable and therefore persistently attached to the organisation, I will have given strong support to their existence.

My method will be logical – deductive, contrasting with inductive procedures, that would extract general features from the observation of multiple empirical cases, and from analogies, that would draw models from other sciences, such as biology or ethnology, to enlighten the study of organisations. I will start from a general definition of an organisation, from the very basics of what an organisation is, and consider the minimal hypotheses necessary for an organisation to exist and operate. I will then deduce from this definition the existence of some simple structures, and expose the processes that make them stable. My conclusions should have a very general, potentially universal, applicability. Indeed, the lesser the hypotheses, the more general the conclusions.

Identifying these stable structures with very general applicability may serve three purposes: (1) in the practical perspective of designing and understanding engineered organisational change, the work may help identify those elements that belong to the organisation's stable core, and thus deserve being handled with care, and those organisational changes that are indeed feasible and desirable, because they respect the continuity of the organisational stable structures; (2) in the more theoretical perspective of classifying organisations along relevant categories, the identification of stable structures, i.e. of invariants, in a system is a first step in describing it and the very base of a taxonomy: by being stable, they are persistently attached to the organisation; by being very general, they are very broadly applicable; by being observable, they are amenable to scientific study; (3) ultimately, by attaching persistent features to organisations, they justify the existence of notions that would otherwise remain fuzzy and unspecified, namely "organisational culture" and "organisational capabilities". The first objective has practical consequences for management, that I will not develop further in this thesis. The second and third purposes will be used in the following chapters on these topics (chap.3 and 4).

I will, in a first section, provide the general definition of an organisation that I will use, and deduce from it the existence and the definition of the universal structures that I believe are stable invariants: the organisation "*world view*" (inspired by Aerts *et al.* (1994) and its "*purposive communication network*" (drawing upon seminal insights by March *et al.* (1958)). In section 2.2, I will expose how an extension of the Attraction-Selection-Attrition framework proposed by Schneider (1987) confers stability to the organisational 'world view'. In section 2.3, I will propose that the 'purposive

communication network' itself also is highly stable, because of sunk costs in the establishment of the network. I will draw conclusions on the existence of 'organisational culture' and 'organisational capabilities' in the final section 2.4.

2.1 General definition of an organisation and its core structures

In what follows, I investigate the very minimal hypotheses necessary for an organisation to exist and operate as a collective body. I start from a 'zero' reference state made of a fully disaggregated and anarchic collection of individuals. Beyond this 'zero' state, I will adopt the following definition:

> *An **organisation** is a group of people that act in a co-ordinated fashion to achieve common large-scale goals, with a division of labour and knowledge among them.*

'Large-scale' here simply means that the goals are at a scale greater than what could be handled by a single individual, and this scale of action is the very reason why this collective assembles to pursue these goals together.

I will also, for the sake of simplicity of analysis, focus on the cohesive and co-ordinated features of organisations. I will deliberately disregard the sources of conflict and divisions within it, be they political, economic, social, or other (Parker, 2000), although I am conscious that they are highly relevant in many perspectives of organisational studies, and that these considerations constitute a limitation to my study.

From the definition above, I deduce that an organisation may be described as: (1) a group of people that (2) have a common action agenda to achieve the group's large-scale goals and that (3) co-ordinate to perform these actions. I will characterise these elements and their implications in further detail hereafter.

2.1.1 The group is the outcome of a piecemeal aggregation process

The group of people that constitutes the organisation is not created at random. Two considerations may be made. First, the group did not appear fully staffed from day one. It is the result of the piecemeal aggregation of people around an initial nucleus of founder(s), in an historical process. In that sense, my vision of the foundation of an organisation differs from that of Schein (1991), who, based upon his experience of therapy and continuous learning groups, considers that organisations emerge from groups of 10 to 15 people that don't know each other previously. Second, a work organisation, in contrast to most national, religious or ethnic groups, is made of people that have entered it at an adult age, with an element of mutual choice between the group and the individual entering it. I will draw consequences of these considerations in section 2.2 hereafter.

2.1.2 The definition of an action agenda implies that of a "world view"

In order to establish its action agenda, that is, the ordered set of actions that it undertakes over time, I contend that any agent needs to define three elements: (1) an ontology, (2) a mission statement and (3) an axiology. I will refer collectively to this set of three elements as the agent's "*world-view*", following and simplifying a framework initially proposed by Aerts *et al.* (1994).

The content of an agent's action is framed by its **ontology**. Action is indeed only possible upon the entities that are perceived by the agent, as exemplified in the biosemiotics "*Umwelt*" theory of von Uexküll (1909). The ontology of an agent is made of the things, objects, concepts or fields of knowledge (technical, scientific, professional, on markets) that exist, or are worth considering as important or relevant by the agent, those whose existence or worth is taken for granted (and don't need to be demonstrated), and upon which action is therefore possible. The agent's ontology also includes the potential goals of its action, that need to be granted some form of reality, relevance and importance if they are to be at all desirable.

Once the ontology defines the entities upon which action is possible, the nature of the action that the agent will consider undertaking (i.e. the content of the action agenda) is defined by its **mission statement**, while the purpose and direction of action (and thus the priorities and order of items in this action agenda) are oriented by the agent's **axiology** or set of values. I will define these two concepts in greater detail below.

The 'mission statement' is the set of actions that the agent considers as belonging to its business (for an organisation), to its mission (for a team or a department) or to his/her profession (for a person). The 'mission statement' may be connected to the German concept of "*Fach*" and to the French "*métier*", with a connotation in the former case of craftsmanship and of professional ability gained through experience, and in the latter of a global responsibility for the field being managed. The reason why a 'mission statement' exists at all scales of the organisation is directly related to the physical and cognitive division of labour embodied in the very essence of what an organisation is, and that I have summarised in the definition given above (§ 2.1). Some form of separation of the areas of responsibility of the actors involved needs to be established and maintained, in order for co-ordinated work to take place, and to ensure that a significant proportion of the overall collective tasks are indeed performed (or that loopholes are reasonably few), and that overlap and contradictions are maintained at a reasonably low level. A 'mission statement' also exists at the scale of the whole organisation, because its working capacity is by essence limited (which places boundaries to its possible action agenda), and because interactions with the outside world are necessary (which forces to specify them explicitly). The existence of a 'mission statement' may therefore be considered as an extremely general phenomenon in organisations.

The justifications given by agents on why they consider a set of tasks and actions as belonging to their 'mission statement' must bear a form of legitimacy, and thus mainly stem from either (1) the agent's professional ability in performing these tasks well (technical-instrumental legitimacy), or (2) from laws, contracts, customs, historical precedent or conventions (legal-conventional legitimacy). There is a form of circular, self-reinforcing phenomenon here, in which the set of actions performed define a 'mission statement', that itself frames the set of actions considered as legitimate for the agent (both technically, in a learning-by-doing process, and conventionally, by creating a precedent).

Once (1) the relevant objects on which action is to be performed have been defined by the 'ontology' and (2) the set of actions and tasks that may legitimately be undertaken by the agent on these objects are defined by the 'mission statement', the last step to define

the action agenda is to decide the order of priority among the possible actions and tasks. This is the purpose of the 'axiology', that ranks and hierarchises the admittedly 'existing' and 'relevant' goals defined by the ontology and that may be reached by performing tasks belonging to the 'mission statement'. Action will concentrate on those tasks within the 'mission statement' that attempt to reach the goals considered as most important and of higher worth, and will tend to neglect the others. The existence of such a hierarchy in the achievable goals is rooted in the limited nature of resources available to humans: whatever the size and power of a human organisation, it cannot perform all possible actions simultaneously with an equivalent level of physical, cognitive and emotional involvement. It is therefore a very general trait of organisations.

I have thus shown that the definition of an action agenda by any organisational agent requires that of a 'world view', in its three components of ontology, mission statement and axiology. The 'world view' although necessary, is not sufficient to define the action agenda: external circumstances play also a critical role – but that I will not explore any further.

This 'world-view' exists at the scale of the whole organisation, and is translated and adapted at the smaller scales of departments and teams, which are the most immediate working environment of the individual employee. As an example, a preference for volume and market share at the potential expense of quality and immediate profitability will translate into high sales objectives for salespeople (with relaxed constraints on the unit sale price) and into high throughput requirements for manufacturing (with relaxed constraints on quality). Thus, although they are not phrased in the same vocabulary nor result in the same requirements from the top management to the shop-floor worker, the 'world-view' remains homogeneous across the hierarchical levels of the firm.

A striking illustration of such a 'world-view' (and of its persistence) is given by Lorino (2001), in a case study of the French computer manufacturer Groupe Bull at the beginning of 1980's. The collective identity of the company was that of a designer and manufacturer of high-technology material hardware products. The rest, and specifically software development and installation services, was considered as immaterial and thus void and of no relevance nor existence (specifically, it was not included in the accounting systems): it did not belong to Groupe Bull's ontology. This blindness to immaterial beings proved a curse for the future development of the firm, at a time of fast evolution away from proprietary mainframe computers and towards open "solutions", in which software and operating system are success-critical.

2.1.3 Co-ordination of action requires the existence of a "purposive communication network"

In order for agents to co-ordinate their actions, I contend, following and deepening intuitions by March *et al.* (1958), that a very basic requirement is that there exist between these agents a "*purposive communication network*". What I mean by 'purposive' communication is that it leads to action: the information transmitted has the purpose of triggering an action by the receiver (be it merely that of transmitting it further). I define a 'network' as a set of "*links*" connecting the agents.

Following my general perspective of simplification, I will not consider the conditions necessary for action to actually be implemented by the recipient of the information,

specifically the issue of its motivation. I will not consider either the information flow between agents that would be unrelated to action, even though it may be very important for building the emotional sense of cohesiveness within a group of humans.

In order to be more specific than March *et al.*, and to complement their work, I will further model the communication network, considering first the one-off individual communication between two agents, then define a 'link' and finally the whole 'network'.

The 'purposive' communication from agent A to agent B, when considered as a one-off event, contains the four steps of (1) decision by agent A, (2) "*specification information*" transmitted from A to B, (3) action by agent B, and (4) "*feedback information*" from B to A (which may then lead to a new decision by A, and to a new loop).

I define the 'specification information' as follows:

- what to do, the functional specification, or the overall objective
- why it should be done, the justification of the action to be undertaken, which is an component of its legitimisation, and of the recipient's motivation
- when to do it, the trigger or the "*stimulus*" (March et al., 1958)
- how to do it, the technical specification of the process, the method
- who should do it, the staffing instructions.

In the same way, I define the 'feedback information' as either (1) pre-defined reports, such as those on sales, accounting, project milestones, technical data, etc. or (2) free-form reports, on unexpected results.

When 'specification' or 'feedback' information on a set of related subjects are repeated over time between the two same agents, and following the same pattern, this repetition over time may be called a "*message*". A 'message' may be very formal, such as a weekly sales report, a manufacturing order or the minutes of a regularly-held meeting, or more informal, such as the re-phrasing of a set of instructions by a subordinate or a colleague as an acknowledgement that s/he understood them well. The existence of a message between two agents creates a communication "*link*".

The communication links described here do not need to be official or formalised, nor to follow the hierarchical lines (although many of them do). The full purposive communication network is described by the set of active 'messages' along each 'link', and also, from a macroscopic point of view, by the set of 'links' that actually exist and are active (and that generally are a strict sub-set of all those possible), which is called the "*topology*" of the network.

The only assumption made here is that, in order for the organisation to effectively function as a co-ordinated body, this sort of purposive communication **must** exist between its members. Without a purposive communication described in these very generic terms, no co-ordination is possible between the individual agents, and the organisation as such simply cannot work.

I have thus exposed two core structures of an organisation: (1) its 'world-view' and (2) its 'purposive communication network'. My purpose in the two following sections is to expose the processes that stabilise them: respectively an extension of the Attraction – Selection – Attrition (ASA) model proposed by Schneider (1987) and a 'sunk costs' effect.

2.2 The "world-view" of an organisation is stabilised by the Attraction – Selection – Attrition – Promotion process

2.2.1 The ASA(P) process explains the homogeneity and stability of groups built by piecemeal aggregation of individuals

The Attraction – Selection – Attrition (ASA) process was formalised by Schneider (1987), to understand the correspondence between the people's personality and that of the organisation they work with. The argument is that people already in an organisation are the main elements of a newcomer's environment, and their collective shared personality strongly shape or "*make the place*" (p.451). The argument thus fully relies on the process of piecemeal aggregation of individuals to form a group that I described above, and that is highly general.

This ASA process may be described as follows:

1. People are selectively **attracted** to organisations and occupations that fit their personality
2. People are **selected** by the organisation according to how well they suit its culture and requirements
3. In case of error in the earlier selection, people that do not fit leave the organisation, in an **attrition** process.

In a nutshell: *"[People] behave the way they do because they were attracted to that environment, selected by it, and stayed with it*" (p.440).

These features of the organisation are the result of its historical development, since the day of foundation, and of the founder's personality. "*The goals, structures and processes that attract people to organisations are determined by the founder's choices [...]*" (p.443). It is thus rather contingent on the personality of this founder (or group of founders), provided of course that this initial set of cultural traits is indeed compatible with survival in the competitive environment of the organisation.

This process leads to a great **homogeneity** of personalities in an organisation, according to Schneider. He further argues that this phenomenon also leads to a great organisational **stability**: *"[Researchers and consultants] have also probably oversold the speed with which organizations can change; **change** will be **slow***" (p.450, emphasis added). The main argument for this stability is that the organisational traits concerned by this process are incorporated in the personalities of the very people that were aggregated piecemeal to the group, along its historical growth and development. These traits can thus only be changed by changing the peoples' personalities, or by replacing them.

This proposition was later supported by literature reviews (Schneider et al., 1995) and by a systematic statistical measure of the homogeneity of organisations (Schneider et al., 1998).

I would add a component to this framework: that of selective **promotion**. The selective promotion process adds to the general ASA process a self-reinforcing loop leading to even greater homogeneity in the higher ranks of an organisation. This self-reinforcing selective promotion process may be described as follows. In a first step, at any rank in the hierarchy, the people that fit best into the organisational culture are being promoted. Once promoted, they are supported in their favourable opinion of themselves and of the culturally dominant traits of the organisation by the observation that people like themselves and sharing the same cultural traits are in commanding positions in the organisation. This leads to the belief that such people indeed are 'good professionals' (in absolute terms), under the logical fallacy that if they were not objectively good professionals, they wouldn't be in commanding positions. Once this belief is established (or reinforced) as an 'objective' truth, the people newly appointed in commanding positions pursue the selective promotion of those subordinates having these cultural traits, feeling fully justified by their belief that what they are is in essence 'good'. This new generation starts a new loop of selective promotion. Since this phenomenon of selective promotion operates at every rank in the hierarchy, it may be anticipated that the higher the ranks in an organisation, the greater its cultural homogeneity. This greater stability and homogeneity in the higher hierarchical levels reinforces the features being selected and promoted by the organisation, since management obviously has a greater capacity to shape them than shop-floor workers. I call this full stabilising and homogenising process of organisations the Attraction – Selection – Attrition – Promotion, or ASA(P), process.

Schneider does not, however, describe the organisational features upon which the Attraction – Selection – Attrition (– Promotion) process operates. The dimensions along which organisations should be considered as being stabilised and homogenised by the process remain unspecified. He does not go beyond the rather generic terms of "*climate*" and "*culture*" of the organisation: "*Climate focuses on how the organisation functions (what it rewards, supports and expects), while culture addresses the assumptions and values attributed to why particular activities and behaviours are rewarded, supported and expected*" (p.448).

In order to complement, enrich and specify Schneider's reflection, I posit that significant elements of the features upon which the ASA(P) process operates are the 'world-view' (that I described earlier) of the group, when assumed that it was constituted by piecemeal aggregation.

2.2.2 The ASA(P) process operates on the group's 'world-view'

I will now attempt to show why the group's 'world-view', its ontology, mission statement and axiology, are the features on which the ASA(P) process operates. The main idea is that, as exposed earlier, it is this 'world-view' that shapes the action agenda of that group.

The sharing of an ontology is essential in a group, for it is only once people handle the same entities considered as 'real' and 'meaningful' that they can effectively act together

on them. Any single new entrant that does not perceive the same 'reality' as the existing members of the group literally lives in a different world, in a different "*Umwelt*" (as described by von Uexküll), and will persistently disagree with the existing members of the group. S/he is bound for an early exclusion or exit.

Similarly, the sharing of a mission statement and of an axiology also is a key feature of an group of people acting together. The disagreement of a single new entrant with the mission statement and axiology of the existing group leads to conflicts on the agenda, its content and the ordering of tasks to be undertaken, and on the strategic goals. The most probable outcome of such conflicts is the exit of the newcomer.

In the cases outlined above, the only option left to the individual new entrant that does not share elements of the 'world-view' of the existing group is that of exit, be it in the shape of physically quitting the organisation or by the 'internal exile' attitude of apparent compliance coupled with emotional dis-investment and absence of motivation. The alternative 'voice' option proposed by Hirschman (1970) rarely exists. Indeed, in order for the 'voice' option to be effective, there must be a possibility for the existing group and the people within to change under the pressure of this single new entrant. In the cases described above of conflicts about essential elements of the group's culture, that engage the deepest beliefs of its members, the chances of internal evolution under the influence of a single person are close to nil, specifically if this single person's legitimacy is weakened by his/her outsider and newcomer status.

2.2.3 The stable features of a group of aggregated individuals are its 'world-view'

Reciprocally, what is stable in a group of aggregated individuals, is its 'world-view'. Even if the whole population is progressively replaced by demographical turnover, while maintaining this uninterrupted ASA(P) process operational, its 'world-view' remains essentially identical[17]. Indeed, since the ASA(P) process applies specifically to the group's 'world-view', it is the 'world-view' that is maintained and perpetuated by the process, embodied in the successive generations of people that were attracted, selected, retained and promoted. In other words, the 'world-view' is even more persistent than the people themselves that work in the group.

The organisation may thus be considered as a very stable and persistent 'world-view', stabilised by an Attraction – Selection – Attrition – Promotion process. The validity of this result only relies on the conditions of validity of the ASA(P) process: that the organisation may be described as a group of individuals that were aggregated piecemeal. This is a very minimal set of hypotheses: the result is thus extremely general.

[17] I deliberately here disregard discrimination issues, and perpetuation of features, based on gender, ethnicity, sexual orientation, disability, etc. that obviously add a whole new dimension to organisational studies, but are beyond the scope of my research. However, and unfortunately, it is probable that most of the ASA(P) process probably also applies to admittedly unfair discriminations such as those listed here.

2.2.4 Empirical observation of 'world-views'

The 'world-view' may be empirically observed with relative ease. The ontology is best observed through the vocabulary being used in the organisation's documents, both official, unofficial (such as protest blogs and trade-union material) and informal (such as e-mails). It may also be evidenced by the firm's accounting, control and reporting systems (specifically when embodied in ERP software): the nature of the costs being computed, and of the performance criteria being valuated, reveals both what is considered as existent and what is of worth. The mission statement and the axiology may be investigated either through discourse analysis of the same sources, or by qualitative interviews.

I have therefore shown that the 'world-view' of an organisation is stable and observable. I have also shown that this stability stems from a process of Attraction – Selection – Attrition – Promotion, and exposed that this stability only relies upon the very general hypothesis that the organisation be considered as a group of piecemeal aggregated individuals.

2.3 The purposive communication network of an organisation is stabilised by the sunk costs incurred

I will in this section expose what process I believe makes the 'purposive communication network' of an organisation stable. I propose, and will attempt to justify hereafter, that it is the learning and cognitive investment (and therefore the sunk costs) incorporated in the network that bestow it with stability.

2.3.1 A purposive communication network requires learning and cognitive investment

The establishment of a communication network involves learning and investment in time and cognitive and computational resources, both at the level of each individual 'link' and of the whole network.

The learning incorporated in a communication 'link' is related to the mutual adaptation, negotiation and agreement between sender and receiver on key features of the 'messages' being exchanged such as:

- the ontology, which implies defining what **vocabulary** will be used, the words and their meaning
- the **exhaustiveness** of the 'specification' (respectively 'feedback') information provided, i.e. how much is deemed sufficient for the receiver to act (respectively to decide)
- the **univocality** of information.

These features of the communication link may be described as the "*protocol*" associated with it.

This 'protocol' requires an investment to develop and become fully operational, because this process can only be done experientially: however well designed a communication

'link' may be *ex ante*, errors and ambiguity will appear, unforeseen events, requiring new concepts, will happen, that will require *ex post* adaptations and changes. Generally, the more a communication 'link' is used and the more it has been used in the past, the less errors it will generate, because of (1) the frequency of the feedback and this mutual adjustment between sender and receiver about the attached protocol, and of (2) the cumulated effect of the learning and fine-tuning over time.

A good illustration of the difficulty, energy and time required to establish an purposive communication link is given by the United Nations Edifact (Iso-9735) standard (1996): the purpose of the standard was to define electronic messages between firms and an international, unambiguous vocabulary to automate a supposedly simple task of inter-firm commercial orders and purchases of industrial products. The standardisation work started in 1988 and was only finalised in 2002, fourteen years later.

The learning and investment involved in a communication network goes beyond that of an individual 'link'. The path between two distant agents, that have no direct connection, must also be established. A typical case of this happening in organisations is along hierarchical lines, in which the top managers rely upon the intermediate agents (the hierarchical layers of middle managers) to transmit their instructions to the shop-floor subordinates. However, in the actual network topology that generally goes beyond the 'official' communication links, there is a need to discover, establish and learn the appropriate multi-hop path between two distant agents. The learning process of the right multi-hop path between agents also mobilises time and cognitive resources.

In addition to the learning investment required for its set-up, the very maintenance of a 'link' in a purposive communication network requires memory, time and computational resources embodied in human beings. There is a need to memorise all the features of the 'messages' along the 'link', many of which are specific to the 'link', to its history and to the identity of the agent at the other end. There is also a need to intellectually operate the communication 'protocol', which mobilises time and computational resources. Whatever the formalisation efforts made by the 'technostructure' (Mintzberg, 1979) to uniform and depersonalise interpersonal communication within the organisation, the specifics of the communication 'link' remain highly idiosyncratic and demand to be stored in human memory and operated by human brains, with no universal technocratic rule to replace this memory and this computational capacity. The consumption of human power to simply maintain the existing network precludes the possibility to reach a state of universal communication, with all members of the organisation effectively communicating with all the others. The fact that no purposive communication network can be universal is an essential argument for the existence of organisational capabilities, as will be exposed in greater detail in section 2.4.

2.3.2 Purposive communication networks are stable because of sunk costs

The investment in time and learning incorporated in the purposive communication network creates a **sunk cost**, making it a stable and persistent object, an invariant of the organisation. Once large resources have been dedicated in the past to the establishment of a given network (protocol and topology), the high costs associated with the modification of this network, compared those of a mere adaptation, tend to preserve the

legacy structure. An alternative would be to hope that the purposive communication network of the organisation may evolve towards the stable state of an universal communication network. This hope is vain, however, since, as exposed above, this state is not reachable for reasons of maintenance costs in human memory and computational resources.

This stability of the purposive communication network exists at the level of an individual link, when a change must be made to the protocol. Developing a new message requires going again through the greater part of the (mostly experiential) learning involved in the establishment of the first set of messages. Considering the cost and risk of this process, a frequently preferred option will be to re-use and adapt the existing framework of an existing message.

Beyond the individual protocol of a given link, the topology of the network is also stable. When a communication must be established between two distant agents (i.e. between two agents that are not directly connected), establishing a new, direct link between these two agents requires the time and energy necessary to establish a new message between agents that have no experience of communicating with one another, and that are limited in the number of simultaneous communication links that they may maintain at a given time. A preferred option is often that of keeping and adapting existing communication links over existing (but longer) paths, rather than creating new ones.

2.3.3 Empirical observation of 'purposive communication networks'

A 'purposive communication network' may be empirically observed, specifically in environments where this network is supported by technical infrastructures, such a telephony, electronic mail, instant messaging or Intranet systems, as very recent studies have started to do (Oberg and Walgenbach, 2008; Meijer, 2008). The analysis of the origin and destination(s) of messages (and telephone calls) gives access to the network topology, while the analysis of content provides a view of the protocols. This latter study may be facilitated by the frequent existence of explicit forms and of pre-defined message templates. Since the data generally is available in electronic format, statistical analysis is possible. The empirical study of the purposive communications network of the organisation should thus be reachable at a reasonable cost.

I have thus shown that the 'purposive communication network' of an organisation is stable. This stability relies upon the sunk costs of the learning and cognitive investment incorporated in the establishment of the communication network, and in the memory and cognitive limitations of the human agent in the network. I have also justified the existence of this network under very limited hypotheses on the organisation: the only, very general, assumption is that it is a co-ordinated collective. These conclusions are therefore very general. Finally, I have supported that the empirical observation of such a purposive communication network should be reachable at reasonable cost.

2.4 Justification of the existence of organisational capabilities and cultures

2.4.1 Existence and stability of 'world views' and of 'purposive communication networks'

I have justified that two stable structures - invariants - exist in organisations:

1. their 'world-view' (ontology, mission statement and axiology), embodied in the people that were aggregated piecemeal into the group along its constitution around the initial (group of) founder(s)
2. their 'purposive communication network' necessary for the co-ordination of actions within them.

I have also exposed the processes that stabilise these stable structures, respectively the Attraction – Selection – Attrition – Promotion process and the sunk costs of the learning and cognitive investment in the purposive communication network.

I have also shown that the existence of these invariants relies on minimalist models of organisations, and is therefore very general. The stability of an organisation's 'world-view' only requires the hypothesis of the organisation to have been built over time by piecemeal aggregation of individuals, and makes no further hypothesis on the organisation's internal structure. The existence of a 'purposive communication network' only requires the organisation to function as a collective engaged in co-ordinated tasks. This definition appears as the minimal set of hypotheses to be placed on a group to be able to describe it as a functional organisation worth its name. The stability of this purposive communication network only requires that the establishment and maintenance of effective communication between agents in an organisation require mutual adaptation, and therefore memory and computational resources embodied in humans. This is also a very minimal set of hypotheses.

These stable, universal structures may thus claim to be core elements of the organisation's very identity, if an identity is what is both specific to an agent and persistently attached to it. Attempts to change these stable structures prove to be both difficult and risky – and probably deservedly so, because they engage the very essence of what the organisation is, and of what the people participating in it are, both individually and as a co-ordinated group.

2.4.2 Existence of 'organisational culture'

The organisational 'world-view', as defined here, is an observable and stable element of the 'organisational culture'. I have thus demonstrated that at least this component of 'organisational culture' exists and is stable. I will come back to the definitions of organisational culture in § 4.3 and on its operationalisation in § 4.5 and 5.5.

2.4.3 Existence of 'organisational capabilities'

The demonstration of the existence of organisational capabilities requires a slightly longer development.

The general argument is that a **trade-off** between **efficiency** (i.e. the capacity to operate at low cognitive cost) and **genericity** (i.e. the capacity to transmit a large variety of information) exists over the whole purposive communication network.

This trade-off exists in each communication **link** in the network. The higher the amount of implicit contextual information alongside the main message, the more efficient the communication will be, since what is implicit does not need to be repeated at each message. The 'implicit' information incorporated in the communication must not be mistaken with "*tacit*" knowledge (Polanyi, 1967). This 'implicit' information may very often be fully verbalised and generally is codified somewhere in the organisation. It being 'implicit' in the communication is related to both the economy of not repeating stable and well-known contextual information, and to the whole set of taken-for-granted assumptions on which the organisation relies (whatever the ethical and political value of these assumptions). It has none of the non-verbal, kinaesthetic and automatic features of "*tacit*" knowledge.

The ultimate in the direction of high implicit content is the "*stimulus*" described by March et al. (1958, chap. 6): the communication channel only carries the minimally short "go!" order. An archetypal example of such 'stimulus' is the one given to paratroopers jumping from their aeroplane, while the implicit part of this message is the whole mission description transmitted earlier and the professional military training. The recipient, receiving this stimulus, will execute the full action programme, without the sender needing to provide any further information. However, this implicit information also restricts the genericity of the communication: the message only remains valid as long as the implicit information is true. Any message for which the implicit information does not hold may not be transmitted through this highly specific and efficient channel, and must use another, more generic one. In the example above of the simple stimulus, any specification of the programme to be used, or its relevant parameters, will need to be added to the simple "go!" order, using another, more generic, but less efficient, communication channel.

For each communication link in the network, the choice of the genericity level, and consequently of its efficiency, is fully open. As in any trade-off, there is no obvious "best" choice, or "best practice". Higher efficiency is paid by higher specificity, due to the higher level of implicit information required in the link, and less resilience and capability to react to unforeseen events. Considering the huge (and potentially infinite) amount of contextual information that would need to be transmitted in a fully generic communication channel, I will assume that no communication channel is fully "generic". Consequently, any real-life communication channel is (somewhat) specialised, able to perform some communication tasks better than others.

The same trade-off between efficiency and genericity exists for the overall network **topology**. Indeed, the human cognitive costs associated with establishing and maintaining a purposive communication network in the organisation preclude the existence of an universal one beyond the scale of a small organisation (cf. §2.3.1).

A cost-efficient network will therefore have a limited number of links: only those links that are used often will be direct, while rare or unusual messages will transit through several nodes. In such a network, efficiency will be gained at the expense of being able

to react to rare or unforeseen events. On the other hand, the maintenance of a large number of rarely used links increases the genericity and the ability to react to the unexpected, at the expense of efficiency and of large cognitive costs associated with this maintenance of numerous communication links.

I again meet the situation in which trade-offs are necessary, with no obvious "best" solution: the choice of the network topology is fully open. The information flow will be efficient, fast and reliable along the short routes, those with no or few intermediary nodes, on those links whose high traffic justifies the expense of establishing and maintaining them. On the other hand, it will be slow and error-prone on long communication paths.

Following the previous discussion, and because of this trade-off between efficiency and genericity, I may see that, as a whole, the purposive communication network embedded in the organisation bears some form of **functional specialisation**. It will be good at transmitting and processing some type of information, and therefore at engaging some type of actions, and much worse for some other. Typically, it will be good at transmitting and processing, and therefore at acting on, the information that simultaneously:

1. is recognised as existent by the ontology attached to the individual communication protocols
2. is surrounded by a large amount of usual, taken-for-granted contextual background, that doesn't need to be repeated and is included in the implicit part of the communication protocols
3. follows well-established, short communication paths within the organisation.

If I provisionally define organisational capabilities as the capacity to engage in some actions better than in others, I have demonstrated that these **organisational capabilities exist**. This existence is proven because all organisations embody a purposive communication network (§2.1.3), and because this purposive communication network is functionally specialised, as demonstrated above. This existence is proven under the very general hypotheses, and therefore with very general validity. Since I have also demonstrated above (§ 2.3) that the purposive communication network is stable and persistent, I may conclude that organisational capabilities are also stable and persistently attached to the organisation.

This conclusion may be supported by empirical findings, such as the long-term persistence of coherent product portfolios within firms, evidenced by Teece *et al.* (1994). It is because organisational capabilities exist, and are persistently attached to firms, that they maintain a stable product portfolio, that embodies this stable set of capabilities.

Having justified the existence and the stability of organisational capabilities and culture, I may now proceed to a more detailed examination of their existing definitions in the extant literature, and propose my own concepts. This is the purpose of the next two chapters.

3 Organisational capabilities

I have justified that the concept of 'organisational capability' should have a form of existence, be stable (but not immobile) and persistently attached to an organisation. I now need to proceed further in the definition of the concept, in order to ultimately be able to operationalise it in the empirical part of my research. To that end, I first need to summarise the existing definitions of organisational capabilities from the literature (§ 3.1), before I provide the one that I developed and will use in my research (§ 3.2).

3.1 Existing definitions of organisational capabilities

The notion of "*organisational capabilities*" is rather inter-disciplinary, being at the intersection of three disciplines of management, that focus on units of different scales:

- Strategic Management, at the macro-level of the whole organisation (§ 3.1.1)
- Evolutionary Economics, at the meso-level of aggregation of individual "*skills*" and of group "*routines*" (§ 3.1.2) and
- Human Resources Management, at the micro-level of the individual, with extensions to small-scale teams (§ 3.1.3).

These disciplines consider the concept from very diverse perspectives. For Strategic Management, it is one hypothesis among others in the quest for sustainable competitive advantage, but the focus clearly is the latter; for Evolutionary Economics, the capabilities of organisations are a theoretical foundation stone, since they are a feature that is being selected and retained by the organisation following the test by the environment; for Human Resources Management, they are an extension of the core concept of individual competencies, and this extension may contribute to better justify the existence of the discipline, for if the source of an organisation's performance lie in its competencies, this justifies a greater role for those people in charge of managing them.

In addition to the explicit and coherent definitions of 'organisational capabilities' and of (individual) competence exposed in these theories, the Systematic Review exposed hereafter on their operationalisation methods (§ 5.2) evidences that capabilities can also be considered as a performance level (§ 3.1.4).

In the first understanding of capability as a performance level, the evaluation of a firm's capabilities is performed along a single dimension, with the ambition to predict the firm's overall economic or financial 'performance'. In this literature, the word 'organisational capabilit**y**' is often used in the singular. The intention is that of **ranking** the firm, either against its own set objectives, or against its nearest competitors. The general framework is that of competition among essentially identical organisations, on a commoditised market. This position is dominant, with several variants of ranking organisations by (a) proximity to a supposed 'best practice', (b) efficiency with which a given performance level is achieved or (c) the level of performance being reached along a potentially diversified set of metrics. This view is related to the discipline of Business Performance Measurement, that could provide some key tools and concepts.

However, a minority understanding of the purpose of evaluating collective capabilities also exists. For these authors, the purpose is that of **classifying** firms among a set of

equivalent categories. The issue is to know what category the firm belongs to, what is the nature of the capability or ability the firm masters, what it is able to do or achieve. The purpose is not to know how it behaves within its category compared to the other firms of the same category, or how well it masters its capability. In this framework, the firms are considered as essentially heterogeneous in the *nature* of their abilities, more than in their *level* of competence. They are therefore more susceptible to co-operate. This understanding is very important in the perspective of my thesis on the co-operation of heterogeneous firms around R&D projects.

3.1.1 The Strategic Management perspective

In Strategic Management, the aim of research is to identify the sources of **sustainable competitive advantage**. Two main approaches have been used in the literature: the consideration of the environment of the firm, and that of its internal status.

The first approach is rooted in the 'Structure-Conduct-Performance' paradigm familiar to Industrial Economics (Porter, 1985). Porter describes the list of features that an industry should have in order for the firm to thrive in it. For the author, the "*attractiveness*" of an industry is determined by his well-known "*five competitive forces*": "(1) *the entry of new competitors, (2) the threat of substitutes, (3) the bargaining power of buyers, (4) the bargaining power of suppliers, and (5) the rivalry among the existing competitors*" (chap.1). The author claims that a firm may change this competitive landscape by using appropriate strategies among the "*three generic strategies for achieving above-average performance in an industry: cost leadership, differentiation, and focus*". However, this vision considers that the firm has little limitation on the range of its available choices, and that the firm is able at any time, and at zero cost, to choose the industry it operates in or the 'generic strategy' that it considers as 'optimal' within the chosen industry. This assumption, based upon neo-classical vision of the firm as a free-floating optimising agent, appears little grounded empirically: firms do remain in a given industry for long periods, and have limited strategic mobility. The additional flaw that I see in this this theory is that for a firm to sustain any advantage obtained from the clever usage of Michael Porter's analysis framework, it would need to be able to prevent imitation by competitors, and no phenomenon in this framework prevents this.

In reaction to this belief that the sources of a firm's competitive advantage are external to it, Penrose (1995) coined the notion that "*the firm is more than an administrative unit; it is a collection of productive resources, the disposal of which between different uses and over time is determined by administrative decision*" (p.24). These resources can be physical and tangible: "*plant, equipment, land and natural resources, raw materials, semi-finished goods, waste products and by-products and even unsold stocks of finished goods*" (p.24). They can also be human resources, with different forms of (skilled or unskilled) labour and professions.

More importantly, according to Penrose "*it is never the resources themselves that are the 'inputs' in the production process, but only the services that the resources can render*" (p.25). What she calls "*the services yielded by resources*" are "*a function of the way in which [the resources] are used*" (p.25). In other words, the differences in the way a similar set of resources is actually mobilised are rooted in the capabilities present

in the firm, and forms "*the uniqueness of each individual firm*" (p.25). It is the dense interaction and the co-evolution between highly heterogeneous human and material resources that build together the competitive position of the firm. This competitive position never is generic: it is specific to a given product-markets couple, and is based on a highly evolutionary and history-dependent path.

> *"No firm does produce just anything that happens to be in strong demand at any time in the economy [...] Each firm [...] focuses its attention on particular product-markets selected from the total market. The selection of the relevant product-markets is necessarily determined by the 'inherited' resources of the firm - the productive services it already has"* (p.82)

These early insights by Penrose were not fully formalised until much later works by Barney (1991), almost simultaneously with Prahalad and Hamel (1990).

The main contribution of Barney (1991) is a formalisation of the features that a set of resources need to have in order for the firm to gain a sustained competitive advantage. His reasoning is that, in order for a set of resources to yield sustainable competitive advantage, they should not be mobile between firms, nor easy to acquire on an open market for production factors. Indeed, if the resources were mobile or easily accessible, any firm having initiated a winning strategy using this mobile or easily accessible resource would be imitated by its competitors and lose any advantage it may temporarily have had.

Barney posited that in order for resources to yield sustainable competitive advantage, they must simultaneously be "*valuable, rare, imperfectly imitable and non-substitutable*" (p.100). This list of features has become known under its acronym of VRIN resources. The resource must be developed internally, over time, since (by definition) they are not available in open factors markets.

Prahalad and Hamel (1990), in a more practitioner-oriented article of great influence, expose analogue theses, based on examples more than theoretical considerations. The "*core competencies*" are the technological and organisational bundles of "*diverse production skills and […] multiple streams of technologies […]in new and interesting ways*" (p.82). These resources build the common root of diverse families of innovative and difficult-to-imitate products. These product families, bringing high value to numerous customers, can be sold in large quantities at a premium. They should therefore generate high profit margins. In addition, if they are the result of an unique bundle of technologies and manufacturing skills, they should remain unchallenged in the market for long periods of time, and generate these above-average profits sustainably.

The vision of a firm's resources being static, in a sort of immobile repository, was first criticised by Teece and Pisano (1994) and then by Teece *et al.* (1997). In their view, the firm is embedded in a highly mobile and changing environment, to which it must adapt to survive and be profitable. They therefore define "*dynamic capabilities*" as "*the firm's ability to integrate, build and reconfigure internal and external competences to address rapidly changing environments*" (p.516). The competitive capacity of the firm isn't rooted in its position, as contended earlier (Barney, 1991; Prahalad and Hamel, 1990),

but in its mobility and internal processes: "*Competitive advantage of firms lies with its managerial and organisational processes, shaped by its (specific) asset position, and the paths available to it*" (p.518). The key capabilities become that of learning and reconfiguration, essentially by trial and error. This learning is a slow, path-dependent process, because changing many elements of a firm's activity simultaneously would jeopardise it: "*Learning is a process of trial, feedback and evaluation. If too many parameters change simultaneously, the ability to conduct [...] experiments [and] to ascertain cause-effect relationships is confounded*" (p.523). It is also slow because of the coherent nature of existing productive models and organisations, with organisational processes and incentives reinforcing one another (Boyer and Freyssenet, 2000). As a result, "*capabilities cannot be bought, they must be built. This sometimes takes years - possibly decades*" (p.528).

Although the inclusion of dynamics in strategic management brought in by Teece and Pisano (1994) and by Teece *et al.* (1997) was welcomed, it was also criticised on two grounds. On the first hand, the dynamic capabilities as "*internal processes*" were felt as vague and difficult to connect to empirical evidence. On the other hand, they were also considered as "*second-order*" capabilities, as "*capabilities to acquire capabilities*", in a potentially endlessly recursive fashion.

Eisenhardt and Martin (2000) reconsider this concept of 'dynamic capabilities', and contribute an answer to these critiques. For them, 'dynamic capabilities' correspond to specific, identifiable corporate processes, well-described in empirical research. They provide examples for each broad category of 'dynamic capabilities':

- integrating resources: product development, strategic decision making
- reconfiguration of resources: knowledge transfer processes, corporate re-organisation of business units
- gain and release of resources: knowledge creation, alliances & acquisitions, exit from obsolete positions.

Therefore, they conclude that the notion is indeed valid as a descriptive concept. However, they criticise the belief that they may explain competitive advantage. Following the (unsupported) assumption that organisational behaviours necessarily converge towards an industry "*best practice*", whatever the initial position, a phenomenon that they designate as "*equifinality*", they posit that the 'dynamic capabilities' are imitable and transposable. Therefore, according to Eisenhardt and Martin (2000) competitive advantage doesn't lie in the dynamic capabilities themselves, but rather in the instantaneous set of resources existing. This explains why, according to the authors, the validity of the Resource-Based View of the firm is limited to "*moderately dynamic*" markets. On the other hand, in "*high-velocity*" markets, the relevance of any resource may be challenged by the evolutions of the market environment.

A rather comprehensive and ambitious theory of capability of organisations was developed by Sanchez (2004): "*Competence is the ability to sustain the coordinated deployment of assets in ways that help a firm achieve its goals*" (p.521). The author

defines a conceptual model of five hierarchical "*competence modes*", listed here in descending order (Figure 1, p.520):

1. "*cognitive flexibility to imagine alternative strategic logics*"
2. "*cognitive flexibility to imagine alternative management processes*"
3. "*coordination flexibility to identify, configure and deploy resources*"
4. "*resource flexibility to be used in alternative operations*"
5. "*operating flexibility in applying skills and capabilities to available resources*".

The author considers each level of 'competence' as a source of strategic flexibility, as a means to open more modes of potential action by the firm. Despite its claim to conceptual novelty, this theory mainly appears as a re-arrangement and re-labelling of existing corporate functions:

- 'competence mode I' may be associated to Strategic Marketing,
- 'competence mode II' to Strategic Human Resources, Methods and Organisational design
- 'competence mode III' to Methods, strategic Sourcing / Procurement and operational Human Resources Management
- 'competence mode IV' to scheduling of manufacturing operations
- 'competence mode V' to personal and small-scale collective robustness in front of variations in the environment.

The theory therefore forgets some other corporate functions, such as R&D / New Product Development, operational procurement, most of manufacturing and sales, that are essential for the firm to operate on a daily basis and are also a source of competitive advantage.

In contrast, a very convincing clarification of the relationship between static and dynamic capabilities was given by Winter (2003), followed by Helfat et al. (2007). According to Winter (2003), "*ordinary or 'zero-level' capabilities [are] those that permit a firm to 'make a living' in the short term*" (p.991). The 'zero-level' capabilities defined here are also called "*operational capabilities*" by Helfat et al. (2007), while "*a dynamic capability is the capacity of an organisation to purposefully create, extend or modify its resource base*" (p.4).

This recent set of definitions also removes a conceptual ambiguity that tended to relate the concepts of 'competence' or 'capability' with superior performance, in the wake of the earlier works (Prahalad and Hamel, 1990). For Helfat et al. (2007), "*capacity refers to the ability to perform a task in at least a minimally acceptable manner*" (p.5) The word 'capacity' only implies adequate performance, sufficient for some effect to be obtained. The qualification of the capacity as being 'mediocre' or 'outstanding', its level of "*evolutionary fitness*" or "*external fit*" (p.7) is a different, subsequent problem to be solved, and isn't any more implied in the word 'capacity' alone.

The ideas that capabilities exist at organisational level, and that they evolve over time are a very valid and highly relevant contribution of this school of thought to my research.

3.1.2 The Evolutionary Economics perspective

I introduced Evolutionary Economics theory earlier (§ 1.8.4), and underscored that its vision of heterogeneous agents, with persistent differences and yet a capacity to evolve and learn, was in phase with my point of view. This school also developed a concept of 'organisational capabilities', going beyond the initial building block that 'routines' constitute.

Indeed, the semi-automatic behaviour mode of routines was considered not satisfactory when the issue is to consider actions of greater reflection level and intentionality. Dosi *et al*. (2000) thus refined the concept of "*organisational capabilities*" defined previously by other schools of thought and inserted it into the Evolutionary Economics framework . For them:

> *"To be capable of some thing is to have a generally reliable capacity to bring that thing about as a result of intended action. Capabilities fill the gap between intentions and outcome, [...] in such a way that the outcome bears a definite resemblance to what was intended."* (p.2)

Followers of Dosi *et al.* (2000) gave empirical examples of such *'organisational capabilities'*: in semiconductor and automotive manufacturing (Appleyard et al., 2000; Flaherty, 2000; Florida and Kenney, 2000), in drug discovery (Henderson and Cockburn, 2000; Pisano, 2000), in bank process replication (Szulanski, 2000), in electronic equipment maintenance (Narduzzo et al., 2000) and even in pizza baking (Argote and Darr, 2000).

The empirical evidence does display the existence of 'organisational capabilities', although the distinction between these and 'routines' (supposedly in the intentionality level) does not appear as being very clear-cut. However, the investigation methods being used to evidence these 'organisational capabilities' generally are ethnographic. They are extremely costly to replicate, unless one may use "*an army of ethnographers*" (Cohen et al., 1996). The 'organisational capabilities' evidenced in these studies also are extremely idiosyncratic. They do not appear to relate to a common structure or pattern that would make them re-usable in another context than the one in which they were observed. It thus appears very difficult to use them in a cross-sectional investigation of several firms or organisations.

Despite these limitations in the measurement and operationalisation methods, and despite my reservations about the focus on 'routines' as the main observable, stable elements of organisations (considering the alternative that I propose in chap. 2), I retain from this school its bottom-up approach, that organisational capabilities are rooted in the meso-level assembly and co-ordination of small-scale, well-mastered tasks.

3.1.3 The Human Resources Management perspective

In Human Resources Management, the concept of **individual competence** is the cornerstone for recruitment, assessment and promotion. At each step, decisions are

taken by comparison between what is expected from the individual in terms of these competences and what is actually measured from him/her (Tyson, 2006).

For Tyson, individual competencies are measured according to four broad, potentially overlapping dimensions: "*(1) knowledge, (2) skills, (3) attitudes, (4) personal attributes*" (p.129). The process of "*job analysis*" defines the competences necessary for each position. The methods used for this analysis are direct observation, interviews, diaries and questionnaires of people that are actually engaged in the job being analysed. The general principle is that of functional breakdown, a global task or capacity being decomposed into smaller, hopefully measurable components. For each component of the competence, a scale is defined, with each mark being associated to a short text defining the achievement level. The global competence requirements of a given position are typically displayed according to a "*spider diagram*".

Considering the strategic importance of competence, great care is taken to measure it for each individual, be it a recruitment candidate or a member of staff under periodic evaluation, according to reliable and valid instruments (p.163). The methods used are numerous (pp. 165-168), but their very number indicates how difficult the goals of reliability and validity are to reach:

- ability tests of achievement, on the technical aspects of the work that the person has learnt previously
- ability tests of aptitude, to evaluate what the person may develop after training
- personality tests
- group situational tests
- interviews
- "*behaviourally anchored rating scales -BARS*" (p.200)
- 360° feedback from colleagues, customers, managers and subordinates (p.201).

The evaluation tools for the individual performance and competence of employees are very often proprietary. The first reason is that the very job analysis is specific to each company and to the way it performs its division of labour, and as such may be considered as confidential information. Another is that the function of evaluating people is in itself a (lucrative) business, and the firms operating in this field keep their tools as internal trade secrets or under copyright protection.

Despite its paradigmatic dominance in the field of Human Resource Management, the notion of competence remains elusive in its nature. An interesting effort to conceptualise it was performed by Le Boterf (1994).

According to this author, competence is the ability to do something in a situation of action. He uses an analogy with linguistic competence (p.27):

- the ability to speak is the capacity to integrate vocabulary and grammar rules into individual linguistic performances (the sentences)
- the ability to act (in a professional environment), or professional competence, is the capacity to integrate knowledge, cognitive capabilities and skills (p. 25) into

individual professional performances (actions and results).

He develops a "*systemic model of competence*" (pp.44-46, table 8), in which:

- the inputs are the professional situations and tasks
- the functions are:
  - the cognitive elaboration of an operative representation of the situation, which mobilises the person's 'ontology' (in the model presented § 2.1.2)
  - the consideration of "*self-image*"[18] (which I would relate to my concept of 'mission statement' presented in § 2.1.2) that determines the extent to which resources will be mobilised, according to whether the task is considered reachable, compatible with one's dignity or within one's area of responsibility
  - the activation of memorised knowledge and of cognitive skills ("*inference operations of induction, deduction, transduction, comparison, operationalisation*" - p. 45),
  - the decision of choosing a given professional action
- the outputs are professional actions
- the feedback learning loops are activated according to the post-hoc results of the decisions taken.

This model will be later exploited in the definition I will use of organisational capabilities (§ 3.2).

Human Resources Management has thus developed a very large theoretical and practical expertise and toolkit to handle, evaluate, manage, plan, reward **individual** competences. In this sense, it mimics the methodological individualism prevalent in economics, and very present in Anglo-Saxon culture. However, organisations do exist as collective bodies, and the literature on strategic management has underscored the importance of collective capabilities. Therefore, additional conceptual work is needed.

Building upon the existing expertise in Human Resources Management in competences in general, some authors have endeavoured to explore the first steps of collective capabilities, in a bottom-up movement.

The first scale of collective action being considered is that of the team or small group of people. Tyson (2006) identifies two important tasks in a group: to ensure that the collective task is indeed performed; and to build up cohesiveness by to socio-emotional labour. He also lists 20 components of team competence (p.29), following this broad framework, that were the result of earlier work.

[18] "image de soi"

Le Boterf (1994) associates team competence with a "*common operative image*" of the situation and of the problem to be solved, a "*common language and code*", and a "*co-operative ability*[19]" (p. 129). He lists 3 types of teams (p.135):

- base-ball or cricket teams, in which people "*play within a team, but not as a team*"
- football, in which "*each player occupies a specific position, but co-ordinates its action with the others*"
- double tennis, in which each player "*permanently adapts himself to the other [player's] action*".

Although the reflection of Human Resources Managers on the definition and assessment of individual competence has proven to be very thorough, it seems from these rather recent references that the reflection on collective capabilities in this field remains in its infancy.

3.1.4 The three understandings of capability as a performance level

The understanding of a capability as a performance level often stems from the general ambition of the discipline of Strategic Management (described in §3.1.1 above) to identify the sources (or even the single source) of sustainable competitive advantage. When researchers investigate in the direction of immaterial sources of competitive advantage, to which 'competencies' (or 'abilities', 'capabilities', 'capacities') belong, they tend to consider that any such immaterial source or predictor of further performance may be indifferently labelled as a 'competence' (or an 'ability', 'capability' or 'capacity'). This leads to a significant amount of intellectual confusion, present at various degrees (Grimes et al., 2007; Stratman and Roth, 2002; Hitt and Ireland, 1985).

In order to introduce some clarity, I have further subdivided this understanding of 'capability' into three schools of thought. An organisational capability may be understood either as (1) the proximity to a pre-defined set of 'best practices' or routines; or (2) as the economic efficiency with which a goal is achieved, with the implicit understanding that the goal is in essence achievable by all, the only difference among organisations being the cost at which it is reached; or finally (3) as the degree to which a collective goal is achieved, considering that not all organisations are able to reach it, which may be related to Business Performance Measurement.

3.1.4.1 Organisational capability as proximity to "best practice"

The understanding of organisational capability as the proximity to a single set of practices deemed to be 'best' is illustrated by authors such as Ritter (2002), Stratman (2002), Grimes (2007) and Tu (2006). This approach appears to me as essentially flawed by the assumption that there be a single, eternal 'best' practice, and by a confusion between the end and the means to reach this end. The very history of management practices and management research shows that an evolution takes place, with no reason to stop at any point of time. Therefore, assuming that 'capability' in a field is measured by the distance to what is, temporarily and provisionally, considered

[19] "savoir coopérer"

as the 'best' practice cannot be correct. In addition, considering that there only is one valid operational mode negates the very possibility of innovation and improvement of the practice, and negates the fact that several paths may exist to reach the same end.

3.1.4.2 Organisational capability as an efficiency in reaching goals at low cost

The understanding of capability as an efficiency to reach one's goals at a low expenditure in resources is found in a string of related articles by a stable group of researchers (Dutta et al., 1999; Dutta et al., 2005; Murthi et al., 1996; Narasimhan et al., 2006). These articles define capabilities in their fields of interest - marketing, R&D, operations, 'absorptive capacity' (Cohen and Levinthal, 1990) - as the ratio of attained goals to the expenditures needed to reach these goals.

More specifically:

> *"capabilities as the efficiency with which a firm uses the inputs available to it (i.e., its resources, such as R&D expenditures) and converts them into whatever output(s) it desires (i.e., its objectives, such as developing innovative technologies)"* (Dutta et al., 2005, p.278).

In this understanding of capability as an efficiency, the focus is on how well the organisation mobilises its resources towards its objective, how effective it is in doing so. This efficiency probably gives an indirect indication on how clever and how cohesive the people are in the organisation. However, it makes the key assumption that all firms are able to reach any technical objective, the only difference being the cost at which they reach it. In this world, the only differentiator in the market is the mere cost, which is typical of commodities markets.

3.1.4.3 Organisational capabilities as an effectiveness in being able to reach set objectives

This understanding of capabilities as **efficiency** contrasts with one of capability as an **effectiveness**. In the latter, the issue is to know what target the organisation can reach or aim at, or how far it goes in the way to that objective. In this vision, the assumption is that not all organisations are able to reach any target: some can achieve technical or organisational feats that others simply can't - and this is not an issue of pouring more resources into attempting to reach that goal. In order to achieve the same performance, specific knowledge and capability needs to be developed, and this takes time and expertise - more than bare financial or material resources. In this view, the differentiators between firms on the market lie in the non-cost dimensions of product performance and functionalities, which is more relevant for innovative, high-technology markets that I investigate.

In this perspective, an organisational capability may be understood as the degree by which an organisation is able to achieve certain goals, these goals being expressed in functional terms. The stress is not placed on the tools and practices used to achieve the specified goals, nor on the cost incurred to reach them, but on how far the organisation is able to go along this path. This definition is rather well expressed by Escrig-Tena (2005), for whom a competence

> *"will appear in the performance of certain activities and the achievement of certain results. [...] Competencies can be operationalised by identifying and evaluating the activities and the results arising from them" (pp.230-231).*

A linguistic analogy, following Le Boterf's metaphor may be the wording of the Common European Framework for Languages developed by the Council of Europe (2001) to assess the competence level of individuals in a foreign language, for whom "*Competences are the sum of knowledge, skills and characteristics that allow a person to perform actions*" (p.9).

This understanding of an organisational capability as the ability to achieve a goal described in functional terms is rarely explicitly present. In several of the questionnaires being used in the literature, items relevant to such a concept do appear, although they are intertwined with other items that relate more to the other understandings of 'organisational capability' as a performance described above. Examples of such implicit definitions of capability as an ability to achieve functional goals may be found in an article by Hitt (1985) where, among the 55 items describing the firm's potential "*distinctive competence activities*" (Appendix, pp.289-291), 16 describe practices, and 39 describe the capability to achieve goals expressed in functional terms.

This functional expression of capabilities may also appear in the definition of specific abstract and high-level capabilities like:

- the "*absorptive capacity*" (Cohen and Levinthal, 1990) defined as "*the ability to exploit external knowledge", and "to recognise the value of new information, assimilate it and apply it to commercial ends*" (p.128);
- the definitions given by McGrath (1995) of "*comprehension*" (p.254) as "*what do we know and how well do we know it?*" (p.267) and of "*deftness*" as "*how well group processes are operating*" (p.267)
- the "*strategic capability*" (Lenz, 1980) as "*the capability of an enterprise to successfully undertake action that is intended to affect its long-term growth and development*" (p.226)
- "*knowledge processing*" (Jantunen, 2005) as the firm's "*ability to recognise emerging trends and identify latent market needs [...] in sensing weak signals and seizing opportunities*" (p.337)
- "*organisational learning*" (Jerez-Gomez et al., 2005) as "*the capability of an organisation to process knowledge - in other words, to create, acquire, transfer and integrate knowledge, and to modify its behaviour to reflect the new cognitive situation, with a view to improving its performance*" (p.716).

This functional concept of capability may also be very clear and apparent in the case of smaller-scale collective professional capabilities, where the capability being investigated is the forecasting ability in the context of short-term money market portfolio management (Makadok and Walker, 2000), or where forecasting ability is applied to the "*effort*" needed and the "*schedule*" of a software development (Ethiraj et al., 2005).

Similarly, Durand (1988) primarily aims at identifying the nature of scientific and technical capabilities present in a given R&D organisation, in functional terms, and only secondarily to measure them. This purpose may also be detected in an article by Moehrle (2004), that identifies the nature of the 'inventive processes' (as defined the TRIZ model) being mastered by third-party organisations, in order to select potential co-operation partners that would be complementary of the focal firm being studied.

3.1.4.4 Usability of measurement and conceptual tools inherited from Business Performance Measurement

This view of capabilities as a performance level may be related to **Business Performance Measurement**. This discipline of Management follows suit on the developments of accounting as a tool for managers to have a representation of the current situation of their business. The purpose is for business managers to have the relevant information at the right time, in order to take the right decisions.

Historically, the first methods were to re-use the data produced by the accounting procedures, and to adapt them to operations control and decision-making. From a cost of measurement perspective, it leveraged the mandatory costs incurred for an accurate accounting system and attempted to re-use the data in a broader scope. These first developments, initiated in the second half of the 19th century by DuPont, resulted in analytical cost accounting, in which costs were attributed to individual products according mainly to the direct labour effort attributable to them (Kaplan, 1984). The main perceived advantage of financial, accounting-based data is the high accuracy, reliability and repeatability of the figures provided.

However, these methods solely based upon financial data have proved to become increasingly limited in their usage and their relevance to business control and action needs. A very popular concept incorporating a much broader view of the information needed to make decisions, called the "*balanced scorecard*", was developed by Kaplan and Norton (1992). This set of measures attempted to group into a single view the elements considered as key for the future success of the firm (p.72):

1. "*How do customers view the company? [customer perspective]*" generally "*time, quality, performance and service, and cost*" (p.73)
2. "*What must the company excel at? [internal perspective]*", for example "*cycle time, quality, employee skills, and productivity*" (p.75)
3. "*Can the company continue to improve and create value? [innovation and learning perspective]*", mainly in a continuous improvement framework
4. "*How does the company look to shareholders? [financial perspective]*", typically "*profitability, growth, and shareholder value*" (p.77).

These developments have led to the progressive creation of the discipline of Business Performance Measurement; whose work programme was defined by Neely et al. (1995). For these authors, "*performance measurement*" is "*the process of quantifying action, where measurement is the process of quantification and action leads to performance*" (p.80). The purpose is indeed to design systems that set quantified, objective goals to people or sub-divisions within the organisation, in line with the organisation's overall strategy, and to assess in what extent these goals have been met, in order to trigger

either rewards or corrective action. The key evaluation criteria for the appropriateness of a Performance Measurement System is then "*how much does [the measurement process itself] cost?*" and "*what benefit does [it] provide?*" (p.81). The individual performance measures typically focus on quality, time, cost and flexibility (Table 2, p.83). The overall vision is that of a form of company-wide cybernetics, with the Performance Measurement system providing the information necessary to close the feedback loop. As described by a 'white paper' of the leading supplier of Business Performance Measurement software, Business Objects, the issue is "*to set goals, measure success, and take the action needed to improve performance*" (Business Objects, 2007).

The main interest of this perspective is that measurement is at the very centre of the issues being investigated: what metrics should be used, how do they relate to the phenomena of interest, how reliable, accurate and noise-free are they? On the other hand, the difficulties in using this approach in a research on the capabilities of organisations seem to be the following:

- first, what is measured is performance levels, and not specifically capabilities. Indeed, the issue in Business Performance Measurement is much more "How well and efficiently does the organisation perform its (pre-defined) tasks?" than "What is the list of tasks that the organisation is able to perform?"
- second, apart from the financial reporting that is specified in great detail and mandated with universal applicability within a given jurisdiction by law or by Generally Accepted Accounting Practices, the performance measurement system of a given organisation is highly specific to that firm. Since the objectives being set are deduced from the organisation's strategy, the very entities being measured are a consequence of this strategy. There is little reason why the metrics used should be comparable from one organisation to the next. The transposability of measurements may thus be questioned
- third and finally, the data retrieved from those performance measurement systems is (probably righteously) considered as both strategic and confidential. Access to the data may be highly problematic in a study performed by an external researcher, such as me.

3.2 Definition of organisational capability to be used in the thesis

After having considered the extant literature attempting to define organisational capabilities, I observe that they all have significant weaknesses. The Strategic Management perspective (§ 3.1.1), although this changed recently (Helfat et al., 2007), tends to consider capabilities mainly as a source of competitive advantage, and therefore to conflate the variety of the skills necessary for an organisation to function onto a single scale, that would hopefully predict performance. The Evolutionary Economics view (§ 3.1.2) tends to consider 'capabilities' as highly idiosyncrasic combinations of 'routines', with a focus on the way things are done (rather than on what is done) which makes them difficult to observe and to describe using a generalisable vocabulary. The research in Human Resources Management on capabilities (§ 3.1.3) is mainly concerned with individuals, and has the greatest difficulties in scaling up to collectives. The perspective of capability as a proximity to 'best practice' (§ 3.1.4.1) is a-historical and

partially tautological. The understanding of capability as an efficiency (§ 3.1.4.2) considers that all goals are reachable by all organisations, which is of little relevance in the field of high-tech innovation that I consider in my research. The re-use of tools inherited from Business Performance Management (§ 3.1.4.4) in an empirical research appears as fraught with practical difficulties.

I will retain and systematise the understanding of capabilities as an effectiveness (§ 3.1.4.3), while adapting to collective environments some of the concepts developed in the field of Human Resources Management for individuals by Le Boterf (1994).

I will thus call collective capabilities of an organisation, or **organisational capabilities**, the conjunction of:

1. the **capacity** for the organisation, considered as a collective whole, to **perform well** a set of **actions** and
2. the **context** in which these actions are undertaken.

I define an 'action' as a transformation performed on an entity, the entity being material or informational, and very often both simultaneously (e.g. sending an invoice is both the material act of printing and posting a sheet of paper and the informational action of filling in the fields of the pre-defined form according to the good or the service being sold). The action is defined in functional terms by its final result (i.e. the final state of the entity being transformed) and by the boundary conditions set on the acceptable means to reach that final result, as defined by law, regulation and social acceptability. The action therefore, is not defined by any specific procedure or 'best practice'.

I define by a 'well performed action' an action that is performed at a performance level that has historically proven to be sufficient for the organisation to survive and exist in its competitive environment until the present, and that is performed better than other actions that the organisation may want to do. It does not therefore mean that the level of performance reached is remarkable by any metric, nor that performing this action is a source of any competitive advantage of any sort. In that sense, I follow the definition by Helfat et al. (2007): "*capacity refers to the ability to perform a task in at least a minimally acceptable manner*" (p.5). The word 'capacity' only implies adequate performance, sufficient for some effect to be obtained. The qualification of the capacity as being 'mediocre' or 'outstanding', its level of "*evolutionary fitness*" or "*external fit*" (p.7) is a different, subsequent problem to be solved, and isn't any more implied in the word 'capacity' alone.

The 'context' determines the success of collective action in much the same way as it does for individual action. As illustrations of this contingency, environmental norms or raw material costs impact the capacity of a factory to manufacture at a market prices and in compliance with law; time to market requirements determines the capacity of an engineering department to design new products that still meet functional specifications; familiarity with customers influence the success rate of a sales department; and financial regulations modify the very nature of accounting operations.

I now have a definition of 'organisational capabilities', that is usable, and that I will be able to employ for an operationalisation in my empirical work (§ 5.6). I can now proceed to the same task regarding organisational 'culture', in the next chapter.

4 Organisational cultures

'Organisational culture', and more generally, the 'culture' of any collective body, is probably one of the most elusive concepts in Management, and has elicited a very extensive, and sometimes inconclusive, literature. I will not attempt here to provide a comprehensive overview of the subject, but rather an idea of the intellectual environment that I have considered in my own research, and expose the typology that I developed to classify organisational 'world views'.

I will start with some consensual definitions of organisational or collective culture (§ 4.1). I will then describe some broadly used typologies of cultures in organisations (§ 4.2), and underline their limitations.

My intention however is to integrate a description of organisational 'culture' in the design of an empirical study, and not to write a dissertation on the topic. This is why I restrict the object that I attempt to describe to what I called earlier (in § 2.1) organisational 'world views' (§ 4.3). I will then expose the unified model of organisational 'world views' that I developed from an underlying coherence between some of the theoretical sources exposed above (§ 1.7) and other fields of knowledge (§ 4.4). This model is the second theoretical contribution of my thesis. I will finally describe the parsimonious model of organisational 'world views' that I will use further in the empirical part my research (§ 4.5).

4.1 Existing definitions of collective culture

Several **definitions** of collective culture have been provided in the literature. Following an extensive literature review of the subject, Parker (2000) states that "*the most common formulation of organisational culture is as a consensual whole, a set of beliefs, values, norms, rules and so on that are shared across a particular institution*" (p.187). Going into greater detail, Trompenaars (1996) identifies three concentric layers of cultural phenomena: (1) "*artefacts and products*" at the outside; (2) "*norms and values*" in the middle layer; and (3) "*basic assumptions*" at the core. These layers are almost identical to those proposed by Schein (1991, Figure 1, p.14). Following the same inspiration, Hofstede (1991) considers that cultures are revealed by "*symbols, heroes, rituals and values*", while for Lenartowicz (1999), they are a "*set of learned characteristics shared by a particular group of people […] embedded in symbols, rituals or practices*".

Following Schein (1991, p.6), I would reserve the term of 'culture' "*for the deeper level of basic assumptions and beliefs that are shared by the members of an organisation, that operate unconsciously, and that define in a basic 'taken for granted' fashion an organisation's view of itself, and its environment*". I will therefore deliberately concentrate on the most internal components of collective culture, and disregard the more exterior manifestations of culture, such as rituals and artefacts, as well as the explicit values.

For Schein, these basic assumptions "*are **learned** responses*" (p.6) of the organisation, that help it "***cop[ing] with its problems** of external adaptation and internal integration*" (p.9, emphasis added). This vision of culture as a response to problems is shared by

Trompenaars, for whom it is a "*compromise to solve universal dilemmas in relationships with people, time and the natural environment*" (p.51).

Once these basic assumptions have been learned, by having proven their efficiency in some crucial events of the organisation's history, they are maintained and "*taught to new members as the correct way to perceive, think and feel in relation to those problems*" (Schein, 1991, p.9).

The importance, in the build-up of organisational culture, of having "*shared experiences*" explains why Schein considers that:

> *"Culture should be viewed as a property of an **independently defined, stable social unit**. That is, if one can demonstrate that a given set of people have shared a significant number of important experiences in the process of solving external and internal problems, one can assume that such common experiences have led them, **over time,** to a shared view of the world around them and their place in it. There has to have been **enough shared experience** to have led to a shared view, and this shared view has to have worked **for long enough** to have come to be taken for granted and to have dropped out of awareness. Culture[…] is, therefore, to be found only where there is a **definable** group with a **significant history"*** (p.7, emphasis added)

Following this consideration, the concept of collective culture may be applied to any collective that gathered humans for a period long enough for them to have developed this common history of shared experiences. It may be a whole formal organisation, but also any sub-component of it that has a long enough common history.

In contrast to these views of organisations that emphasise consensus and co-ordination, Parker (2000) considers that organisations are the loci of permanent debate, "*a continuing process of articulating contested versions of what the organisation should be doing, who it should be responsible to and who does what work for what reward*" (p.226), just as in the usage of a language, there is a permanent discussion about the meaning of words and phrases.

4.2 Existing typologies of collective culture

Considering the breadth of the subject, and in order to provide a form of order in it, several scholars have attempted to classify organisational cultures, or to define at least the dimensions that should be considered when describing them.

For Schein, since the purpose of an organisation is both "*external adaptation*" and "*internal integration*", he lists the issues for which an answer must be provided. As regards 'external adaptation', the main issues are:

1. *Mission and strategy: Obtaining a shared understanding of core mission, primary task, manifest and latent functions*
2. *Goals: Developing consensus on goals, as derived from the core mission*

3. *Means: Developing consensus on the means to be used to attain the goals, such as the organisational structure, division of labour, reward system and authority system*
4. *Measurement: Developing consensus on the criteria to be used in measuring how well the group is doing in fulfilling its goals, such as the information and control system*
5. *Correction: Developing consensus on the appropriate remedial or repair strategies to be used if goals are not being met* (Table 1, p.52)

Concerning 'internal integration', on the other hand, the problems to be solved are:

1. *Common language and conceptual categories. If members cannot communicate and understand each other, a group is impossible by definition*
2. *Group boundaries and criteria for inclusion and exclusion.[...]*
3. *Power and status. Every organisation must work out its pecking order, its criteria and rules for how one gets, maintains and loses power; consensus in this area is crucial to help members manage feelings of aggression*
4. *Intimacy, friendship and love. [...] peer relationships, relationships between the sexes [...]*
5. *Rewards and punishments. Every group must know what its heroic and sinful behaviours are; what gets rewarded with property, status, and power; and what gets punished in the form of withdrawal of rewards, and, ultimately, excommunication*
6. *Ideology and 'religion'. Every organisation, like every society, faces unexplainable and inexplicable events, which must be given meaning so that members can respond to them and avoid the anxiety of dealing with the unexplainable and the uncontrollable* (Table 2, p.66)

Once the answers have been given by the group to these questions, via an evolutionary process of trial and errors, the organisational culture stabilises. For Schein, the values taken for each parameter cannot be fully random, and there should be a convergence towards "*paradigms or coherent patterns*" (p.109). He does not, however, describe these paradigms any further, beyond giving some examples of organisations with strong and coherent cultural features.

In the absence of such 'paradigms' susceptible to reduce the number of eligible combinations, Schein's framework generates so many possible types that it is all but useless: even in the favourable hypothesis where each dimension could take two alternative values only, the resulting number of possible types would still reach 2^{11}, that is 2048 possibilities!

The dimensions evidenced by Schein to define an organisational culture resemble those that Harrison (1972) uses to define an organisational "*ideology*". For him, such an 'ideology':

- *"specifies the goals and values towards which the organisation should be directed and by which its success and worth should be measured*

- *prescribes the appropriate relationships between individuals and the organisation (i.e. the "social contract" that legislates what the organisation should be able to expect from its people and vice-versa)*
- *indicates how behaviour should be controlled in the organisation and what kinds of control are legitimate and illegitimate*
- *depicts which qualities and characteristics of organisation members should be valued or vilified, as well as how these should be rewarded or punished*
- *shows members how they should treat one another, competitively or collaboratively, honestly or dishonestly, closely or distantly*
- *establishes appropriate methods of dealing with the external environment - aggressive exploitation, responsible negotiation, proactive exploration*" (p.120).

Following this definition of relevant variables, Harrison postulates a typology with four 'organisational ideologies': "*(1) power orientation, (2) role orientation, (3) task orientation, and (4) person orientation*" (p.121):

- "*An organisation that is **power-oriented** attempts to dominate its environment and vanquish all opposition. It is unwilling to be subject to any external law or power. And within the organisation, those who are powerful strive to maintain powerful control over subordinates*" (p.121). Such organisations are "*ruthless*", working "*at the expense of others*", "*voracious*", "*sometimes outside of the law*" and the "*law of the jungle*" reigns inside.

- "*An organisation that is **role-oriented** aspires to be as rational and orderly as possible [... It has] a preoccupation with legality, legitimacy and responsibility [...It has] developed partly in reaction to power orientation*" (p.121). Such an organisation is analogous to a constitutional monarchy, with a strong adherence to rules and procedures, even at the expense of efficiency. Examples are given in quasi-monopolistic industries (banks, insurance companies, public utilities and social work).

- "*In the organisation that is **task-oriented**, achievement of a superordinate goal is the highest value. The goal need not to be economic: it could be winning a war, converting the heathen, reforming a government, or helping the poor. The important thing is that the organisation's structure, functions and activities are all evaluated in terms of their contribution to the superordinate goal. Nothing is permitted to get in the way of accomplishing the task*" (p.122): neither authority, nor rules and regulations, nor individuals, nor personal need or social considerations. "*Emphasis is placed on rapid, flexible organisation response to changed conditions*" (p.122). Often at the start of organisations, but "*internal conflicts and external stress drive these organisations toward power and role orientations*" (p.122). Such ideologies may exist in temporary project teams of large and old organisations.

- "*Unlike the other three types, the **person-oriented** organisation exists primarily to serve the needs of its members*" (p.122). "*Individuals are expected to influence each other through example, helpfulness and caring*" (p.123). The author testifies a push by younger generations (in 1972) to work in such

> organisations, on projects that are "*interesting and congruent with their own values*" (p.123).

Harrison performs a viability analysis of these types: 'power' and 'role' orientations are too rigid to adapt to fast external changes, while 'task'-oriented organisations are best suited. In case of external threat, the 'power'-oriented organisations are better. 'Power'-oriented organisations "*work well when problems take the form of overt challenges that can be comprehended and solved by one or few intelligent, courageous men at the top*" (p.124).

In terms of historic development, Harrison sees a trend toward 'task' or 'person' oriented organisations, that fulfil more elaborate requirements of humans, beyond mere security. "*Unfortunately, [...] some people are dependent, apathetic or insecure. They do need external incentives to work and directives or rules to guide their activities*" (p.125).

Considering the inevitable conflicts between the interests of the people (security, meaningful work, personal development) and of the organisation (responses to threat and change, internal coordination of efforts), no 'ideology' satisfies simultaneously all the needs of people and of organisations, although some are better suited, according to circumstances. The author thus calls for organisations that have parts of each 'ideology', either as a mix or in separate, ideologically pure, departments.

This work, although it has been extensively cited, appears to me as an illustration of the poor work that can be written in "practitioner"-oriented journals: no empirical support is provided, no theoretical coherence appears, no hint is given as to where the author writes from (although the several allusions to TRW may imply that he has worked for them either as a manager or a consultant).

The typology provided seems to be grounded on absolutely nothing else than the postulates of the author. The underlying rationale of this typology seems to be that the "natural" evolution of an organisation is to move from an enthusiastic group (task-oriented) to a ruthless dictatorship (power-oriented), with a milder form of constitutional monarchy in between, whose formalism and slow adaptation restricts to small niches (role-oriented), while a minority of dreamers want the organisation to serve them as persons (person-orientation). This story is very much coherent with the very brutal social and economic relationships in the United States of America that are described by Storper (1993). In addition, Harrison's work precedes the absorption of the hedonistic revolt on the 1960s (represented in his typology by the the 'person-orientation') by the "*projects polity*", in the "*new spirit of capitalism*" (Boltanski and Chiapello, 2005). Therefore, the typology proposed by Harrison appears to me as highly located historically, geographically and culturally.

Miles *et al.* (1978) proposed a "*strategic typology*" of firms, containing four archetypes, each of which defined by a coherent set of answers and solutions given to entrepreneurial, engineering and administrative problems:

- "*The Defender [...] deliberately enacts and maintains an environment for which a stable form of organisation is appropriate*" (p.550)

- "*The Prospector's main capability is that of finding and exploiting new product and market opportunities*" (p.551)
- "*The Analyser is a unique combination of the Prospector and Defender types*" (p.553), and is an intermediate between these two extremes
- "*The Reactor exhibits a pattern of adjustment to its environment that is both inconsistent and unstable [... It] is a residual strategy*" (p.557).

This typology was later re-used in empirical studies (Snow and Hrebiniak, 1980; Conant et al., 1990). My main concern about this typology is its lack of balance and closure. Indeed, the fact that the 'Reactor' type be considered as "residual" places it in an inferior position compared to the other three, and questions the reasons why an organisation would choose this strategy at all. Similarly, the 'Analyser' type is intermediate, a combination, an "*hybrid*" between the two only "*pure*" types, the 'Defender' and the 'Prospector'. If the position along a continuum between two 'pure' types is a viable situation, then the number of possible 'hybrids' is potentially infinite, and the very definition of the 'Analyser' type may be questioned.

Quinn and Rohrbaugh (1983) define a "*competing values*" model in which they discuss the underlying rationales that justify the operationalisation of "*organisational effectiveness*" by scholars. They identify two dimensions of values that can justify the evaluation of organisations:

> *"The first value dimension is related to organisational focus, from an internal, micro emphasis on the well-being and development of the people in the organisation to an external, macro emphasis on the well-being of the organisation itself. The second value dimension is related to organisational structure, from an emphasis on stability to an emphasis on flexibility."* (p.369)

They then develop four models to define 'effectiveness', according to the emphasis placed on one extreme or these axes or the other, that are summarised in Table 4.2.1 hereafter.

(The space below is deliberately left blank)

Model	Emphasis along the **internal** vs. **external focus** axis	Emphasis along the **flexibility** vs. **control** axis	**Means**	**Ends**
human relations	internal	flexibility	cohesion and morale	human resource development
open system	external	flexibility	flexibility and readiness	resource acquisition and external support
internal process	internal	control	information management and communication	stability and control
rational goal	external	control	planning and goal setting	productivity and efficiency

Table 4.2.1: 'Competing values' models for the evaluation of organisational effectiveness (adapted from Quinn and Rohrbaugh, 1983, p.371)

My main concern with this typology lies in its interpretation of the 'internal' vs. 'external' focus dimension, that mixes concern for people and their feelings with the first extreme and abstract, rational preoccupations with the second. As a typical counter-example, an introvert, bureaucratic and formal organisation would both be inward-looking and yet have a focus on rules rather than on people, while a charitable organisation would both be concerned with the success of its action rather than on its internal operations, and yet be very involved with people. This conceptual confusion makes the whole typology difficult to interpret and somewhat misleading.

Hofstede (1991) used a huge set of survey data obtained with IBM employees world-wide (116,000 employees in 50 different countries) to empirically establish a set of cultural dimensions: (1) the "*Power Distance"* Index, a mix of social inequality and obedience to authority; (2) the "*Indivualism*" index, a difference between considering the individual or the group; (3) the "*Masculinity*" index refers to two different issues: the strength of the separation of sexual roles and the prominence of being "*assertive, tough and focused on material success*" (p.95); (4) the "*Uncertainty Avoidance*" Index, expressing to what extent what is unknown, different is considered as dangerous, and should be avoided by ambiguity-reducing procedures, laws and regulations, even if inapplicable; and (5) the long term / short term orientation.

This study, although it received very broad recognition, appears to me as flawed by the very design of the research. The initial questionnaire was set up without any previous idea of the cultural dimensions that would deserve being investigated. As a result, the 'dimensions' drawn from the results appear to me as being mere *post-hoc* rationalisations: they were made up from a clustering exercise, in which those questionnaire items that were correlated were given a common label. The internal,

semantic cohesion of the items contributing to the same 'dimension' is therefore not checked.

In addition, the dimensions are fraught with ideological assumptions. such as "*in politics there is an inescapable trade-off between freedom and equality*" (p.72), or the negative connotation of law and procedures in the 'Uncertainty avoidance' index, and with gender stereotypes, such as in the 'Masculinity' index.

Another important concern is that Hofstede considers that the relevant geographic scale for the investigation of culture is the nation-state. Considering the historical set-up of nation-states, that incorporated territory piecemeal around a political centre, and the very long-term persistence of cultural phenomena on a given territory (one striking example of which, among others, is the persistence of the Basque language through Roman, Wisigothic, Spanish and French political dominations), specifically in Europe; smaller units of analysis, such as the regions, would have been relevant, as the growing literature on regional sources of economic prosperity illustrates (Porter, 2003).

A final observation would question the balance of Hofstede's typology. Along the first four dimensions, one side is positively connoted, respectively low "power distance", high "individualism", low "masculinity" and low "uncertainty avoidance". The countries that are closest to this set of features are Denmark and the Netherlands. Coincidentally - or not so much so - Hofstede happens to be Dutch. For all these reasons, I believe that his typology of national cultures deserves being significantly reconsidered.

Trompenaars (1996) also developed his typology of national cultures, displaying seven dimensions (Universalism vs. Particularism; Collectivism vs. Individualism; Affective vs. Neutral relationships; Specificity vs. Diffuseness; Achievement vs. Ascription; Orientation towards Time; Internal versus External Control), without explaining more than Hofstede where they come from. The survey was administered to 25,000 "managers", and resulted in different mean values for different nationalities of respondents. The respondent population is not described (although elements in Trompenaar's article would suggest that they are students at the Centre for International Business Strategy in Amstelveen, the Netherlands), nor are the confidence levels around the mean values being evidenced. Overall, the justification for the scales given is essentially inexistent.

Markus and Kitayama (1991) compare Western (actually, United States American) and Asian (actually, Japanese) cultures. For them, the main difference between both relates to the self and its relatedness to others:

> *"Many Asian cultures have distinct conceptions of individuality that insist on the fundamental relatedness of individuals to each other. The emphasis is on attending to others, fitting in, and harmonious interdependence with them. American culture neither assumes nor values such an overt connectedness among individuals. In contrast, individuals seek to maintain their independence from others by attending to the self and by discovering and expressing their unique inner attributes." (p.224)*

This study claims that all Western cultures are akin to that of the United States of America, and that, symmetrically, all Asian ones resemble the Japanese one. Both

assumptions appear to me as being false, for reasons that I will expose later (§ 4.4.3). However, the distinction evidenced by Markus and Kitayama between American and Japanese cultures seems relevant, and well identified. Therefore, a typology of cultures should account for them.

Amable (2005) also attempted to devise a typology of national cultures, based upon a pre-existing theory, that of institutional economics. The author uses data for 21 countries of the OECD, where reasonably homogeneous, reliable and comparable statistics exist. on five essential sectors of institutions:

> *"the competition on the markets for goods; the employment relationship and the institutions of the labour market; the financial intermediation sector and corporate governance; social protection; the education sector*[20]*"* (p.25)

The actual variables being considered in each field are detailed pp.345-353 of his book.

Each set of institutions leads to a specific clustering of the 21 OECD countries, in 4 or 5 categories each time, by separating countries along one or two axes. The synthesis of these groups leads to a final grouping in 5 (or 6) categories (according to whether the Netherlands and Switzerland are considered as a category in itself or as belonging to the 'continental European' model). As a conclusion, the author

> *"proposes the existence of five types of capitalism, characterised by specific institutional forms and particular institutional complementarities: the model based on the market [United States of America, United Kingdom, Canada, Australia]; the social-democratic model [Sweden, Finland, Denmark]; the continental European model [France, Germany, Austria, Belgium, Ireland, Norway, with the Netherlands and Switzerland forming a sub-group apart]; the Mediterranean model [Italy, Spain, Portugal, Greece]; and the Asian model [Japan, Korea]*[21]*"* (pp.25 and 32)

The tables summarising the features of each model are described Table 3.2 (pp.137-139), while the institutional complementarities between the features of each model are given in Tables 3.3A to 3.3E (pp.140-148) of Amable's book.

Although the intention is good of defining the different modes of capitalist organisation of the economy, the book mainly is an exercise of statistics and of clustering of countries according to Principal Component Analysis, leading to rather inconsistent and uncertain categories. The categories being defined have blurred boundaries, and a weak internal logic.

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[20] la concurrence sur les marchés de produits; le rapport salarial et les institutions du marché du travail; le secteur d'intermédiation financière et la 'corporate governance'; la protection sociale; le secteur éducatif

[21] Je propose l'existence de cinq types de capitalisme, caractérisés par des formes institutionnelles spécifiques et des complémentarités institutionnelles particulières: le modèle fondé sur le marché [États-Unis d'Amérique, Royaume-Uni, Canada, Australie]; le modèle social-démocrate [Suède, Finlande, Danemark]; le modèle européen continental [France, Allemagne, Autriche, Belgique, Irlande, Norvège, avec les Pays-Bas et la Suisse formant un sous-groupe à part]; le modèle méditerrannéen [Italie, Espagne, Portugal, Grèce]; et le modèle asiatique [Japon, Corée]

The choice is made of categorising countries, and is applied to the 21 countries of the OECD. The fact that the outcome is a classification into 5 (or 6) classes, leaving only an average of 4 countries in each class (and some classes containing only 2 countries), questions the very purpose of the exercise. Talking of a "model" that would only be represented by 2 countries is in itself partially self-contradictory, unless one believes that each country is a "model" in its own right.

In addition, the usage of statistics and of legal institutions on each country is justified by the claim to be objective and factual. However, since no underlying logic is presented, the generalisability and robustness of the findings is low: if a new country is added to the list, and according to its own statistical information and legal base, it may either justify a category of its own right, move the boundaries or the very list of categories (by bridging the gap between two groups and justifying their merger). Specifically, since several categories are defined in semi-quantitative way by having attributes at intermediary values, between the values reached by other categories, the classification is in essence highly debatable, since the location of the boundaries between categories on the continuum represented by the attribute is arbitrary. Finally, the exhaustiveness of the classification system is in no way assured: one does not know whether any new country, in addition to the 21 being investigated would necessarily fall into one of the existing categories. Considering the variations of each single country over time, and the fact that the OECD countries are a highly specific sub-set, the answer most probably is no.

Finally, Keirsey (1978; 1989) presented a simplification of the Jungian (1923) personality model presented later (§4.4.2). According to Keirsey, in a first, static analysis, people belong to either one of four "*temperaments*", each gathering four MBTI 'types' (Briggs-Myers et al., 2000): "*(1) Guardians, (2) Idealists, (3) Artisans and (4) Rationals*". These 'temperaments' may be briefly described as follows (adapted from: Keirsey, 1989):

> *"**Guardians** (MBTI "SJ" types) tend to be dutiful, cautious, humble, and focused on credentials and traditions. They are the cornerstone of society, preserving social institutions, customs and traditions. Practical and down-to-earth, Guardians believe in following the rules, in working steadily within the system*
>
> ***Idealists** (MBTI "NF" types) are enthusiastic, prize meaningful relationships, and pride themselves on being loving, kind-hearted, and authentic. Idealists are naturally drawn to working with people. They dream of creating harmonious personal relations for the good of all.*
>
> ***Artisans** (MBTI "SP" types) tend to be fun-loving, optimistic, realistic, and focused on the here and now. They pride themselves on being unconventional, bold, and spontaneous. They trust their impulses, seek stimulation, and prize freedom. Artisans are most at home in the real world of solid objects that can be made and manipulated, and of real-life events that can be experienced in the here and now. Above all, Artisans need to be free to do what they wish, when they wish.*
>
> ***Rationals** (MBTI "NT" types) tend to be focused on problem-solving and systems analysis. Rationals pride themselves on being ingenious, independent, and strong willed. They are interested in the abstract concepts*

> *involved, the fundamental principles or natural laws. They are rigorously logical and fiercely independent in their thinking"*

The reasons why the MBTI 'types' were collected this way are not provided by Keirsey, nor do they appear as fully evident *post-hoc*. Indeed, if some clear relations are traced by Keirsey between 'temperaments' and Jungian 'psychic functions'[22], it is not the case for all. The 'Artisan' temperament gathers four MBTI types that all share Extravert Sensing as a well-mastered psychic function. In the same manner, the 'Guardian' temperament gathers four MBTI types that all share Introvert Sensing as a well-mastered psychic function. The relations between the other two 'temperaments' and 'psychic functions' are not explicitly drawn by the author, and not very clear either. Although it is simple and appealing, this model appears to me as both simplistic and not very well grounded.

My conclusion, following this overview of models and typologies describing organisational and collective cultures, is that none of them is satisfactory.

4.3 Perspective of organisational culture in this thesis: restriction to 'world views'

Because of the breadth and complexity of the notion of 'organisational culture' that I hinted at above (§ 4.1 and 4.2), I will not attempt to design a descriptive tool able to account for all its multiple facets. Instead, I will limit the scope of what I consider in my research to what I called the **'world view'** of an organisation, that is, the conjunction of its 'ontology', its 'mission statement' and its 'axiology' (§ 2.1.2).

This choice of restricting the scope of my research to those elements of organisational culture that I call the 'world view' is coherent with the fact that the other important focus of my research is on 'organisational capabilities', that is, on the organisation's capacity to **act** on its environment (§ 3.2). Indeed, as exposed when I presented the concept (§ 2.1.2), a 'world view' is the set of parameters that need to be defined for an aggregate of people to agree upon an **action agenda**. An organisation's 'world view' therefore frames the actions that it can perform, and consequently its capabilities. It is then logical that I restrict the scope of my research to those components of culture that have an influence on the actions that an organisation performs, namely to its 'world view'.

I will describe and justify the tools that I use to describe and classify 'world views' in the next section (§ 4.4), relying upon other academic sources and authors than those listed above (§ 4.1 and 4.2).

4.4 A unified model of organisational "world views"

I intend in this section to design a measurement tool of organisational 'world views' that is simple and easy to implement. To that end, I will develop a **typology** of such 'world-views', where organisations may each be assigned to one class, and to one class only.

[22] I will provide a further explanation of these Jungian 'psychic functions' later on (§ 4.4.2).

My requirements in developing a typology of 'world views' is that it should satisfy the following conditions. (1) It should be **balanced**. My understanding of 'world-views' is that they should be, in essence, valid and adapted in certain circumstances, at the expense of being of lesser use, or even dysfunctional, in others. On any dimension, no extremity of the scale should be evidently 'morally better' or 'intellectually / socially more developed' than the opposite one. (2) It should be **general** enough to account for many observed phenomena and to claim validity in a broad numbers of cultural environments, at least able to cover the diversity of European settings, but also of industries, organisations and populations. This argues in favour of a typology based on existing theories (and not on *post hoc* rationalisation of blind data analysis). (3) It should contain a **limited number of categories**, in order to remain understandable and manageable. (4) Finally, it should be **closed**, i.e. it should contain the justification for the number of categories present, and exclude by design any later addition or substraction of categories. Indeed, if the number of categories were not pre-defined, and thus could be increased by one at each new observation, the worth of the typology would be annihilated: each new organisation could justify a new specific category, and the predictive and classifying capacity of the typology would be lost.

If these four conditions were satisfied, I would reach a general objective of **parsimony**, of describing many diverse observations with a limited amount of highly relevant data.

Several attempts have been made in the literature to develop such typologies of organisational or national cultures, and I justified why I do not consider them as being satisfactory (§ 4.2).

My method will be to mobilise three fully independent streams of empirical observations and theoretical constructions, that I contend converge towards a coherent model: (1) the "*polities*" model (presented earlier in § 1.8.3) from the field of economic sociology; (2) the "*psychic functions*" (Jung, 1923) that agents mobilise at a different levels of mastery and that both mould their perception of the world and rank their moral criteria, from analytical psychology; and (3) the "*family models*" (Todd, 1985) that shape at a very early age the fundamental notions of collective life, from historical anthropology. These three theories, although born completely independently from one another, and based upon highly different empirical material, bear striking convergences that support the existence of a common underlying structure.

In a first section (§ 4.4.1), I will present the seven 'polities' listed by Boltanski and Thévenot and by Boltanski and Chiapello (2005; 1999), and will underline the main limitation that I see in their work, namely that the list of 'polities' is not justified. In a second section (§ 4.4.2), I will describe the Jungian model of the mind and the eight 'psychic functions' present, at varying degrees of mastery and consciousness, in every human. In a third section (§ 4.4.3), I will depict the four European 'family models' proposed and evidenced by Todd. In a fourth section (§ 4.4.4), I will draw analogies and comparisons between six of the seven 'polities', four 'psychic functions' and the four European 'family models', and build four renovated "collective polities", that organise collective action and support a full social order. In a fifth section (§ 4.4.5), I will construct four additional "individual polities", each based on one of the remaining 'psychic function' and using material from one remaining 'polity'. In a sixth section (§ 4.4.6), I will describe the conflicts that may occur between the 'world views' relevant

at different scales of social groups around a given person, that should elicit caution when ascribing the 'world view' relevant for him/her. I will then conclude in a last section (§ 4.4.7).

4.4.1 Boltanski, Thévenot and Chiapello's "polities"

The Conventions Economics theory (§ 1.8.3) provides a highly coherent theoretical framework to specify the structuring axis of 'world views', as I have defined them earlier (§ 2.1.2). Indeed, the nature of the 'polity' specifies the ontology of the 'world view', because only those beings and agents of high 'worth' deserve being included in the frame of perception and meaningfulness. It also defines the mission statement and the axiology of the 'world view': the actions that deserve being undertaken are those that contribute most to reaching positions of higher 'worth' in the 'polity', or in other words, that contribute most to the 'common superior principle'. Therefore, I expect that the list of 'polities' identified by Boltanski, Thévenot and their followers should be relevant to classify possible 'world views'.

According to Boltanski and Thévenot (1991), the set of stringent 'axioms' specifying a morally legitimate 'polity' limits their numbers. They identify only six 'polities' satisfying all axioms of moral acceptability, to be observed in contemporary France: (1) "*inspired*", (2) "*domestic*", (3) "*fame*", (4) "*civic*", (5) "*market*" and (6) "*industrial*" (pp. 200-262). They base their description of these 'polities' by referring to a "*canonical work*" of (mainly French) political philosophy: each 'canonical work', and each selected author, is related to one 'polity'. A seventh, "*projects-driven*"[23], 'polity', was later added by Boltanski and Chiapello (1999, pp. 154-238). The main features of these seven 'polities' are summarised in the Table 4.4.1 below.

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[23] "cité par projets"

Name of the 'polity'	Canonical work describing the 'polity'	Common superior principle	Measure of worth	Typical people of high worth in the 'polity'
1. Inspired	(Augustine, 1945)	Dedication to something greater than oneself	Divine grace, inspiration, creativity	Artists and political "*avant-gardes*"
2. Domestic	(Bossuet, Jacques Bénigne,successi vely Bishop of Condom and of Meaux, 1709)	Benevolent paternalistic hierarchy	Position in a genealogy or in a social order, Trustworthiness	The monarch, the nobles, the father
3. Opinion	(Hobbes, 1650)	Capacity to convince and to gather around a person	Number of supporters, Fame	Popular people, stars, opinion leaders
4. Civic	(Rousseau, 1762)	Dedication to the common good	Democratic election, Representative-ness	Elected officials
5. Market	(Smith, 1759)	Prosperity through competition and the "*invisible hand*"	Wealth	Rich people
6. Industrial	(de Saint-Simon, 1841)	Productivity, technical efficiency	Performance	Professionals, experts, engineers, social planners
7. Projects-driven	Management literature of the 1990s	Capacity to gather around a project	Number and quality of connections	Project leaders

Table 4.4.1: The seven 'polities' - adapted from Boltanski and Thévenot (1991) and Boltanski and Chiapello (1999)

Despite the quality of their breakthrough theoretical intuitions, neither Boltanski and Thévenot, nor Boltanski and Chiapello explain the reasons for having selected these six (and later seven) polities. Why were seven polities selected, and neither more nor less, and why were these selected rather than others? This critique had already been expressed by Piteau (1992), and by Jagd (2004), who underlined the lack of coherence between the six 'polities' by Boltanski and Thévenot, the three 'conventions of quality' by Eymard-Duvernay (1989) and the four 'worlds of production' by Salais and Storper (1992).

4.4.2 Jung's "Psychic functions"

The Swiss psychologist and philosopher C.G. Jung defined in the early 1920s a set of "*psychological types*" (Jung, 1923), in order to classify human behaviours. The main

assumption is that differences in behaviours are not random, but are due to differences in the preferences that people have for either one of the alternative ways to perform action. This model is the basis of the very broadly used MBTI® (Myers-Briggs Type Indicator) personality assessment questionnaire (Briggs-Myers et al., 2000).

In this model, the actions to be performed are (1) the Perception of phenomena and (2) the Judgement about what the person should do, based upon the perceived phenomena. The Perception may be either according to Sensing - in a "*factual and detailed manner*" (Cauvin and Cailloux, 1999) – or to Intuition - "*globally and immediately*". The Judgement may be either according to Thinking – "*according to objective, impersonal principles*" – or to Feeling, - "*according to personal values and subjective beliefs*". A key additional distinction is the general orientation of the person's energy, towards the outer world of activity, people and things (Extraversion) or towards the inner world of reflections, feelings and ideas (Introversion). Each of the Perception and Judgement actions may be performed according to two alternative modes, and each mode itself in the two alternative orientations of energy. This results in a total of eight "*psychic functions*", that are described in the Table 4.4.2 below.

(The space below is deliberately left blank)

Action	**Psychic function**	**Description, adapted from Cauvin** (2001)
Perception	Extravert Sensing	Pragmatic, concrete, efficient, adaptive to the changes in the environment. At ease with operational issues and in finding creative solutions to immediate problems. Learns by experimenting. Typical activity: to repair.
	Introvert Sensing	Concrete, organised, methodical, efficient. Relies upon the lessons of experience. Deep sense of order and of traditions. Very stable. Learns in a methodical way. Typical activity: to maintain
	Extravert Intuition	Creative, flexible, always ready to innovate, to explore new ways. For it, the world is in a permanently nascent state, a locus of experimentation to launch new ideas. It learns in effervescence, the boiling of ideas. Typical activity: to explore
	Introvert Intuition	Resembles Athena coming out fully armed from Zeus' head. Internally, reflection is intense, but only the final result appears of this internal work. Then a methodical, organised and complete vision presents itself in a concentrated form. Typical activity: to plan
Judgement	Extravert Thinking	Organises the outside world. Naturally in commanding positions. At ease when the issue is to set up a plan, share tasks, give orders. Takes fast, efficient decisions. Typical activity: to lead
	Introvert Thinking	Discovers theories, investigates the ultimate reason of things. Dwells deep into complex issues to find the final solution. Typical activity: to search
	Extravert Feeling	Enthusiastic, dynamic. Wants to transform the world according to his/her values. Missionary. Very well connected in social networks. Excellent social skills. Typical activity: to nurture
	Introvert Feeling	Deep sense of ideal, attachment to internal core values, irrespective of socially approved opinions. Motivated by the moral meaning of issues. Typical activity: to assess the moral value

Table 4.4.2: Psychic functions according to Jung (1923)

In Jung's model, each person masters psychic functions at different levels. A "*preferred*" mode of action will be well-mastered, result in easy, efficient, highly differentiated and appropriate action, and be related to the conscious part of the psyche. A "*non-preferred*" mode will only be executed at a lower level of performance, slower, grossly and will be related to the unconscious part of the psyche. A MBTI "*type*" (Briggs-Myers et al., 2000), built upon this model of human behaviour, is defined by a set of two 'preferred' psychic functions, that satisfy conditions of viability: one among these functions performs Perception while the other performs Judgement; one is

Extravert while the other is Introvert. This leads to a total of 16 different MBTI 'types'. Jung's personal development programme, that he calls "*individuation*", is the progressive integration of the unconscious psychic functions into the field of consciousness.

This model of 'psychic functions', in addition to providing the theoretical substrate for a very broadly used personality description tool, has also been very successfully used to anticipate and improve the efficiency of industrial innovation processes (Stevens and Burley, 2003). Those analysts having the MBTI 'type' most appropriate for early-stage innovation demonstrated a 50-fold higher financial return on their projects than those having the less appropriate 'type'. It was also used to study innovation processes in other environments (Rabson and DeMarco, 1999).

It was also generalised to the scale of organisations by Bridges (2000), whose works have been re-used in later empirical studies (Barabasz, 2007; Kim et al., 2008; Jessup, 2002).

Jung's model of 'psychological types' and 'psychic functions' may be integrated into the framework of 'world views'. The ontology of a 'world view' related to a 'psychic function' would be what a Perception function the is best able to identify, detect and differentiate, or what a Judgement function considers as most important to consider when taking a decision. The axiology of the 'world view' places the 'typical activity' of the 'psychic function' at the top of the agenda.

4.4.3 Todd's "Family models"

The demographer and historian Todd (1985; 1996; 1983) provides a model describing family structures in Europe. According to Todd, two dimensions are determinant in this description: (1) the dimension of *authority* of the father over his children vs. that of a *liberal* relationship, the former being traditionally evidenced by the cohabitation of three generations under the same roof, while the latter translates into the early departure of grown-up children form their father's home; (2) the dimension of *equality* among siblings vs. that of *inequality*, specifically at the time of heritage. The combination of the two possible values for each variable leads to four family models, each to be found in specific regions of Europe : (1) the authoritarian and unequal "*stock*" family model[24], (2) the liberal and non-equal "*absolute nuclear*" family model[25], (3) the liberal and egalitarian "*nuclear egalitarian*" family model[26] and (4) the authoritarian and egalitarian " *communitarian*" family model[27].

The importance of family models for the shaping of personal values has been recognised by Schein (1991):

> *"One of the models we bring to any new group situation is our own family model, the group with which we spent most of our early life. Thus, the rules that we learnt from our own parents for dealing with them and with our*

[24] "famille souche"
[25] "famille nucléaire absolue"
[26] "famille nucléaire égalitaire"
[27] "famille communautaire"

> *siblings are often the initial model we have for dealing with authority and peer relationships in a new group" (p.75)*

As an additional support of the validity of Todd's analytical framework, I have noted that the relevance of the values of liberty and authority is recognised in political science (Brooks, 2006), while that for equality vs. non-equality is accepted in the field of Human Resources Management of organisations (Schlesinger, 1983).

According to Todd, these family models, although their material translation has been blurred in recent decades due to the prevalence of an urban way of life, have had a structural influence on the intellectual and ideological development of Europe over the last five centuries: on the dissemination of literacy, on the adoption of the Reformation, on the de-christening process, and on the adoption of specific destructive ideologies (Nazism, Jacobinism, Communism, and even Victorian market liberalism, if I were to follow Davis (2000)). Indeed, by structuring the way people understand the world and relations among humans from a very early age, the family models have, according to Todd, a determinant influence on the ideologies and values present in each geographic area of Europe.

Todd's observations, based on the exploitation of massive demographic and historical data over Western Europe (the pre-2004 European Union, Switzerland and Norway) is that, in each region, a given family model prevails, with a remarkable historical stability. As an illustration, the Communitarian zone in Central Italy (the "Third Italy" concentrating most of its 'industrial districts') fits with the geographical extension of the Etruscan kingdom of the 7th to the 3rd centuries BC.

Family model	**Examples of geographical zones in Europe *and outside Europe***
"Stock" = authoritarian, unequal	Germany, Austria, German-speaking Switzerland, Alsace, Netherlands except Holland and Zealand, Belgium, Sweden, East of Norway, North-Eastern Italy Southern half of France, North of Spain Brittany, Wales, Western Scotland, Ireland Jews, Gypsies *Japan, Korea, French-speaking Canada*
"Absolute nuclear" = liberal and non-equal	England, Holland and Zealand, Denmark, South-West of Norway *United States of America, English-speaking Canada, New Zealand, Australia*
"Nuclear egalitarian" = liberal egalitarian	Greater Paris Basin, Provence and Languedoc (France) Centre and South of Spain and of Portugal, Northwest and South of Italy Poland
"Communitarian" = authoritarian egalitarian	"3rd Italy" (Emilia-Romagna, Umbria, Tuscany, Marches) Centre of Finland, Hungary Serbia, Russia *China, Arab world*

Table 4.4.3: Geographic location of family models in Europe, according to Todd (1996, 1998)

These family models were briefly cited by Storper (1993) in his analysis of the "regional worlds of production".

In the following sub-sections, I will present, for each of the family models, the mental and ideological frameworks related to it as described by Todd (1996), and add the connections that I have established with literature describing economic behaviour.

4.4.3.1 The 'stock' family model

For Todd, the authoritarian, unequal, 'stock' families are solid, conservative; they display robustness and cohesiveness. They are extremely efficient in the transmission and persistence of moral, cultural and religious values. The social hierarchical order, public discipline and solidarity are natural extensions in society of the same values in the family cell: "*the inequality of brothers becomes that of persons, peoples, social classes. The authority of the father becomes that of the State […] the submission of the sons is converted into a submission of humans to some overwhelming forces: the State, reason, language, blood, destiny*[28]" (Todd, 1996, p.309). 'Stock' families have the capacity of very powerful, efficient and disciplined collective action, in organisations where the aptitude for disciplined self-organising "*stems from the authority principle included into the 'stock' family*[29]" (p.318). Solidarity is restricted to the well-being of an homogeneous community, preferably at a smaller scale (city or region), bound by family, ethnic or cultural ties. Hierarchical order is deeply embedded in a society governed by the 'stock' family model. Two people chosen at random may always be ranked: father ahead of children and the only heir ahead of all other brothers (and of sisters).

Political thinkers, philosophers and social-economic theorists from regions where the 'stock' family model is prevalent, such as Germany, have produced material highly illustrative of the intellectual and moral framework related to it. Hegel (1963) is cited by Todd as having justified philosophically the hierarchical order of society into "positions" ("*Stände*").

I would add to Todd's observations that the importance of the transmission of moral values from one generation to the next in this cultural environment may be recognised in the writings of Schmoller (1893-1894), the major figure of Historical School of political economy that dominated the discipline in the second half of the nineteenth century Germany:

> *"every disposition of mind, every word, every idea, every conception [...] is the result […] of a social process. The greatest genius even thinks and feels as a member of the community; ninety per cent of what he possesses is a trust conveyed to him by forefathers, teachers, fellow-creatures, to be cherished and bequeathed to posterity." (chap.2)*

[28] "l'inégalité des frères devient l'inégalité des hommes, des peuples, des classes. L'autorité des pères devient l'autorité de l'État […] La soumission des fils est convertie en soumission des hommes à certaines forces les dépassant: l'État, la raison,la langue, le sang, le destin"
[29] "dérive du principe d'autorité inclus dans la famille souche"

> *"To be sure we also know how to appreciate the value of the institutions transmitted to us, we know that the sacred traditions of the past fill our mind with awe [...]. We admit that institutions must never disappear in form and substance, that nations can never create anything wholly new, but must always build on what exists [that we are] furnished with the inheritance of tried wisdom and justice, contained in traditional institutions." (chap.4)*

Along the same line of inspiration, the German economist List (1856) set the intellectual basis of the science- and skills-based economic growth model of Bismarckian Germany. He stressed the importance of the continuity of economic effort and of skills acquisition over generations, in a very stable social order, very typical of the 'stock' family model.

This economic thinking still is present in the industrial orientation of Germany, Switzerland, Sweden towards the manufacturing of specialised machinery, requiring deep and tacit skills, and in their economic fabric based on medium-sized, family-owned firms, the "*Mittelstand*".

4.4.3.2 The 'absolute nuclear' family model

"*The absolute nuclear family […] supports only one positive value, liberty […] it is* par excellence *the individualistic model* [30]" (Todd, 1996, p.455). The independence of the children towards their father, as soon as they have reached adulthood, is completed by an independence of the children towards one another: no principle, be it that of equality or of inequality, governs their mutual relations. It is the foundation of a pure liberal political order, with an absolute indifference to equality, and hostile to any intervention by the State.

As a complement to Todd's description, I have observed that Mill (1871) expressed the political and moral programme of the 'absolute nuclear' family with great clarity:

> *"[T]he sole end for which mankind are warranted, individually or collectively, in interfering with the liberty of action of any of their number, is self-protection. […] The only part of the conduct of any one, for which he is amenable to society, is that which concerns others. In the part which merely concerns himself, his independence is, of right, absolute. Over himself, over his own body and mind, the individual is sovereign"*

A further illustration of political and economic thought born in this intellectual environment is provided by Cooper (1826) "*Hence as a general proposition approaching to an universal truth, every man is the best judge of his own business*" (p.117).

The economic organisation related to this family model is that of self-organisation of economic agents, with the assumption that it leads spontaneously to the best overall outcomes by simple aggregation of individual actions, as Smith (1776) illustrates in his well-known text:

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[30] "La famille nucléaire absolue […] n'affirme qu'une seule valeur positive, la liberté[…] Elle est le modèle individualiste par excellence "

> *"He generally, indeed, neither intends to promote the public interest, nor knows how much he is promoting it. […H]e intends only his own security; and by directing that industry in such a manner as its produce may be of the greatest value, he intends only his own gain, and he is in this, as in many other cases, led by an invisible hand to promote an end which was no part of his intention".*

The economic model based upon the 'absolute nuclear' family is at the source of the British, Dutch and North American economic development, based on the fast exploitation and rapid relinquishing of economic opportunities, with a preference for commerce and finance rather than manufacturing. It provides also the underlying ideological support for contemporary dominant economic theories, unsurprisingly mainly developed in the United Kingdom and the United States of America.

4.4.3.3 The 'nuclear egalitarian' family model

Liberal and egalitarian, or "*nuclear egalitarian families […] hate authority* per se*, whatever its form*[31]" (Todd, 1996, p.265). The State, although it is "*affectively rejected, is technically necessary to defend the right to individual property*[32]" (p.266), which is considered as a fundamental human right in an idealised society of "*small, independent, free and equal producers*[33]" (p.269). Society therefore "*permanently oscillates between anarchistic dissolution and military reorganisation*[34]" (p.266). It also leads to an highly universalistic vision of society, in which all humans, whatever their origin, are invited to participate to citizenship, on an egalitarian basis. Its ideological product, the French Revolution, *"conceives itself immediately as universal […] born for the happiness of humankind*"[35] (p.303).

Rousseau (1762), cited by Todd, typifies the equalitarian and liberal political thought born and explicitly rooted in this family model.

In addition to Todd's writings, I would relate to this family model the social, economic and industrial organisation theorised by Saint-Simon (1841), for whom

> *"the direct goal is to improve as much as possible the fate of the class that has no other means of existence than the work of its arms; my goal is to improve the fate of this class not only in France, but in England, in Belgium, in Portugal, in Spain, in Italy, in the rest of Europe and in the whole world*[36]*" (Vol. 1, 2nd Part)*

The means proposed by Saint-Simon to reach this goal is that of a rationalist organisation of society, led by the arts, science and industry:

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[31] "la famille nucléaire égalitaire nourrit une haine de l'autorité en soi, et non de tel ou tel type d'autorité"
[32] "l'Etat, rejeté sur le plan affectif, est techniquement nécessaire à la défense du droit de propriété"
[33] "petits producteurs indépendants, libres et égaux entre eux"
[34] "oscillation permanente entre dissolution anarchisante et réorganisation militaire"
[35] "se pense immédiatement universelle […] née pour le bonheur de l'humanité"
[36] "le but direct […] est d'améliorer le plus possible le sort de la classe qui n'a point d'autre moyen d'existence que le travail de ses bras ; mon but est d'améliorer le sort de cette classe non seulement en France, mais en Angleterre, en Belgique, en Portugal, en Espagne, en Italie, dans le reste de l'Europe et dans le monde entier"

> *"Society will be organised for the progress of science and industry"*[37] *(L'Organisateur)*
>
> *"the most capable men [for government], since their works contribute most to social prosperity, are the artists, the scientists and the industrialists*[38]*" (Vol.39)*

The organisation inspired by Saint-Simon led to the universalistic, science- and industry-based, State-sponsored projects that fuelled the growth of the French "*Second Empire*", such as the railway network, the large water utilities, the universal banks, and the Suez canal (Picon, 1994; Coilly and Régnier, 2006) and, more recently, of the Gaullist "*Trente Glorieuses*" (Fourastié, 1979), in a form of State-sponsored technocratic capitalism or "*high-tech Colbertism*" (Cohen, 1992).

4.4.3.4 The 'communitarian' family model

"[T]he communitarian family produces [as a typical political ideology] communism, a simple, radically authoritarian and egalitarian ideology, supporting the submission to State power of equal individuals[39]" (Todd, 1996, p.414). In this family model, all humans are equal, but are considered as members of a group, rather than as independent individuals.

This family model being less represented in Western Europe than the others, its ideological description is less developed by Todd. However, apart from Communist, Leninist ideology of proletariat dictatorship, I have identified an original and specific political thought produced in regions where the 'communitarian' family model prevails. This thought is based on the very notion of 'community': a warm collection of people, affectively bound together, seeking mutual support and unity, under the protection of a paternalistic leader, whose legitimacy is based on the positive feelings that he generates.

This situation may be identified in the writings of an reactionary political thinker and legist, and an influential advisor to the Russian Czar Alexander III, Pobedonostsev (1965)

> *"In human souls there exists a force of moral gravity which draws them one to another […]. Without this force mankind would be as a heap of sand, without any bond, dispersed by every wind on every side. By this inherent force, without preparatory accord, are men united in society. It impels them out of the crowd of men to seek for leaders with whom to commune, whom to obey, and whose direction to seek. […]To live without power is impossible. After the need of communion the need of power is of all feelings most deeply rooted in the spiritual nature of man."*

[37] "La société sera organisée pour le progrès de la science et de l'industrie"
[38] "les hommes les plus capables, attendu que ce sont leurs travaux qui contribuent le plus à la prospérité sociale, sont les artistes, les savants et les industriels"
[39] "La famille communautaire produit […] le communisme, une idéologie simple, radicalement autoritaire et égalitaire, prônant la soumission à l'État d'individus égaux"

In Central Italy, and specifically in Florence (Tuscany), the affective component of social relations binding society together may be identified very early in the writings of political advisors and actors. Machiavelli (1992) recommends that "*it is necessary for a prince to have the people friendly*" (chap.9), and that "*a prince should guard himself, above all things, against being despised and hated*" (chap.16). For him, " *the best possible fortress is- not to be hated by the people. Although you may hold the fortresses, yet they will not save you if the people hate you*" (chap. 20). For Savonarole (1993), "*if [the tyrant] performs a good thing, he doesn't do it for good's sake, but to acquire renown and make friends*"[40] (Treaty 2, chap.2), and "*for all the honours and dignities that are distributed to citizens, [the tyrant] presents himself as their artisan […] to acquire renown and benevolence from the people*" [41] (Treaty 2, chap.3).

This family model has not developed a unified and coherent economic theory, but has led to some very well-documented and efficient practices and behaviours, that are at the root of the economic prosperity of the "industrial districts" of the "Third Italy" and of contemporary (and Ancient) China. These practices revolve around the notion of networking, of mutual social obligations and of personal reputation and trust.

In the 'Industrial districts' of the 'Third Italy', the typical economic organisation is that of a network of very small firms, engaged in a very dense web of mutual obligations, based on reciprocal trust, with no written trace of agreements, but with a very high price placed on personal reputation. As early as the 14th century, Savonarole already stated that "*citizens seek dignity and reputation in the city more than money*"[42] (Treaty 3, chap.1). Should a member of the district fail to honour his oral commitment, he would instantly lose his reputation of trustworthiness within the tightly knit community, and lose any further business opportunity. Each of the small firms is led by an undisputed owner and manager (the "*padrone*"), often employing his own family and relatives, in a typical authoritarian position. However, any employee is fully entitled to attempt setting up his own business, and to seek support from his former employer for this venture. This extensive spinning-out process leads to a highly egalitarian landscape of equally microscopic independent firms, each ideally exploiting its own specific market niche (Dei Ottati, 2002; Dei Ottati, 1994; Dei Ottati, 1991).

Guanxi, that can be translated as 'personal relationships', is qualified by Luo (1997) as "*one of the major dynamics in the Chinese society*" and is defined as follows:

> *"The Chinese word* Guanxi *refers to the concept of drawing on connections in order to secure favours in personal relations. It is an intricate and pervasive relational network […]. It contains implicit mutual obligation, assurance and understanding, and governs Chinese attitudes toward long-term social and business relationships" (p.43)*

Guanxi is "*reciprocal*", "*intangible*", "*utilitarian*" and "*personal*" (p.44). It may be cultivated beyond the "*determined*" relations of family. One of the main issues to

[40] "se pure ne fa qualcuna buona, non la fa per far bene, ma per acquistare fama e farsi amici"
[41] "E di tutti li onori e dignità, che si distribuiscono alli cittadini, lui se ne monstra autore, […] per acquistare fama e benivolenzia nel popolo"
[42] "li cittadini cercano piú tosto degnità e reputazione nella città, che danari"

establish and maintain a *Guanxi* network is that of nurturing one's reputation or "face" (*Mianzi*) as a trustworthy and reliable individual.

The reliance on personal, *Guanxi*-based, relations rather than on explicit contracts has led the Chinese to develop an organisational form that is

> *"neither market nor hierarchy and formal inter-organisation alliance […] In such a context, firm boundaries are blurred in that multiple network connections can be found, but direct ownership is rare. They engage in extensive networking activities based on* Guanxi *and informal agreements through a great deal of trust building and favour exchanging. Based on these efforts,* Guanxi *partners loosely structured networks on the basis of* Guanxi *to coordinate activities, pool resources, and pursue joint growth" (p.46)*

The source of the analogy of this organisational form with that of the 'industrial districts' of the Third Italy lies in that of the common, 'communitarian', family model underlying these economic and social organisations.

4.4.4 Construction of the four "collective polities"

At this stage, I propose to construct, on the basis of six of the seven of the 'polities' proposed by Boltanski and Thévenot (2006) and by Boltanski and Chiapello (2005; 1999), of four 'psychic functions' evidenced by Jung (1923), and of the four 'family models' evidenced by Todd (1996), a revised set of four 'polities' that still respect the rules of moral and political legitimacy proposed by Boltanski and Thévenot. I designate these first four polities as "collective polities", because their area of validity may encompass whole societies and justify fully developed social orders. The reason for this assertion is that, in each of these polities, the attribution of 'worth' to an individual respects the following rules: (1) it may be assessed by objective metrics, independently of the individual claiming the worth, and (2) the proportion of individuals with zero or negligible 'worth' remains small or marginal. These four 'collective polities' are: (1) the polity of "Tradition", (2) the polity of "Liberty", (3) the "Visionary" polity and (4) the "Communitarian" polity.

I will, in each of these four descriptions of polities, specify: (1) the common superior principle being sought by the members of the polity, and therefore the main danger against which the polity attempts to protect itself, (2) the metric of 'worth' in the polity and the features of the prominent people resulting from it, and the contribution to the 'common superior principle' that justifies their prominence, (3) the original name(s) of Boltanski and Thévenot's or Boltanski and Chiapello's 'polity' or 'polities' from which it is inspired, the Jungian 'psychic function' that dominates in the polity, and the 'family model' whose political and economic ideology matches with that of the 'polity', (4) a well-known character of the economic literature illustrating the polity, (5) the industrial 'world of production' (Salais and Storper, 1992) to which it relates, and (6) some relations of the polity with other disciplines of human and social sciences: (6a) the functions within a typical contemporary industrial organisation and the industries in which the values of the 'polity' are best represented, (6b) the most used and most legitimate mode of innovation in the 'polity', (6c) the personality disorder, as defined by the American Psychiatric Association (2000) that epitomises the behaviour prevalent in

the 'polity' and (6d) the typical expression of dissent, along the "*exit*, *voice and loyalty*" framework (Hirschman, 1970) to be expected in each 'polity'.

The striking coherence between the theories being mobilised in (3), (4), (5) and (6c) to describe each 'collective polity', despite the fact that they were developed fully independently from one another in widely different disciplines of human sciences (sociology, clinical psychology, demographics and economics), is a strong indication of the validity of the taxonomy that I propose.

4.4.4.1 Preserving the heritage: the polity of "Tradition"

In the polity of Tradition, the most important value, the common superior principle, is the preservation of what was received from the past, of heritage. The succession of previous generations is considered to have slowly and incrementally accumulated a highly valuable treasury of knowledge, practice, institutions, wisdom and skills. This treasury deserves being maintained, gradually and cautiously improved, and preserved from decadence, dissolution and social or political disorder, and to be transmitted further to later generations. 'Worth' in this polity is defined by the incorporation of this heritage, in the form of a long education, of skills, knowledge, craftsmanship and wisdom slowly acquired by a pupil under the direct tutorship of his/her master. This slow and respectful acquisition of past knowledge, and sometimes a family lineage drawing deep into the past, signal a respect for traditions, a desire to perpetuate them, and thus the prominent people in this polity. The main interaction among humans in this polity is along a vertical dimension of time, by maintaining a relation between generations (ancestors and descendants), with a preferential orientation towards the past.

This polity was originally designated as the 'domestic' polity by Boltanski and Thévenot (2006). The Jungian 'psychic function' best suited for a person to reach positions of high worth in this polity is that of Introvert Sensing. It is the polity related to the 'stock' family model, geographically predominant in Germany, German-speaking Switzerland, Sweden, the Southern half of France, the northern half of Spain, Japan and Korea, and in the Jewish people.

The values of this 'polity' for economic development were identified by List (1856):

> *"If we investigate the origin and progress of individual branches of industry we shall find that they have only gradually become possessed of improved methods of operation, machinery buildings, advantages in production, experiences, and skill […] A law of nature lies at the root of important achievements […] whose principle, namely, consists in the circumstance that several generations following one another have equally united their forces towards the attainment of one and the same object, and have participated in like manner in the exertions needed to attain it" (chap.24)*

The polity of Tradition is related to the 'Marshallian market world' described by Salais and Storper (1992), where firms base their prosperity "*on the basis of a reputation for quality*" (p.178) and on "*deep, customary secrets of fabrication*" (p.179). This is typically represented by traditional industries such as food processing, metallurgy, machine-building ("*Maschinenbau*").

In an industrial organisation, the people representing this polity are typically those in charge of operations, of maintaining the structure against the instabilities of the external threats or disruptions and against internal dissolution. They are most represented in Manufacturing, Accounting and Quality Assurance. The innovation mode typical for this polity is incremental, by patient and cautious, but endless and persistent, accumulation of small improvements over long periods of time.

The personality disorder (American Psychiatric Association. Task Force on DSM-IV, 2000) illustrating a caricature of this polity would be the obsessive-compulsive personality disorder, "*characterized by a chronic preoccupation with rules, [procedures], orderliness, and control*", and a desire for everything to be perfect.

In this polity, 'loyalty' is high, 'exit' (Hirschman, 1970) only happens very late, and only if deeply grounded. The person remains in the organisation with limited expression of 'voice' discontent, until the situation is fully unbearable. Then, s/he leaves to create a deeply different alternative, inaugurating a new and completely transformed lineage of tradition, an archetypal example of which being Martin Luther.

4.4.4.2 Pursuing opportunities: the polity of "Liberty"

In the polity of Liberty, the essential value is individual freedom, and specifically that of pursuing any (economic or business) opportunity that may arise. The outside world is considered as an limitless field of application of one's ingenuity, in which clever tactics and reactivity are the key to achieving short-term personal and material gain. The widespread belief in this polity is that the common good arises from the natural and spontaneous aggregation of uncoordinated and free individual actions, and that economic and social welfare is reached by letting every individual seek his/her own happiness independently from any other person. All efforts in this polity are made to avoid any form of rule or regulation, or any bind with other humans: these would be considered as unacceptable tools of servitude, and as essentially illegitimate restrictions to liberty. 'Worth' in this polity is demonstrated by a superior ability in exploiting the opportunities presented by life and trade: by monetary wealth. The contribution of prominent people of this polity, the rich and wealthy, to the common good contains both a non-specific and a specific part: as any member of the polity, by following their personal interest, they contribute to the general movement towards the fulfilment of one's personal goals; as rich people, they have a specific role of being a model for others to follow, an emulation target that drives the desires of those less wealthy towards the ambition of taking their chance. This polity is very immersed in the present, with relations to others that are as limited as possible, short, revertible, with no long-term commitment.

This polity was originally designated as the 'market' polity by Boltanski and Thévenot (2006). The Jungian psychic function best suited for a person to reach positions of high worth in this polity is that of Extravert Sensing. It is the polity related to the 'absolute nuclear' family model, geographically predominant in England, Holland, Zealand, Denmark, the United States of America, English-speaking Canada, Australia and New Zealand.

The values of this 'polity' are best represented by the classic economic figure of the *homo economicus* developed in the wake of Smith (1776).

The polity of Liberty is related to the 'industrial world' described by Salais and Storper (1992), where firms compete on price alone in fully commoditised and undifferentiated markets and where the key to success is the rapid exploitation of short-term opportunities, in industries such as consumer goods, trading, retail, and real estate.

In an industrial organisation, the people representing this polity are typically those in charge of seizing the short-term economic opportunities present in an immediately available market. They are most represented in Sales, in (operational) Marketing of existing products and services, and in all trading operations on liquid, commoditised assets (such as stocks, raw materials, currencies or interest rates). The innovation mode most prevalent in this polity mobilises powerful external financial resources (such as venture capital, but also borrowed funds) to seize short-term opportunities of any sort (scientific, technical, commercial, arbitrage possibilities, legal loop-holes, whatever…), with a preference for high-stake "winner-takes-all" situations of "first past the post", frontally competitive races.

The personality disorder (American Psychiatric Association. Task Force on DSM-IV, 2000) illustrating a caricature of this polity would be the paranoid personality disorder, "*characterized by extreme distrust and suspicion of others*" and for whom any relationship to others is a source of danger.

In this polity, as already observed by Hirschman (1970) early 'exit' and low 'loyalty' are the norm. The person will leave at the first sign of disagreement. S/he may very well create a direct clone of the organisation s/he left, or something very different: there is no rule. Within the organisation, as noticed by Hirschman himself, the expected behaviour is that of strong, even rigid discipline and of low 'voice' expression of dissent: the assumption is that if people are unhappy, then they may (and should) just as well leave.

4.4.4.3 Planning universal justice and efficiency: the "Visionary" polity

In the Visionary polity, the belief is that social happiness lies in a future of universal justice and technical efficiency. This future, improved, state of the world can and should be defined beforehand, in a grand, universalistic and rational design, the primary concern of which is not the connection to the existing state of things, but internal coherence and logic. It should be reached by the methodical and systematic implementation of an abstract, objective, rational, large-scale and long-term transformation and improvement plan. The universal justice being sought is based upon the assumption that all humans are equal; the distribution of rights, if it needed at all to be differentiated, should be done along impersonal, objective metrics. Efficiency may, in this polity, be assessed according to purely technical or scientific artefacts. Discretionary favours and personal relations are considered as unfair, arbitrary and a source of disorder and chaos. 'Worth' is measured by the successful completion of uniform, fully standardised and anonymous competitive examinations ("*concours*") that measure objectively abstract, theoretical knowledge, and by the (temporal and spatial) scope of the transformation project being worked upon. A proxy for the latter generally is the size of the organisation: the larger the organisation, the greater the worth, the ultimate being the State (or larger) government. Prominent people in this polity tend to be rational designers and planners, civil servants and engineers that define the target and design the path to reach it. Their contribution to the common good is that of anticipating

evolutions, of designing clear, logical and objective systems that transform the world towards the expected intention of greater justice and improved efficiency. In this polity, the relation to time is that of a projection towards the future. The relation to others is highly abstract and dematerialised.

This polity was originally designated as the 'civic' and the 'industrial' polities by Boltanski and Thévenot (2006): being French, they have tended to overstate the minor differences between two means to essentially reach the same goal of universal justice and efficiency. The Jungian psychic function best suited for a person to reach positions of high worth in this polity is that of Introvert Intuition. It is the polity related to the 'nuclear egalitarian' family model, geographically predominant in the Northern half of France, the Southern half of Spain, North-Western and Southern Italy.

The values of this 'polity' are best represented by the classic economic figure of Schumpeter's (1934) entrepreneur, in his

> *"foresight, the capacity to see things in a way that experience will later confirm, even if at that moment one is not able to justify it, even if it does not grasp the essential and not at all the secondary, even and specifically if one has no consciousness of the principles according to which one acts" (p.122)*

and his

> *"capacity to move ahead alone, not to feel insecurity and resistance as contrary arguments" (p.126).*

The Visionary polity is related to the 'world of innovation' described by Salais and Storper (1992), where "*the market […] is not yet established*" (p.179) and must therefore be fully anticipated with no previous experience to rely upon, and where the main knowledge assets being mobilised are "*theories, concepts, and methods which are formal and generalisable*" (p.179).

The industries where this polity is well represented are those where long-term planning and technical anticipation are determinant, such as aerospace, nuclear energy, and defence. In an industrial organisation, the people representing this polity are typically those in charge of anticipating evolutions and of designing products and services that don't yet exist. They are most represented in New Product Development, in strategic Marketing and in strategic Planning. The innovation mode best connected to this polity is that of large-scale, long-term technocratic plans, often supported by the State as the chief co-ordinator of heterogeneous organisations and interests.

The personality disorder (American Psychiatric Association. Task Force on DSM-IV, 2000) illustrating a caricature of this polity would be the generalized anxiety disorder, a "*pattern of frequent, constant worry and anxiety over many different activities and events*", in a need to permanently anticipate a threatening future.

In this polity, dissent is expressed by permanent 'voice' and limited 'exit' (Hirschman, 1970). Since all humans are considered as sharing a faculty for reason, every member of the group feels entitled to express his/her opinion, often a permanent discontent, and has

minimal respect for hierarchy, orders or personal authority. Thus, 'loyalty' is intrinsically low. However, since all humans are considered as belonging fundamentally to the same community, there is no point in 'exit', as it would entail finding the same situation elsewhere.

4.4.4.4 Building a supportive community: the "Communitarian" polity

In the Communitarian polity, the main issue is to preserve the cohesion and the harmony of the community. This community is nurturing, protective, and provides shelter and support for its members. Each member is known individually and personally by the other members of the community, in an warm, affective relationship.

The very substance of the community is this network of inter-personal, trustful relations. If the set of personal relations that constitute the community disappears or vanishes, then the community collapses. Therefore, great efforts are made to maintain the affective links between people. A second consequence is that 'worth' in this polity is measured by the number of personal and trustful relations, with people that have themselves a high reputation and great fame. The prominent people in the polity are the attractors around which the community coalesces, and without which the community would be dispersed or wrought by discord, division and internal conflicts. The relation to others is personal and horizontal, with people living here and now, in the present, with whom direct, personal contact is possible.

At an individual level, the maintenance of good personal relations to members of the community may be vital: if no personal link to at least one member of the community exists, then the person is lost and may expect no help; since every person is considered individually according to the number and quality of his/her relations, then no objective justice may be expected.

This polity was originally designated as the polity of 'fame' by Boltanski and Thévenot (2006) and as the 'projects-driven' polity by Boltanski and Chiapello (1999). The Jungian psychic function best suited for a person to reach positions of high worth in this polity is that of Extravert Feeling. It is the polity related to the 'communitarian' family model, geographically predominant in Central Italy, Hungary, Finland, Russia and China.

The values of this 'polity' are best displayed in the now well-known economic figure of the "industrial district" (Dei Ottati, 2002; Dei Ottati, 1994; Becattini, 1987), and in the Chinese concept of *Guanxi*, emergent in management literature (Luo, 1997; Buttery and Wong, 1999; Leung et al., 2005).

The Communitarian polity is related to the 'network market world' described by Salais and Storper (1992), where the economic fabric is made of a multiplicity of small firms strongly linked by subcontracting relations.

The industries where this polity is well represented are those in which this network of small, flexible firms are efficient at exploiting all niches offered by a highly segmented (and even fragmented) market, such as fashion and decoration or specialised machinery. In an industrial organisation, the people representing this polity are typically those in charge of nurturing long-term human relations. They are most represented in Human

Resources Management and in the maintenance of long-term commercial links. The mode of innovation in this polity is that of proliferating exploration of market diversity, preferentially by multiple spin-outs, each exploiting its own micro-market with minimal (but real) differentiation from competitors.

The personality disorder (American Psychiatric Association. Task Force on DSM-IV, 2000) illustrating a caricature of this polity would be the histrionic personality disorder, in which "*a person acts very emotionally and dramatically in order to get attention*" because s/he ultimately relies excessively on the opinion of others to support his/her self-image.

In this polity, dissent is expressed by infrequent 'voice', in a framework of very strong 'loyalty' (Hirschman, 1970). Indeed, breaching the personal ties that build the very fabric of the community is the worst that may happen to a person. Therefore, leaving is unthinkable and people remain in the organisation. In normal times, there is little room for protest, but strong 'voice' expression of concerns in times of crisis is legitimate (Dei Ottati, 2003).

Revised name of the 'polity'	**Tradition**	**Liberty**	**Visionary**	**Communitarian**
Initial name of the 'polity' (Boltanski Thévenot, 2006)	Domestic	Market	Industrial, Civic	Fame, Projects-driven (Chiapello, 2005)
Psychic function (Jung, 1923)	Introvert Sensing	Extravert Sensing	Introvert Intuition	Extravert Feeling
Family model (Todd, 1996)	"Stock" = authoritarian, unequal	"Absolute nuclear" = liberal, non-equal	"Nuclear egalitarian" = liberal, egalitarian	"Communitarian" = authoritarian, egalitarian
Common superior principle	Perpetuation and incremental improvement of the heritage accumulated by generations	Individual liberty and material welfare	Design and construction of universal justice and of technical efficiency	Cohesion of the group
Danger against which protection is sought	Decadence and dissolution	Servitude	Arbitrary	Dispersion and discord
Objective metric of 'worth'	Education, skills, experience, wisdom	Monetary wealth	Success in competitive examination, size of organisation	Number and reputation of people in the personal network
Contribution of prominent people to the common superior principle	Shrines for and perpetuators of a fragile and valuable treasury from the past	Emulation targets and models led by the "*invisible hand*"	Efficiency and coherence of the design, Appropriateness of the anticipation	Poles of attraction around which the group coalesces
Classic figure of economics	Generations of craftsmen (List, 1856)	*Homo Economicus* (Smith, 1776)	Schumpeterian (1934) entrepreneur	Industrial district (Becattini, 1987)
Industrial world of production (Salais and Storper, 1992)	Marshallian market world	Industrial market world	World of Innovation	Network market world
Typical industries	Food processing, Metallurgy, Machine-building	Consumer goods, Trading, Retail, Real estate, Finance	Aerospace, Nuclear, Defence	High-diversity (fashion, decoration)
Organisational functions	Manufacturing, Accounting, Quality Assurance	Short-term sales, operational Marketing, commodity trading	New Product Development, Strategic planning, long-term investment	Human Resources, Long-term commercial relations
Innovation mode	Incremental in the same organisation	Disruptive, seeking opportunities, mobilising external capital	Planned, technocratic, State-supported, large-scale	High variety, colonisation of market by spin-offs
Personality disorder (APA DSM-IV, 2000)	obsessive-compulsive	paranoid	generalised anxiety	histrionic
Expression of dissent (Hirschman, 1970)	Late exit, strong loyalty, limited voice	Early exit, no loyalty, no voice	Permanent voice, limited loyalty, limited exit	Strong loyalty, no exit, infrequent voice

Table 4.4.4: the four collective polities, their relations to family models and psychic functions and to other phenomena in the human and social sciences

4.4.5 Construction of the four "individual polities"

In contrast to the four 'collective polities' described above, I will describe the four next polities as "individual polities". Indeed, they cannot build social orders by themselves. They may however nurture the minority vocation of individuals in a society, or support the existence of homogeneous groups that live in separation. The reason for this assertion is that, in each of these polities, the attribution of 'worth' to an individual either: (1) may not be assessed by objective metrics, independently of the individual claiming the worth, or (2) the proportion of individuals with zero or negligible 'worth' would be predominant. They are built upon the four remaining Jungian 'psychic functions' and upon one remaining 'polity' by Boltanski and Thévenot, but do not relate to any of Todd's 'family models'. These four individual polities are: (1) the "moral" polity, (2) the " creative and innovative" polity, (3) the "management and military " polity and (4) the polity of "science and academia".

I will follow the same descriptive pattern as above, adding the homogeneous community being constructed around the exclusive pursuit of the 'common superior principle' of the 'polity'.

4.4.5.1 Setting examples for higher ends: the "Moral" polity

In the "Moral" polity, the common superior principle is a set of moral values. These moral values generally have a source external to immediate perception by the senses and to society. They are considered as eternal, absolute and divine (in those societies where divinity is present). They do not need to be supported or justified by either experience, knowledge or by general agreement: they are an object of immediate, intimate and internal perception by the person sensitive to them. Their value for society is considered as being intrinsic: heeding them is good *per se*, is the very definition of what "being good" means. Prominent people in this polity are those whose relation to the source of moral values is of higher quality and purity, that are a reference by their behaviour and discourse, but this is extremely difficult to assess objectively. Their contribution to society lies in being an example, a source of teaching and an exhortation. They prevent society from falling into gross materialism and into neglect for the weaker and voiceless beings.

This polity was originally designated as one aspect of the 'inspired' polity by Boltanski and Thévenot (2006). The Jungian psychic function best suited for a person to reach positions of high worth in this polity is that of Introvert Feeling.

This polity is that of generally lonely people, that set moral examples for their fellow citizens. The homogeneous and closed communities built around this polity typically are religious (e.g. monasteries).

4.4.5.2 Guiding humans towards permanent novelty: the "Creative and Innovative" polity

In the "Creative and Innovative" polity, the common superior principle is that of novelty, of innovation *per se*. Things are good because they are new, and *déjà vu* is the worst that may happen. The belief is that permanent renewal of the existing is a condition for life itself, and that repetition is akin to sterility and death. Prominent people in this polity are the innovators, the trend-setters, the pioneers, the creators of the

yet unseen and unheard of, those at the permanent frontier of newness, the first to do or think something and who will later be followed by the herd. They protect society against routine and sclerosis. Defining an objective metric for this creative and innovative capacity is extremely uneasy, since being the first to do something is not a sufficient criterion: the issue is to be followed, with a key uncertainty as to when and to what extent this will happen, if at all.

This polity was originally designated as the second aspect of the 'inspired' polity by Boltanski and Thévenot (2006). The Jungian psychic function best suited for a person to reach positions of high worth in this polity is that of Extravert Intuition.

This polity is present in the rather closed *milieux* of fashion, contemporary arts, the creation of marketing concepts, of advertising, of industrial design and architecture.

4.4.5.3 Taking responsibility for decisions: the "Management and Military" polity

In the " Management and Military" polity, the common superior principle is that of taking timely decisions, specifically when complex and sensitive issues are at stake, and of bearing the responsibility for them. In this polity, the most important is that a decision be taken, on time required by the situation, even if it is not the optimal one. It relates to a specific form of courage and firmness, a capacity to "cut the Gordian knot". Prominent people in this polity are the courageous and large-scale decision-makers, specifically in times of crisis, that protect society against procrastination and indecisiveness. 'Worth' in this polity is measured by the size of the organisation, the number of people, the material means and budget being commanded. It may only be accessed by the relatively few in commanding positions: for all other humans that command little more than themselves, it is unreachable.

This polity was not identified by Boltanski and Thévenot (2006). The Jungian psychic function best suited for a person to reach positions of high worth in this polity is that of Extravert Thinking.

This polity is well represented in the decision-making positions in firms and organisations. The homogeneous and closed community built around this polity is the armed forces.

4.4.5.4 Discovering truth: the polity of "Science and Academia"

In the polity of "Science and Academia", the common superior principle is that of truth and knowledge, with minimal consideration for human acceptability. The aim being pursued is to improve, deepen, refine and broaden the explanation and interpretation of phenomena, the fit between description, prediction and observation. Prominent people in this polity are those who provide the deepest, the broadest, the most integrative, the most accurate and the most objective description or prediction. They protect society against ignorance and prejudice. 'Worth' in this polity is measured by proxies for the importance and relevance of the contribution to knowledge, such as the number of citations of scientific publication, and the time during which these citations are made.

This polity was not identified by Boltanski and Thévenot (2006). The Jungian psychic function best suited for a person to reach positions of high worth in this polity is that of Introvert Thinking.

This polity dominates the rather separate and homogeneous academic community.

Revised name of the "polity"	**Moral**	**Creative & Innovative**	**Management & Military**	**Science & Academia**
Psychic function (Jung, 1923)	Introvert Feeling	Extravert Intuition	Extravert Thinking	Introvert Thinking
Initial name of the "polity" (Boltanski and Thévenot, 2006)	Inspired	Inspired	(inexistent)	(inexistent)
Common superior principle	Absolute moral values, higher ends	Perpetual renewal	Appropriate and timely decisions	Truth, Knowledge
Danger against which protection is sought	Materialism	Repetition, routine, sclerosis, sterility	Indecisiveness, disorder, procrastination	Ignorance and prejudice
Objective metric of 'worth'	(none)	(none)	Number of people / resources and budget being commanded	Number, quality and duration of citations
Synthetic description of prominent people	Moral references	Innovators, creators, pioneers, trend-setters	Managers, leaders, commanders	Discoverers, experts, erudites
Contribution of prominent people to the common superior principle	Dissemination and exemplification of moral guidance	Opening the path to novelty	Organising and taking responsibility for collective action	Creation of knowledge
Closed communities built around the values of the 'polity'	Monasteries	Creative *milieux* of fashion, design, arts, architecture	Military	Academia

Table 4.4.5: the four individual "polities" and their related psychic functions

4.4.6 Conflicting 'polities' and 'world views' at various scales of social groups

I have in the last two sections systematically developed a set of 'polities', and claimed that each 'polity' may be related to a 'world view' (§ 4.4.1).

It could appear that the 'world view' relevant for a person be strictly defined by the 'polity' prevalent in his/her social environment, in which s/he was attracted, selected, retained and promoted (as per the ASA(P) process described above § 2.2.1). However, the situation is not as simple, since the 'polities' present at each scale of social groups may conflict with one another.

At a first level of analysis, I would identify five nested scales of social groups, that may each belong to a different 'polity': (1) the individual, (2) the working group, (3) the organisation, (4) the industry, and (5) the region.

These scales may be coherent, and refer only to one 'polity': a person with a preference for Introvert Sensing, working as a Quality Assurance manager in a mid-sized family-owned ("*Mittelstand*") metal-processing firm in Germany would live in a fully coherent environment dedicated to the 'polity' of Tradition, while a person with a preference for Extravert Sensing working as a trader in a brokerage firm in Wall Street would on the opposite be fully embedded in the 'polity' of Liberty. On the other hand, a person with a preference for Extravert Thinking working as a Strategic Partnerships manager of a nimble SME in the Defence sector in Southern France would be susceptible to participate in five different and potentially conflicting 'polities', respectively Management & Military (at the scale of the individual), Communitarian (in his/her working group), Liberty (in the person's organisation), Visionary (at the scale of the industry) and Tradition (at regional level). Therefore, the 'polity', or the 'world-view', that is relevant for a given person is not immediately evident to determine, because the scale of the social group of reference plays a role, that may be determinant. I have attempted to take this into consideration in the design of my survey, as I will describe later on (chap. 5).

4.4.7 Conclusion

At the end of this section, I have shown that 'world views' may be classified along a small set of possible 'polities': four 'collective polities' (Tradition, Liberty, Visionary, Communitarian) and four 'individual' ones (Moral, Creative & Innovative, Management & Military, Science & Academia). I have mobilised to this end the convergent results of independent theoretical and empirical works in economic sociology (Boltanski and Thévenot, 2006; Boltanski and Chiapello, 2005), analytical psychology (Jung, 1923) and historical anthropology (Todd, 1996). These 'world views' build coherent cultural 'paradigms', as called for by Schein (1991, p.109), and cover a very broad range of the possible 'world-views' discussed by earlier literature.

I have additionally justified that this typology satisfies the criteria I had set initially of balance, general applicability, simplicity and closure. All 'polities' are equally valid, morally sustainable and intellectually developed. The model applies across Europe, North America and East Asia. It contains eight types only, and also the justification why

the number of 'polities', based upon the number of 'psychic functions' will not in the future exceed eight.

I therefore use this theoretical construction in the survey that I use for my research, as described further hereafter (§ 4.5).

The main limitation that I may identify for this section is that it relates to European (with its extensions to North America and Oceania) and East Asian cultural settings. It would thus benefit from a broader descriptive framework or from more detailed information, able to include Southern and Southeast Asia, the Muslim world, Africa and Latin America. Another limitation is that I inescapably am embedded in a national and professional culture, and have a specific Jungian type: despite my attempts to account for cultures I am not familiar with and for psychic functions that I master less well (and are deeper in my unconscious), the descriptions of the related 'polities' would most probably benefit from being written by a broader set of authors, to whom the various 'common superior principles' of these eight 'polities' be more familiar.

4.5 Parsimonious description of organisational 'world views' for a research on innovation

Having established a general model of organisational 'world views' in the preceding section (§ 4.4), I need to adapt it to the requirements of my research on innovation. Indeed, the model contains eight possible 'polities', of which many appear as potentially irrelevant for organisations involved in innovation based on science and technology.

4.5.1 Adaptation of the existing survey on organisational 'character'

In order to do so, I have first relied upon the survey developed by Bridges (2000) to determine the full 'character' of an organisation (i.e. the transposition at collective scale of the Jungian 'psychological type' defined for the individual, and that is generally evidenced using the MBTI questionnaire). The issue in fully re-using Bridges' survey is that it investigates all 4 dimensions of the model, in order to determine the full 'character' among 16 possibilities. Since each dimension justifies the administration of nine questionnaire items in Bridges' work, this would have led to a large number of items, many of which could be irrelevant to a research on organisations active in technical and scientific innovation.

I have therefore chosen to restrict myself to evidencing the preference for those 'psychic functions' that are most relevant for innovative technical and scientific activities, and that relate to the 'world views' of specific actors in the innovation chain. These psychic functions are: (1) Extravert Intuition, which is related to the 'Creative & Innovative' polity (§ 4.4.5.2) and to the permanent exploration of novelty necessary at the early stage of innovation and of the generation of ideas, (2) Introvert Intuition, which is related to the 'Visionary' polity (§ 4.4.4.3) and to the figure of the Schumpeterian entrepreneur that transforms the initial idea into a detailed project, (3) Extravert Sensing, which is related to the polity of 'Liberty' (§ 4.4.4.2), to the seizing of opportunities and to the capacity to overcome short-term challenges to reach the concrete goal of bringing a working innovative product to real customers, and (4) Introvert Sensing, which is related to the polity of 'Tradition' (§ 4.4.4.1), and to the industrialisation and stabilisation of the innovation.

In a scientific environment, the psychic function of Extravert Intuition often is present simultaneously among the 'preferred' functions with Introvert Thinking, which is related to the polity of 'Science & Academia' (§ 4.4.5.4), in the INTP type typical of the scientific researcher. This consideration reinforces the relevance of investigating the presence of Extravert Intuition, if indeed the polity of 'Science & Academia' cannot directly be observed.

Identifying the presence, among the two psychic functions being 'preferred', of those listed above restricts the investigation to two dimensions only of the organisational 'character' (instead of four):

- the "*Mode of perception*", that contrasts between Intuition (conventionally noted with the letter N for iNtuition) and Sensing (conventionally noted with the letter S): "*Is the organisation primarily focused on the present, the details and the actuality of the situation [sensing] or the future, the big picture and the possibilities inherent in situations [intuition]?*" (Bridges, 2000, p.2)
- the "*Behaviour in the outside world*", that contrasts between the J and P polarities: "*Organisations in which J[...] predominates prefer to reach firm decisions, define things clearly, and get closure on issues. Organisations in which P[...] predominates are always seeking more input, preferring to leave things loose, or opting to keep their choices open*" (Bridges, 2000, p.2).

The exact meaning of the letters J and P in the dimension of 'Behaviour in the outside world' is rather technical in nature, and hinders more than helps the understanding of each polarity. This is why I have not made it more explicit here.

The association between the two dimensions above and the underlying 'world views' is provided in the Table 4.5.1 below.

	'**Sensing**' polarity of the dimension 'Mode of perception'	'**Intuition**' polarity of the dimension 'Mode of perception'
'**J**' polarity of the dimension 'Behaviour in the outside world'	***Exploitation*** *polity*: 'Tradition' *psychic function*: 'Introvert Sensing'	 *polity*: 'Visionary' *psychic function*: 'Introvert Intuition'
'**P**' polarity of the dimension 'Behaviour in the outside world'	*polity*: 'Liberty' *psychic function*: 'Extravert Sensing'	*polity*: 'Creative & Innovative' *psychic function*: 'Extravert Intuition' ***Exploration***

Table 4.5.1: Association between (1) the polarities of the two retained dimensions of the organisational 'character' and (2) the 'polities' and psychic functions relevant for scientific & technical innovation, with materialisation of the diagonal "Exploitation - Exploration" axis

The 'Introvert Sensing' psychic function, and the related 'polity' of 'Tradition' may be associated to the "*Exploitation*" mode of innovation (March, 1991), while the 'Extravert

Intuition' psychic function, and the related Creative & Innovative 'polity' may be associated to "*Exploration*". I have materialised this axis diagonally on the Table 4.5.1.

Considering the benefit in parsimony of this restriction, and the fact that this restriction still covers the 'world views' most relevant for scientific and technical innovation, I have concentrated the investigation in my research on these two dimensions only of the full model of organisational 'character'.

4.5.2 Creation of items exploring the dimensions of 'family models'

The second path that I followed to describe organisational 'world views' parsimoniously was to concentrate on the four 'collective' polities that I have identified above (§ 4.4.4), and more precisely on their description as 'family models'. I considered this as specifically relevant for an international study, covering European regions in which various 'family models' are present.

I have therefore developed a specific set of survey items, aiming at identifying preferences along two dimensions of organisational values: (1) liberty vs. authority and (2) equality vs. inequality.

I have reached the end of the theoretical part of my thesis. I have exposed and justified the two main theoretical concepts that will use: organisational capabilities and 'world views'. I am thus in a position to proceed to Part 2 of my research, the empirical study.

Part 2: Empirical study

The empirical study is the core of my doctoral research, to which I can proceed now that I have completed the preliminary theoretical work of Part 1.

In a very standard fashion, I will first expose and justify my research **methodology**. The justification will both be theoretical, by stating my epistemological position, and by reference to earlier work on the operationalisation of organisational cultures. I will then present my variables of interest, the survey itself, my data collection and exploitation methods (chap. 5).

Having presented my methods, I will expose the empirical **results** of my work, namely the regression models with which I attempt to predict various potential outcomes of co-operative R&D projects, using as explanatory variables: (1) control variables from previous literature and (2) organisational capabilities and 'world views' that I introduce in my research. The outcomes are considered at project level, when they involve both partners symmetrically, and at organisational level, when partners have asymmetrical roles. For each outcome, I provide three models, in order to compare the effects of the control variables and of those introduced by my research (chap. 6).

Finally, I will **interpret** these empirical results. On the one hand, I will underline that very little of previous research is confirmed by my study. On the other hand, I will attempt to provide qualitative explanations for the statistically significant effects that I evidence in my research (chap. 7).

5 Methodology

Before I present my results in the next chapter, a necessary preliminary step is to explain how I obtained them, with what method, and why I chose this method rather than any of the others available to researchers in economic and social sciences. This is the purpose of the present chapter.

I will first expose my epistemological position, in order to clarify where I tallk from (§ 5.1). I will then remind the results of an earlier Systematic Review of literature that I performed (Zibell, 2007) on the tools to measure collective competencies of organisations (§ 5.2), and conclude on the ideas and concepts that may be retained from earlier literature for the further design of my research instrument. I will then justify my methodological choices, in coherence with my epistemological position (§ 5.3), specify and justify the focus of my observation (§5.4) and the variables that I believe are of interest in my research (§ 5.5), and that I have collected. I will expose in a sixth section (§ 5.6) my data collection tools, and justify the items of my on-line survey. I will finally (§ 5.7) outline the computer-based tools and methods that I used for the quantitative treatment of my data.

5.1 View of knowable reality and purpose of scientific activity

My epistemological position may be connected to the one developed by Latour (1999). For me, the purpose of science is to develop mental representations - that I call 'models' – that describe and predict the evolution of entities observable by human senses or by instruments – that I call 'phenomena' (Kant, 1934). The nature of the phenomena considered as being relevant for investigation, and the level of accuracy deemed 'satisficing' (Simon, 1979), with which descriptions and predictions should be made, are subject to permanent and public debate, specifically according to the engineering that humans are engaged in. Engineering, be it social or physical, is the activity of purposely designing and constructing artefacts aimed at performing pre-defined functions deemed (socially or individually) desirable. The functions are the set of desired phenomena that the engineered artefact is intended to generate.

The models generated by scientific activity have no claim to "absolute" truth. They follow an history of punctuated equilibria, in which temporarily stable "*paradigms*" (Kuhn, 1962) are permanently challenged by potentially "*falsifying*" experiments (Popper, 1963).

Going into greater detail, my position originally follows that of Kant (1934)

> *we can have no cognition of an object, as a thing in itself, but only as an object of sensible intuition, that is, as phenomenon* (preface to the 2nd edition -1787).

To me, the only objects that are accessible to human knowledge are phenomena, i.e. sensations that appear to our senses or to our instruments. It is impossible, and therefore fruitless to attempt, to know the "underlying reality" of "things in themselves". I therefore significantly differ from plain "positivism".

Following partly Latour (1999), I believe that these phenomena are not mere illusions either. They are the entities we as humans are related to, those that have an interaction with us, and that can benefit or harm us. Besides, it happens, although there may be no ultimate explanation for this, that these phenomena are reasonably consistent over time, and that they present regularities. There is no convincing reason to me of why these regularities happen in our perceptions, but my subjective experience so far is that they do, and the inference that an already observed phenomenon will indeed happen again if placed in the same circumstances seems to hold reasonably well. To me, the purpose of scientific activity is that of discovering operational relations between phenomena, of being able to predict these phenomena, and of being able to use these relationships in engineering activities.

To that end, humans have developed a set of mental representations of phenomena and of their mutual relationships. I refer to these mental representations as "models", in a very generic sense. These models contain a list of phenomena that deserve attention (the ontology of the model), and of the relationships between these phenomena, that allow to anticipate or predict the appearance of new ones. It happens, although I have not yet encountered any convincing explanation for this apparent serendipity, that mathematical concepts are good tools to connect phenomena with one another. This happens although mathematics may be considered as a sort of "poetics of the logical mind", mainly concerned with self-consistency, and rarely have this ambition of describing or connecting external phenomena to one another. Therefore, mathematical models are very privileged means to describe and predict phenomena, but there is no intrinsic reason for this mathematical form to be universal.

I make no assumption about the ultimate "reality" of any of the phenomena involved: all that is required is that a consistent, repeatable and 'falsifiable' (Popper, 1963) procedure or instrument exists and permits the assessment of existence and the qualification of the phenomenon.

As an illustration, "mass" or "electrical charge" are phenomena of physics, but the "*mana*" of a Melanesian artefact, provided it is observed in a consistent and open fashion, would also qualify as a phenomenon of anthropology. The mass of an object is manifested by its resistance to change in its quantity of movement, the electrical charge by attraction – repulsion forces inversely proportional to the square of distance, and (as far as I understand the concept), the "*mana*" by the awe and sometimes terror that the artefact may induce in people of the relevant cultural environment.

The notions of "instrument" and "measure" do not preclude any concrete shape or operational mode. The qualification of the phenomenon does not need to translate into accurate quantitative figures for the instrument to be valid: a mere detection of the phenomenon, its rating in crude orders of magnitude may be sufficient for the needs of further investigation, modelling and engineering, and may thus be considered as fully satisfactory. The only requirements are functional: the instrument should provide repeatable, consistent, transmittable results. As such, an instrument may very well be located in the highly personal feelings of an observer, provided these features of repeatability, consistence and transmittability are present.

The existence of phenomena is not a closed issue of things being "self-evident", or "natural". The existence of a given phenomenon is the subject of debate and progressive consensus-building. This debate centres around the means to measure the phenomenon, the instruments to do so and about the importance of the phenomenon for the stakeholders of the science being considered. New considerations, politically (or otherwise) suppressed observations are permanently invited to be included in the field of studied phenomena, in the "*collective*" as defined by Latour (2004), provided they satisfy the formal requirements of being observable with "instruments" as defined above.

In parallel, a debate is underway on the theory correlative to this purported phenomenon, about its generalisability, conceptual parsimony and explanatory power. The procedures of this debate are that the predictions of the model are tested and tentatively refuted by dedicated experiments correlating the phenomena being observed and those that had been predicted by the model, following the general framework described by Popper (1963). This debate exists in all sciences, natural or social, and along the same lines. In my opinion, the goal of these debates is ultimately to stabilise, at least temporarily, in a consensual 'paradigm' (Kuhn, 1962).

The models derived from scientific activity and research cannot legitimately claim to be (absolute) "truth". They only are mental representations that account well for the already known observed phenomena, that predict them well. Sometimes this prevision capability reaches amazing levels of accuracy, specifically in physics and optics[43]. They may be used operationally, in engineering work that use these models to design and construct physical or social artefacts following human and political intentions. The levels of accuracy that are deemed satisfactory for the scientific and technical models are not "absolute" either, nor do they continue endlessly towards ever higher precision. They are social (and economic) in nature, and depend upon the precision and reliability requirements placed upon these engineering works by society as a whole: investigations on the fatigue of materials were historically pressed by the safety requirements of civil air transport and nuclear energy, while the knowledge in the field had been considered sufficient before these applications arose.

These models only have provisional validity, until a better, more accurate, more general and encompassing model appears that supersedes the earlier one, in a scientific "*revolution*" (Kuhn, 1962). Several models often survive in parallel, as Newtonian mechanics survive in the low-speed realm, because of its simplicity and remarkable accuracy, alongside relativist mechanics that is the only one able to account for phenomena happening at speeds comparable to that of light.

The process of research is that of the emergence, modification, progressive stabilisation and further upheaval of scientific models. They are in a perpetual openness to further debate upon the inclusion of new, unforeseen phenomena, in the living parts of science. In the fields where the existing models predict phenomena in a way that is deemed acceptable and satisficing for their practical usage (specifically in engineering), a form of stabilisation takes place. This process of scientific research as a social process of

[43] where the speed of light for example is known with 9 significant figures at 299 792 458 m/s.

generation and selection of satisficing models, of permanent empirical validation and constructive critique is described by Latour (1999).

5.2 Existing research on the operationalisation of organisational capabilities

I performed earlier a Systematic Review of the literature on the existing methods to measure organisational capabilities (Zibell, 2007), reproduced in Appendix A. I reviewed upon this occasion 919 references generated by keyword search in databases of academic journals, of which I extracted 58 relevant papers, following examination of their title and abstract. From these 58 relevant articles, I retained after a quality assessment, and thoroughly examined, 33 relevant and high-quality articles.

The main findings of this Systematic Review are the following.

First, the subject is very **emergent**, with a very small number of articles, growing fast over the last three decades, as illustrated in the Figure 5.2.1 below.

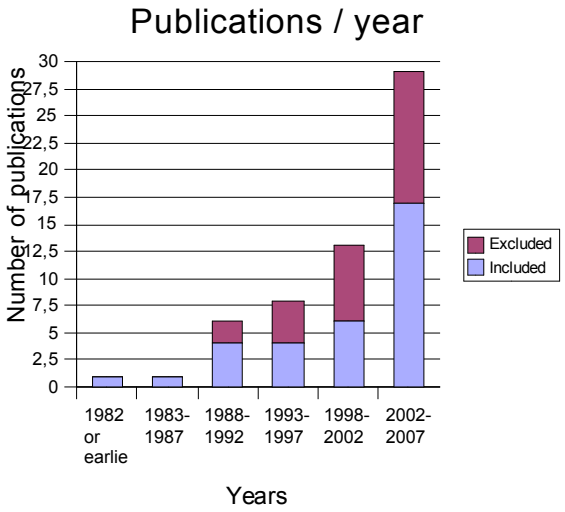

Figure 5.2.1: Relevant articles / year

Second, the field is highly **fragmented**. No agreement is reached in the literature on either the nature of the variables to measure nor on the means to do so. As I noticed:

> "*the description of the competence being measured varies almost with every single relevant article. The only concept being measured in more than one article is that of 'absorptive capacity', that is considered in 4 articles only. All 54 other articles each study a different competence or a different set of competencies*" (p.32).

This observation is coherent with the observation of Newbert (2007) on the "*resources*" considered in his review of empirical validations of the Resource Based View of the firm:

> *"It is important to acknowledge the myriad ways in which the various independent [potentially explanatory] variables have been operationalised.*

> *Of the 417 (76%) tests in which a specific resource, capability or core competence serves as an independent variable, 26 different resources, 32 different capabilities and 6 different core competencies are studied[...]. However, relatively few resources, capabilities and core competencies have received attention in multiple studies"* (p.138).

Following this Systematic Review of the literature on the operationalisation of organisational capabilities, the following elements of method and of instruments appeared as being potentially relevant to be considered in the design of my own measurement tool.

(The space below is deliberately left blank)

Measurement method	**Element to be potentially further considered**	**Reference in the 'core list' of the Systematic Review**
Questionnaire	Questionnaire items on "Managerial experience", "Managerial leadership", "Incentive for change & innovation", "Commitment culture", "Stakeholder cooperation & satisfaction".	(Camison, 2004)
Questionnaire	Questionnaire items describing the ability to achieve goals in functional terms, re-worded towards describing the current situation	(Hitt and Ireland, 1985)
Questionnaire	Questionnaire measuring 'deftness'	(McGrath et al., 1995)
Questionnaire	Metrics for 'exploitation' and 'exploration' capacity	(Garcia-Muiña and Navas-Lopez, 2007)
Exploitation of secondary data	Method to measure the capacity to understand new knowledge from the partner firm	(Lane and Lubatkin, 1998)
Exploitation of secondary data	Metric of patents self-cites to track the build-up of internal capability	(De Carolis, 2003)
Exploitation of secondary data	Idea that forecasting ability may be an interesting organisational capability to measure in an innovative environment	(Makadok and Walker, 2000)
Case study	Programme-competencies matrix method	(Durand, 1988)
Case study	Idea that the collective competencies of an organisation are well evidenced during diversification attempts	(Leonard-Barton, 1992)
Case study	External inventory of the 'inventive principles' of a firm along the TRIZ framework	(Moehrle and Lessing, 2004)
Case study	Metrics for 'project management' and 'client-specific' capabilities	(Ethiraj et al., 2005)
Interview	Procedure of cross-checking information through matched pairs of respondents in partner organisations	(Deshpande et al., 1993)
Interview	Procedure of interrogating 2 people in the same organisation to limit single-respondent bias	(Deshpande et al., 1993)

Table 5.2.1: Suggestions from extant literature to be considered in the design of a measurement instrument for organisational capabilities - reproduced from (Zibell, 2007 Table 4.1, pp 55-56)

I will include some of these ideas and elements of methodology in the measurement instrument used in this thesis, and justify the rationale for keeping or discarding each (§ 5.6.2).

5.3 Rationale for the chosen methodology

As a result of my epistemological position exposed above (§5.1), I aim in my research to obtain consistent, repeatable and falsifiable observations and measurements. A privileged means to reach these objectives is to use a **questionnaire** with **closed** set of pre-defined answers. As any instrument, a questionnaire only measures what it is intended to, and may fall victim to the "garbage in – garbage out" phenomenon: if the questions asked are irrelevant or meaningless, then the results share the same characteristics. On the other hand, if it is well-designed, the neutrality of the interaction allows for a reasonable capacity to transpose findings into new settings, and to have different researchers reaching similar results.

In coherence with the relational view of the firm (Dyer and Singh, 1998), my **unit of analysis** is the **dyad** formed by the partner organisations, and more precisely the "**co-operative R&D project**" that was jointly undertaken by the partnering organisations, as defined above (§ 1.6.2.2).

The questions are framed by the underlying theories that I use. For each respondent, they refer to:

1. the innovation-related capabilities (technical and managerial) of the respondent's organisation
2. the 'world view' present in the respondent's organisation
3. the innovation-related capabilities of the respondent's partner
4. the outcomes of the co-operative R&D project.

Since I use a survey tool, with no third-party, independent data, my variables are declarative. Specifically, I measure the **perception** that each organisation has of its capabilities, and not the capability itself. In order to alleviate this potential weakness, and in line with the methodological suggestions of Deshpande et al. (1993), the sets of questions n°1 and n°3 where I seek the same information from one organisation and from its partner, provide a **triangulated view** on the perceived capabilities of each organisation, while the set of questions n°4 does the same for the outcome of the co-operative R&D project. The detail of the information requested in the survey is provided below (§ 5.5).

As developed above (§ 4.4), I hypothesise that organisational 'world views' are, at least partially, influenced by their country or region of location, according to the regionally prevalent 'family model' (Todd, 1985; Todd, 1996). Considering the cultural diversity present in Europe within small distances, and the ease and low cost of telephone and postal interaction within the continent, I conducted an international and inter-cultural investigation, whose geographical scope of the research was a set of **European** countries. Since there are four family models in Europe, I investigated in the following regions, that share a comparable level of economic, technical and industrial development, and yet have different dominant family models:

- England ('absolute nuclear' family model)
- northern France ('nuclear egalitarian' family model)
- Germany and southern France ('stock' family model)
- central Finland ('communitarian' family model).

My survey investigates a **single industry**, that of **electronics** in a broad sense (including microelectronics, optronics, instruments and embedded signal and image-processing software), in order to restrict the scope of the technical and scientific knowledge to be investigated. In addition, this is an industry I have been active with in my previous professional career: my knowledge of the vocabulary and of the main concepts enhances my credibility as an investigator, and therefore should improve the response quality.

In order to minimise administration and data coding time, I have made the choice of an **on-line survey**. The results are thus directly stored in an electronic database, with the possibility to exploit them using standard quantitative analysis tools. Considering that I address professional respondents in large organisations, the issue of them having access to a computer and to the Internet, and of them being computer-literate, which may be a concern for on-line surveys in the general public, are not relevant.

I mobilise some branching logic (i.e. the possibility to skip some questions according to the answers made to previous ones). I need to display a multi-lingual questionnaire, in order to directly relate to non-Anglophone respondents. Finally, the issues of confidentiality of the answers are paramount to respondents involved in advanced, high-stake ventures. Considering the low level of personal privacy following the "Patriot" Act of 2001 in the United States of America, I rejected any technical solution implying the storage of data outside of the European Union, and specifically any US-based Application Service Provider. I therefore use the **LimeSurvey** (2009) free software tool to implement the on-line questionnaire: it provides a vast set of question types, a complete branching logic, and the possibility to implement multi-lingual surveys.

I have hosted the website containing the survey with a French-based firm. LimeSurvey is in addition considered as the leading free software tool for on-line surveys, with a very active support team and constant enhancements, by the German Social Science Infrastructure Services (Mannheim), a member of the federal Leibniz society for applied research[44].

I order to alleviate the bias in answers to Likert scales evidenced by Nicholls *et al.* (2006), I have both followed their recommendation of "*including occasional reversed items to maintain attention*" and used the feature of the LimeSurvey software that presents responses to a question in a random order.

In order to preserve the confidentiality of the partner's identity, which has proven to be a real issue for several respondents in the pilot study, each initial recipient of the

[44]http://www.gesis.org/en/services/methods/consultations/data-collection/online-surveys/a-guide-to-survey-software/?0=

questionnaire (within the organisation I am in direct relation with) is provided with **two** links to the on-line questionnaire: one for him/her to answer directly, the other for him/her to transfer to his/her partner organisation in the co-operative R&D project. This procedure assures that I have no means to identify either the partner organisation, nor the individual respondent's name within that organisation. However, since the answers are identified by a unique code, I still have the information that the two sets of answers refer to the same co-operative R&D project.

I limited the risks of having my survey polluted by unsolicited responses or by potentially malevolent hackers by providing each authorised respondent with a unique 'token' code. No access to the survey was possible without a valid 'token', that I administered directly. Once the survey was completed, the 'token' was disactivated, which prevented any other external person from reading or modifying the answers. This feature of LimeSurvey limited very strongly the risk that my contact person (the only external person to know both 'tokens', since s/he is responsible for transmitting it to his/her partner) read the answers of his/her partner (either for spying or to modify his/her answers according to this information). Indeed, this would only be possible in the rare cases when all three conditions are simultaneously met: (1) the contact person completes his/her survey after his/her partner, (2) the partner stops in the middle of his/her answer and (3) the contact person uses the 'token' to access the partner's survey during the interruption. These technical features make me consider that the answers from both partners are **independent** from one another.

In order to simplify and speed the answering process, the questions are designed so that the respondent may answer "from the top of his/her head", with **no need to refer to external or written data**: the answers are (with very few exceptions) to be chosen within a limited set of options that provide broad orders of magnitude, so that the respondent may easily choose the rough answer that actually suffices for the purpose of the research.

I have attempted to **minimise *post hoc* rationalisation** and **common instrument bias** phenomena. In this perspective, I used the feature provided by the LimeSurvey software that forbids modifying already answered items. I thus prevented respondents from coming back to their earlier responses to adapt them to the answers provided later. The sheer number of items in the survey (405 in total, of which 262 for the main section) made rationilisation altogether difficult. In addition, I intertwined items related to different dimensions of my model of 'world views', so as to prevent the respondents from identifying the underlying variables and from answering according to the image they have of themselves or would like to project. The random order in which answers to these questions were displayed contributed further to making the identification of the underlying variable difficult. By triangulating between the answers received from both partners, and by forbidding one partner from knowing the answers of the other, my variables on capabilities and outcomes originate from independent respondents. Finally, I deliberately refrained in the section on project outcomes from using judgemental vocabulary such as 'success' or 'failure', and focused on purely material data collection, without implying that any nature of outcome should be qualified positively or negatively.

Following the methodological recommendations by Dillman (2007), I enhanced the response rate of my survey by using **multiple modes** of contact: postal mail, telephone and electronic mail, following a data collection procedure that I will describe in greater detail below (§ 5.6.3).

5.4 Focus of observation

As stated above, my unit of analysis is the co-operative R&D project, observed from the matched pair of organisations that performed it. I need however to specify with some greater accuracy the selection criteria for the project and the scale of the organisations being observed.

The conditions for selection of the project were that it be **finished**, or close enough to completion for the project manager to know its outcomes, in addition of being co-operative and in the scientific & technical field of electronics. When more than one organisation was involved in a project consortium, which is frequent (Saad, 1998), I asked the project manager with whom I had an initial contact to select as its 'partner' in the survey the organisation with which s/he had had the **closest co-operation**.

When investigating the capabilities and cultures of the organisations involved in the co-operative R&D project, I took great care to define the **scale** of the social group that the questions refer to, because of the possible conflicts between 'world views' at different scales (§ 4.4.6), and because not all capabilities of an organisation are mobilisable for a co-operative R&D project, specifically if the organisation is large. I chose therefore to have the questions refer either to the respondent's **Business Unit** (if the organisation is a firm), or to his/her **Research Department** (if the organisation is a public research organisation), that is, to the fraction of the overall organisation that is concerned with the same type of product-market couples (for a firm) or of scientific issues (for a public R&D organisation). If however the organisation is very homogeneous (either because it is small, or because it is fully engaged in a single type of business or scientific activity), then the questions refer to the whole organisation.

5.5 Variables of interest

The variables that I consider of interest in my research are, for each **organisation**, the following. They represent some specific facets, relevant for innovative activities, of the more general descriptive framework of organisational capabilities and 'world views' defined above (§ 3.2 and 4.5).

The "innovation management" capabilities were selected because they have an influence on the innovation process, and also because they may be observed by the partner during the co-operative project itself, and may therefore be subject to a triangulated view. I have selected those management capabilities that have an influence on innovation, that is, on the creation of new products within an stable activity portfolio, in a medium cycle duration. The underlying logic is that of a partition of organisational activities according to their cycle duration, or to the time derivative level of 'dynamic capabilities' (Winter, 2003), as shown in the Table 5.5.1 below.

Cycle duration	**Nature of the offering** being operated upon	**Time derivative level** of 'dynamic capabilities' (Winter, 2003)	**Organisational functions**
short	current offering (products / services, material / immaterial) current activity porfolio	0 *"capabilities that permit a firm to 'make a living' in the short term"* (p.991)	Provisioning Manufactuting operations Operations Maintenance Sales & Sales support Operational marketing Accounting, Invoicing Bookkeeping, Control Personel administration
medium	new offering current activity porfolio	1	Strategic Marketing Research & Development Engineering Co-operative projects Manufacturing technologies & methods Recruitment
long	new activity portfolio	2	Strategic planning Merger & Acquisition management

Table 5.5.1: Partition of organisational functions according to cycle duration. The shaded line is the focus of my research

I tailored the functional breakdown of "scientific & technical" capabilities so as to encompass sub-fields of comparable cognitive size, relying upon my previous technical and professional experience of the industry. The areas covered are those specifically relevant for the electronics and telecommunications equipments industry that I have selected as the scope of my research (§ 1.6.2.4).

The variables I am interested in are:

1. the organisation's "**innovation management**" capabilities, expressed in functional terms as the capacity to perform specific actions, following my definition (§ 3.2). These capabilities are subdivided into the four following areas:
    i. **Strategic marketing** (whose acronym is *StratMkt*) that may be further subdivided into the following sub-fields:
        - *StratMkt1*: Anticipate evolutions of market, competition and strategic environment
        - *StratMkt2*: Define product roadmap, hierarchize and schedule research / development work

- *StratMkt3*: Define functional specification of future products, translate market needs into terms that may be exploited by R&D
- *StratMkt4*: Identify the new usage modes of existing products and their new requirements from customer feedback

ii. **Management of Research & Development** operations (whose acronym is *RDMgmt*) that may be further subdivided into:
- *RDMgmt1*: Anticipate technical and scientific evolutions
- *RDMgmt2*: Identify, locate, and qualify relevant external sources of technical and scientific competencies
- *RDMgmt3*: Specify and control exploratory research
- *RDMgmt4*: Influence decisions in international co-operative technical standardisation work
- *RDMgmt5*: Define technical specification of the final product from the functional specifications provided by Marketing
- *RDMgmt6*: Design the technical solution meeting specified requirements
- *RDMgmt7*: Incorporate user feedback on product failures
- *RDMgmt8*: Anticipate research project / technical development budget (manpower and material resources) and schedule
- *RDMgmt9*: Manage the specific human requirements of R&D scientists, engineers and technicians
- *RDMgmt10*: Share and allocate tasks, set goals among members of the research / development team
- *RDMgmt11*: Meet the research / development duration schedule
- *RDMgmt12*: Meet the research / development costs budget
- *RDMgmt13*: Meet the technical requirements of the product / of the research outcome = compliance with functional specification
- *RDMgmt14*: Meet the cost objectives of the product = successful "design to cost".

iii. **Legal and Intellectual Property** management (whose acronym is *LegalIP*), a component of a generic 'alliance management capability' focused on governance (§ 1.5.3) and that may be further subdivided into:
- *LegalIP1*: Design and word a technical or scientific co-operation contract
- *LegalIP2*: Design and word a patent
- *LegalIP3*: Patent strategy: define the patents deserving being filed, extended internationally, maintained or abandoned
- *LegalIP4*: Design and word a licensing contract

iv. **Systems** design capabilities (whose acronym is *Syst*), which is a generic engineering area of capabilities, independent from any specific technical or scientific field of application, themselves subdivided into:
- *Syst1*: Architecture: functional definition of modules & sub-systems
- *Syst2*: Specification of interfaces
- *Syst3*: Allocation of technical budget (mass, power consumption, error, mechanical or electrical tolerances…) between modules & sub-systems

2. The "**technical and scientific**" capabilities are divided into the following four areas:
   i. Fundamental & applied **Physics** (whose acronym is *Phys*), itself subdivided into:
      - *Phys1*: Quantum and statistical physics
      - *Phys2*: Laser physics
      - *Phys3*: Solid-state physics and materials science
      - *Phys4*: Thin-film and surface physics
   ii. **Hardware** design technologies (whose acronym is *Hard*), themselves subdivided into:
      - *Hard1*: Placement and routing of microcircuits
      - *Hard2*: Radio frequencies, electromagnetic compatibility
      - *Hard3*: Lasers and diodes
      - *Hard4*: Magnetism, electricity, electrostatics, fluidics
      - *Hard5*: Mechanical, optical and thermal design
      - *Hard6*: Chemical and biological design
   iii. **Software** design technologies (whose acronym is *Soft*), themselves subdivided into:
      - *Soft1*: Hardware description language programming (VHDL, Verilog)
      - *Soft2*: Digital Signal Processing (audio, video, radio, xDSL, error detection & correction)
      - *Soft3*: Cryptography
      - *Soft4*: Compiling, synthesising
      - *Soft5*: Real-time programming and scheduling, time-aware parallel programming
      - *Soft6*: Sequential and object-oriented language programming (C, Java, C++…)
      - *Soft7*: Communication protocols, telecommunications and networks
      - *Soft8*: Built-In electrical and functional tests
   iv. **Manufacturing** technologies (whose acronym is *Manuf*), themselves subdivided into:
      - *Manuf1*: Vacuum and ultra-vacuum
      - *Manuf2*: Precision optics and mechanics (machining, polishing)
      - *Manuf3*: Matter deposition technology (CVD, MOCVD, MBE…), including thin films
      - *Manuf4*: Matter removal technology (wet etching, dry etching, plasma…)
      - *Manuf5*: Implantation and ion beams
      - *Manuf6*: Thermal treatments
      - *Manuf7*: Polymers and solvents
      - *Manuf8*: Clean rooms, filters, fluids
      - *Manuf9*: Industrial automation
      - *Manuf10*: Metrology and control
      - *Manuf11*: External test benches

3. the organisation's **'world view'**, expressed along the parsimonious framework described above (§4.5)
    a. a sub-part of its organisational "character" (Bridges, 2000) in the two dimensions of "Mode of perception" and of "Behaviour in the outside world"
    b. its preference along the dimensions of authority vs. liberty and of equality vs. non-equality
    c. the preference for options typical of the four 'collective' polities (§ 4.4.4)
4. some of its **structural features** (inspired by: Teissier du Cros, 1976), that are elements of the "context" of the organisation's organisational capabilities described above (§ 3.2), such as
    a. whether the organisation is a public body or a private firm
    b. its number of employees (expressed as belonging to one of 5 pre-defined classes)
    c. the size and duration of typical R&D projects (expressed as belonging to one of 5 pre-determined classes of team size and project duration)
    d. the safety level required in the industry (expressed as belonging to one of 5 pre-determined classes of consequences in case of failure), that shape the Quality Assurance level of the technical development
5. its **geographic location**, in order to explore the effects of geographic distance as a control variable (§ 1.4.3).

For each **co-operative R&D project** being investigated, I was interested in the variables related to each partner organisation in the project (as described above), and in the following additional variables:

1. some initial conditions:
    a. level of technical risk that was anticipated for the project (expressed as belonging to one of 5 pre-defined classes)
    b. level by which the project was paid for by public bodies (expressed as belonging to one of 5 pre-defined classes)
    c. identity of the leading organisation (as expressed by each partner)
2. the source of **motivation** for having **selected** the partner. For each of the potential sources of motivation, 3 pre-defined classes of motivation level are proposed. The potential source of motivation for co-operation that I investigated are inspired by the existing literature reviewed previously (§ 1.4 and 1.5): (1) Presence with the partner of specific general management competencies, (2) Presence with the partner of specific technical / scientific competencies, (3) Strategic compatibility: compatible goals, absence of competition with the partner, identical set of friends and foes in the industry, (4) Geographic proximity, (5) Cultural compatibility, and (6) Previous co-operation experience

3. **outcomes** of the co-operative R&D project:
    a. **learning** outcomes, i.e. the knowledge that was either jointly **created** by the project partners or that was unilaterally **transferred** from the partner to the focal organisation during the project, and the **modification of capabilities**: whether the project has maintained, improved or created sub-fields of competence (among those considered as "core" competencies). Knowledge creation may happen in any or all of the following fields: (1) Scientific knowledge – "know why" phenomena appear, (2) Technical / engineering knowledge – "know how" to achieve some target functional or performance specification, (3) Marketing knowledge – receptivity of pilot customers, willingness to pay, maturity of the need…, (4) Clearly identified dead end - this project taught that this path should not be pursued, and why, (5) Identification of new, unforeseen opportunities. Knowledge transfer was investigated in the three first fields only. These outcomes on organisational capabilities are the **feedback effect** of the co-operative R&D project.
    b. **concrete** outcomes, along a stage-gate process containing nine **milestones**: (1) Scientific publications, (2) Patents, (3) Technical proof of concept -lab demo, (4) Functional prototype - meeting functional specifications, (5) Industrial prototype – meeting environment, production & cost requirements, (6) Pilot production, (7) Commercial launch & full-scale production, (8) Commercial success, and (9) Spin-out creation, and whether the project management reached its **cost** and **schedule** targets. I classify steps (1) to (4) inclusive of the stage-gate process as "technological milestones", while steps (5) to (9) inclusive are described as "commercial milestones".

5.6 Data collection tools

5.6.1 Structure of the survey

The structure and logic of the on-line survey is the following:

1. an **introduction page** provides a confirmation that the respondent has indeed reached the right location for the administration of the survey, and informs about its structure and anticipated duration. This page also contains the information required by **research ethics**: that participation is fully voluntary, that responses are confidential, and the contact details of the person in charge of the research
2. the **initial questions** locate the respondent geographically, the size of the organisation, and provide the information for later branching
3. the section on **innovation-related competencies of the Research department / the Business Unit** relates to both "innovation management" capabilities and to "technical and scientific" ones (§ 5.5). For each of these categories, if the respondent considers it as a "core competence" (Prahalad and Hamel, 1990), the more detailed functional breakdown of the domain into sub-fields is proposed: the issue is then, for each of the sub-fields, for the respondent to declare it as being Absent, Present but not "core", a

"Weak", a "Standard", a "Strong" or a "World-leading" core competence, following a suggestion by Klein and Hiscocks (1994), and making the meaning of each of these terms explicit by comparison with European or world competitors. The section also includes questions on some basic structural features of the organisation, that shape the way people work in it: the size and duration of R&D projects and the safety level required in the industry (inspired by: Teissier du Cros, 1976)

4. the section on **Culture & values** examines the 'world view' of the respondent's organisation (§ 5.5).
5. the section on the **Initial conditions of the co-operative R&D project** considers some potentially determinant moderating factors of the success of the project, such as its level of technical risk, and the level by which it was paid for by public bodies. The section also enquires about the mutual selection process in the project: who was the leader, and what were the motivations for accepting to work with this specific external organisation (§ 5.5).
6. the section on the **innovation-related competencies of the partner** refers to the same set of capabilities as in section 3 of the survey. The issue is here that the respondent may assess the level of capability of the partner, insofar as s/he has been able to do so during the interaction with them, with the same evaluation grid mobilising the concept of "core competence"
7. the section on the **learning outcomes of the co-operative R&D project** considers the knowledge that was either created or transferred from the partner during the project, and, for each of the respondent's "core competencies", whether the project has maintained, improved or created a sub-field of capability. The section also contains a small free-form space for the respondent to specify qualitatively what s/he believes was the most important thing being learnt during the project
8. the final section on the **concrete outcomes of the co-operative R&D project** considers these outcomes along the nine-steps stage-gate process I specified (§ 5.5), and whether the project management reached its cost and schedule targets. It also contains a free-form space for the respondent to specify qualitatively what s/he believes contributed most to the project's outcome.

Upon the end of the survey, the respondents are asked if they would like to continue answering on some optional issues. These issues, although I had considered them as potentially relevant for my research, were placed into an optional section of the survey (and therefore removed from the principal section of it) very early in the pilot part of the study, in order for the survey duration to remain under the psychological limit of 20 minutes, and in order to concentrate on the gathering of the core information described above. The optional issues in the survey are the following, with a further description provided in Appendix C:

- Demographic features, internal capabilities and structural features of the Research Department / the Business Unit

- Set-up of the project and project operations
- Relationship of the respondent to the region and to his/her geographic environment.

If the respondent declines answering to any of these further sets of questions, the survey is over.

The survey was accessible on-line for respondent at the following URL: http://www.competencies-cooperation.eu.

The full text of the survey is reproduced (in its English version), in Appendix B. The main (non-optional) part of the survey was also fully translated into French, German and Finnish. The respondent could thus choose his/her linguistic version of the survey between French, English, German and Finnish in order to have an immediate and unbiased understanding of the questions being asked.

5.6.2 Justification of the items retained from the Systematic Review on operationalisation of organisational capabilities

Despite the extensive Systematic Review that I performed on the measurement of organisational capabilities (§ 5.2), I have only retained a very limited number of items and methods from earlier literature in my own research. This deserves being explained and justified in the present section.

When considering the full list of operationalisation tools and methods retained as potentially relevant from the Systematic Review, I have proceeded as follows:

- I have retained many of the questionnaire items proposed by Camison (2004), but only in the optional part of my survey on internal capabilities. I have re-worded negatively some of the items, in order not to fall subject to the bias for the left-hand side of the survey sheet evidenced by Nicholls et al. (2006)
- I have retained Hitt and Ireland's (1985) general idea to consider the functional division of labour in the organisation to describe capabilities, and to describe them in functional terms. I have however re-considered the list of management functions, in order to focus on those that are relevant for technical and scientific innovation
- I have retained the questionnaire items that describe the 'deftness' of the co-operative relationship between partners, that had been proposed by McGrath et al. (1995), but again in the optional part of the survey, and with the same frequent inversion of the meaning of questions as described above, in order to limit bias
- I have not retained the metrics for 'exploitation' and 'exploration' capability proposed by Garcia-Muiña and Navas-Lopez (2007), because the semantic relationship between each item and what it is supposed to measure appears to me as somewhat far-fetched, and because the capabilities are too abstract and general for my purpose
- I have not retained any of the methods that mobilise secondary data (Lane and Lubatkin, 1998; Makadok and Walker, 2000; De Carolis, 2003), despite their

potential interest. I took this decision because I wanted to focus on one type of method in the limited time frame available for my research, and because one of my strategic objectives is to explore new variables describing organisational capabilities and cultures, that requested a dedicated survey to be produced, and that were absent from existing data sets

- I have not retained any of the methods that require in-depth case studies (Ethiraj et al., 2005; Durand, 1988; Moehrle and Lessing, 2004; Leonard-Barton, 1992), for epistemological reasons described above (§ 5.1), and because of my desire to use methods that may be replicated
- I have retained from Makadok and Walker (2000) the idea that forecasting ability may be an interesting organisational capability to be measured in an innovative environment, and have included this capability among the list of 'Strategic Marketing' and 'R&D Management' capabilities, applied to (1) market, competition and strategic environment, (2) technical and scientific evolutions and (3) research project / technical development budget (manpower and material resources) and schedule
- I have retained from Leonard-Barton (1992) the idea that the collective competencies of an organisation are well evidenced during diversification attempts. This is why I have mobilised the tool called 'Industrial Morphology', that was developed by Teissier du Cros (1976) to investigate the feasibility of diversification strategies. Items from this tools are however mainly kept in the optional part of the survey
- I have not retained the external inventory of the 'inventive principles' of a firm along the TRIZ framework proposed by Moehrle and Lessing (2004), since there is no evidence (beyond this article) that the fact of mobilising one inventive principle rather than the other is rooted in a persistent feature of the person or the organisation. It is therefore difficult to qualify it as a capability
- I have retained the metrics for 'project management' proposed by Ethiraj et al. (2005): the number of "*in-process defects*" (p.36), the "*effort overruns*" (p.36) and the "*schedule slippage*" (p.37), but not as metrics of organisation capabilities. Applied to a single project, they appear to me as being metrics of the project *outcome*, and I have retained the last two items in my survey as such. These metrics could only be considered as a (rather relevant) metric of project management *capability* if the value of these metrics were averaged over several projects, and if the result were accessible to an external researcher without being impaired by confidentiality issues. Considering the risk of being barred from accessing this sensitive element of data, and that of receiving unverifiable information, I have decided not to ask for it in my survey
- I have however adapted from Ethiraj et al. (2005) the simple metric they use for 'client-specific' capabilities, that is the binary variable "*coded 0 if the [focal] firm has executed projects for the client in the past and coded 1 if it is the first project executed for the client*" (p.36). The existence of a previous successful experience with the partner is investigated in the item in which I ask whether this previous experience was a motivation for selecting this partner again

- I have retained from Deshpande et al. (1993) the procedure of cross-checking information through **matched pairs** of respondents in partner organisations. This is fully coherent with my unit of analysis being the project itself, and with the 'Relational view of the firm' that I mobilise (§ 1.8.1)
- I have renounced attempting to interrogate two people in the same organisation to limit single-respondent bias, as recommended by Deshpande et al. (1993), because of the cost involved in such a procedure, and because of the risk of over-loading the benevolence of respondents.

5.6.3 Data collection methodology

The general purpose for collecting data was to contact specific **project managers**, that have recently closed a co-operative R&D project in the industry I investigate. In order to do so, I mainly used databases of publicly supported co-operative projects, that directly provide some contact details of project managers, or the websites of organisations whose mission is to perform co-operative R&D. In each of these databases, I selected only those organisations that are active in the electronics industry, following the policy described above (§ 1.6.2.4).

In the pilot phase of my study (mainly in France, and marginally in the United Kingdom), I also attempted to ask a high-ranking Director of the organisation, typically the Director of R&D in a firm, or the Director of a public laboratory, for contact with project managers. This method proved to be inefficient, because it added up delays in the answers from both the high-ranking Director and from the project manager, and because the motivation of the latter was paradoxically reduced by the fact that I contacted him/her upon recommendation of his/her superior. I abandoned this after the pilot phase. I also investigated patents databases, and searched for patents that are submitted by multiple applicants ("co-patents") - which could be the sign of the invention being the result of a co-operative project. This method also proved to be inefficient, because the assumption that co-patents resulted from co-operative projects was false, or because the fact that the patent was applied by several organisations actually signalled an unsuccessful co-operation, in which the organisations had not managed to agree on a sensible sharing of Intellectual Property Rights.

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The sources of contacts that I used are the following, in each country:

Country	**Sources of contact**	**Number of obtained contacts**
Germany	On-line catalogue of federal support to R&D: "*Förderkatalog des Bundes*" (Federal Ministry for Education and Research - BMBF)	97
Germany	Patents with multiple applicants	7
Germany	Website of organisations dedicated to co-operative R&D: "*Fraunhofer Institute*"	88
France	Contact through a Director of the organisation (pilot phase)	144
France	On-line catalogue of co-operative Eureka projects	13
United Kingdom	Contact through a Director of the organisation (pilot phase)	29
United Kingdom	On-line catalogue of projects supported by the Technology Strategy Board	83
Finland	On-line catalogue of projects supported by *Tekes*, the Finnish Funding Agency for Technology and Innovation	53
Total		**514**

Table 5.6.3.1: Contacts performed in the data collection phase, for each source

The contact details of Managing Directors of French innovative firms were provided to me by personal contacts in the French National Research Agency (*Agence Nationale de la Recherche*) and of Directors of academic institutions by personal contacts in the Grenoble association for relations between university and firms (*Alliance Université - Entreprises de Grenoble* - AUEG). The contact details of Managing Directors of British innovative organisations were obtained from the website of the Cambridge Network[45].

[45] http://www.cambridgenetwork.co.uk/

The general framework of the final data collection methodology, resulting from the experience gained in the pilot phase, was the following:

1. sending of a postal letter to the project manager, describing the overall framework of the research, requesting his/her participation, and containing the access details to the on-line survey
2. one follow-up telephone call to check the willingness of the project manager to take part in the research and to help him/her identify the project compatible with the research requirements (that could be either the one, described in a public database, with which I had identified the project manager, or another) as well as the partner. This phone call was followed by an e-mail summarising the main information and containing the links to the on-line survey
3. two reminder e-mails, one reminder postal letter and one reminder telephone call.

According to the confidentiality level of the project, the contact with the partner was managed either by the project manager or directly by me. The data collection from the partner was identical to that with the project manager. In order to preserve the confidentiality of the project, I had access neither to the identity of the project, nor to that of the partner organisation: the only information that I collected (and that was sufficient for my investigation) was that the set of two answers matched the same project.

The full procedure was integrated in a stage-gate process with 16 main milestones, that is described in greater detail in Appendix D.

During the whole data collection period, I kept a living database of all contacts, in which I kept track of the status of each one, according to these milestones, and of the dates at which each operation was performed.

5.7 Statistical exploitation methods and tools

5.7.1 Numeric pre-treatment using spreadsheet software

The LimeSurvey software exports the data collected on-line on a CSV- formatted file that can be handled by a spreadsheet software.

I used the open software suite **OpenOffice.org** spreadsheet to edit and transform the data into a form manageable by a statistics computing software. The editing consisted in the suppression of those entries that were incomplete, for which the respondent interrupted the process before the end of the survey: of the 372 individual responses obtained, 326 were complete, and therefore retained for further exploitation. The remainder, that is 46 incomplete answers, were discarded.

The transformation of the data retrieved from the on-line survey consisted in the following steps:

- conversion of the literal specification of the geographic location into latitude and longitude. Considering that the information was sought at regional level, latitudes and longitudes were rounded off at the nearest integer value, expressed

in degrees. When respondents specified an administrative unit (region, "*département*", "*Landkreis*", "*maakunta*", county,…) or a country, the geographic coordinates were chosen at the capital of the administrative unit or country. The cases when respondents only specified the country are very rare (7 cases in the United Kingdom, 3 in Finland, 1 in France). The geographic coordinates of the cities involved were obtained from the ViaMichelin[46] web site.

- conversion of the literal specification of the geographic location into a country, a language and a regional family model, following the map provided by Todd (1996, map 12, p.74) for Western Europe and Scandinavia
- conversion of the qualitative scales into numeric integer values. The lowest pre-defined class among the possible answers is associated with the value "0" or "1", and the others are associated with numeric values each incremented by one as the qualitative classes move by one step
- re-arrangement of answers so that two answers relating to the same project follow one another in the file. The project identity is one of the elements of the data retrieved from LimeSurvey.

The conversion tables used are the following:

Literal description of the capability level in the survey	**Numeric value**
Absent	0
Present, but not "core"	1
"Weak" core capability = the Research Department / the Business Unit considers itself under the level of its competitors, and that it needs improvement	2
"Standard" core capability = at the same level as the competitors of the Research Department / the Business Unit	3
"Strong" core capability = distinctively above the European competitors of the Research Department / the Business Unit	4
"World leading" core capability = the Research Department / the Business Unit is among the top 5 organisations world-wide in this field	5

Table 5.7.1: Conventional numeric values of capabilities levels

[46] http://www.viamichelin.fr/

Literal description of the learning achievements in the survey	**Numeric value**
None	0
Maintained existing capability	1
Improved existing capability	2
Created new capability	3

Table 5.7.2: Conventional numerical values of learning achievements

(The space hereafter is deliberately left blank)

Numeric values	**Total number of employees**	**Team size**	**Project duration** (months)	**Quality Assurance levels** (consequence in case of product failure)	**Set Up Technical Risk**	**Motivation for partner selection**	**Public Support** (Fraction of budget paid for by public bodies, in %)	**Budget compliance** (Comparison of effective operation and budget)
1	1 to 10	< 5	< 3	No human damage, material damage <100 €	Low-risk project, straightforward development from existing knowledge	None	<10	Effective operation well over initial budget (>100%)
2	11 to 49	5 to 10	3to 6	No human damage, material damage 100 - 10 000 €	Medium-risk project, minor uncertainties that only challenge development cost or duration	Minor	10 to 25	Effective operation significantly above initial budget (30-100%)
3	50 to 249	11 to 50	7 to 12	Wounded people, material damage 10 - 1 000 k€	High-risk project, major uncertainties that challenge its very feasibility	Major	25 to 75	Effective operation slightly above initial budget (10-30%)
4	250 to 2000	51 to 200	13 to 36	1 - 100 dead people, material damage 1 - 100 M€	Highly exploratory research, with very limited visibility on potential outcomes		>75	Effective operation on initial budget (±10%)
5	> 2000	> 200	> 36	>100 dead people, material damage > 100 M€				Effective operation under initial budget

Table 5.7.3: Conventional numerical values of pre-defined classes of semi-quantitative answers

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5.7.2 Statistical exploitation tools

I have used the **R Open Source statistical computing software** tool (2009), completed with optional packages (named "*FactoMineR*", "*lmtest*", "*MASS*", "*psy*" and "*psych*") to process the numeric data obtained from the spreadsheet pre-treatment.

The statistical treatment file, written with the R language, provides the following facilities:

- computation of the "**best estimate**" of the capability level of each organisation, by exploiting the data obtained from both respondents. Five algorithms were explored to perform this computation. The "best estimate" of the capability could be either: (1) the smaller of the two evaluations provided, (2) the larger of the two, (3) the self-evaluation by the organisation, that of the partner being ignored, (4) the partner evaluation or (5) the mean of both evaluations.
- computation of the **distance** between capabilities, when these are evaluated in a multi-dimensional space. Two algorithms were explored to perform this computation. The distance could be computed either (1) as a "L_1" distance, equal to the sum of the absolute values of differences along all dimensions or (2) as a "L_∞" distance, equal to the largest of all absolute values of differences along all dimensions.
- computation of the **combination** of the capabilities between the two partner organisations. Three algorithms were explored to perform this computation. The combined capability could be either: (1) the smaller of the two capabilities present in the partner organisations, (2) the larger of the two, or (3) the mean of both capabilities present.

Once these functions are available, the sequence of operations is the following:

1. validation of the scales used to describe the following aggregate variables, using the Cronbach alpha coefficient (1951), and selection of the items that maximise this coefficient:
    a. dimensions describing the organisational 'world views'
    b. overall capability in a given area (by aggregation of the capabilities in the sub-fields of that area)
    c. improvement of capabilities within a given area (by aggregation of the capability improvements in the sub-fields of that area)
    d. concrete outcomes of the project and its compliance with project schedule and budget
    e. knowledge creation
    f. knowledge transfer
2. construction of the aggregate variables that are unidimensional enough to justify the operation, and normalisation of these variables to remain in the [0 1] interval
3. computation of the "best estimate" of the organisational capabilities, using the data available from both partners, and the algorithm selected

4. computation of the level of disagreement between the evaluations provided for the same capability from both partners, equal to the difference in the value provided by each of them

5. computation of the cognitive distance between the "best estimates" of capabilities of both partners in each area, using the algorithm selected, and between the 'world views', using the scores computed for each of the dimensions describing this 'world view'

6. computation of the absolute value of the differences between the conventional numeric values of the following variables for each partner:
    a. team size, project duration, Quality Assurance level
    b. legal status (public / private), size of the organisation
    c. nationality (with a value of '0' if nationalities are identical, and '1' if they are different)
7. computation of the geographic distance between partners, using a L_1 distance in the space defined by latitude and longitude

8. computation of the mean appreciation from both partners on the following variables concerning the project:
    a. public support
    b. technical risk
    c. achivement of each technical project milestone and of the aggregation of the four retained commercial milestones
    d. compliance with project schedule

9. computation of the aggregated "best estimate" of the capability level of each organisation in the given areas, and of that of its partner, after validation of the unidimensionality using the Cronbach alpha coefficient

10. computation of the **combined** "best estimates" of capabilities of partners in the project, in each area

11. Aggregation of outcomes at project level, by computing the mean value from answers received from both partners

12. Aggregation of capability improvement of the organisation in each area, by adding the values in all sub-fields of the area, and then normalising within the [0 1] interval

13. computation of the descriptive statistics for the variables to be incorporated in the regression models

14. **ordered probit regression models** explaining the following variables describing the outcomes of the project, related to **symmetric** explanatory variables at **project** level:
    a. concrete outcomes (technical and commercial)
    b. knowledge creation by the project

c. compliance with project schedule

15. **linear, ordered probit** and **logit regression models** explaining the following variables describing the outcomes of the project, related to **asymmetric** explanatory variables at **organisation** level:
    a. improvement of capabilities of the organisation
    b. knowledge transfer to the organisation
    c. compliance with project budget.

5.7.3 Choice of the computation methods

As described above (§ 5.7.2), the statistical exploitation software that I developed provides different methods to compute the "best estimate" of an organisation's capability from the information received from both respondents, to compute the multidimensional distance between the capabilities of both partners, and to compute their combined capability.

I have chosen to use the **mean** value obtained from both respondents as the "**best estimate**" of an organisation's capability.

The reason for this choice is grounded in the study by Denrell et al. (2004) that compares two assessments of the collective capabilities of Swedish firms' subsidiaries: (1) the self-assessment made by the subsidiary and (2) the external assessment by the central headquarters. The situation is very close to that of my research, with the issue being to evaluate the collective capability of a given organisation, using the self-assessment of the organisation and that from a source that has some direct relation to it, and that experiences directly the consequences of the capability level of the assessed organisation in its own operations.

The main result of Denrell et al.'s study is that the assessments are lightly biased (the self-evaluation tends to be better that the external one by 0.4 points in a 7-points Likert scale), with a large standard deviation (1.62 points in a 7-points Likert scale). Therefore, the priority, in order to improve the quality of the measurement, is to **reduce the noise** (the standard deviation). If only two evaluations are available, the best strategy is to use the mean value: by using 2 observations (instead of only one), it reduces the standard deviation by a factor of $\sqrt{2}$. Using any one observation (as would be the case in any other of the methods considered to compute the "best estimate" of the capability level) would keep the same (and very high) level of noise in the measurement.

I have chosen the **mean** value of the "best estimates" of both partners' capabilities to compute the **combined** capabilities of the partners. The justification for this choice is the following. Had I chosen the larger of both capabilities, this would have meant that the most capable of both organisations can have its partner fully benefit from its capabilities during the project. This is somewhat unrealistic considering the fact that the partners remain separate (and rather eager to preserve their "core" capabilities), even when engaged in a common project. Had I chosen the smaller of both capabilities, this would have meant that the less capable of both organisations prevents the other from using its own capacities, and draws it down during the project. This again implies an intense interaction of partners during the project, with the most capable accepting to be handicapped by the other. The choice of using the mean between partner capabilities as the 'combined' capabilities therefore appears as an (imperfect) attempt

to account for the fact that both partners, although they interact during the project, yet remain somewhat independent.

I have chosen the $\mathbf{L_1}$ distance as the expression of the multidimensional distance between capabilities of organisations, rather than the L_∞ distance. Indeed, the latter method only considers the larger among all differences over the considered dimensions. It would mean that the capabilities within a given area are so coherent that it suffices that they differ in one sub-field to influence the interaction possibility over the whole area of capabilities. Although I have tried to group organisational capabilities in areas that make sense, I would not claim (nor believe) that the different sub-fields of capabilities within a given area are so logically intertwined and inter-connected that a difference in one sub-field only is sufficient to have an influence on the whole area of capability. This is why I have chosen the more balanced L_1 expression of multidimensional distance.

I have described in this chapter the methods used in the empirical part of my research. I can now proceed, in the next chapter, to the description of the results.

6 Results of the empirical study

Having exposed in the previous chapter how I obtained and treated my empirical data, I can now present the results of this process.

I will first report on the data collection process, and on its yield (§ 6.1). I will then provide a quantitative description of my observation sample, along dimensions such as nationality, and the main features of the respondent organisations and of the projects (§ 6.2). I will then justify the aggregation of items on unidimensional scales (§ 6.3). Following this, I will present the common control variables (§ 6.4) and the potentially explanatory variables that I have introduced in my research (§ 6.5), that are valid for all prediction models. I will specify in § 6.6 the methods I used to develop the prediction models and the general presentation template of results.

Following this preparation work, and in order to get fast to the point, I will provide a tabular summary of my positive empirical results at that stage (§ 6.7).

I will then systematically present the prediction of outcomes at **project** level (§ 6.8), namely the prediction of achievement of **project milestones**, of **knowledge creation** and of compliance with **schedule**. The prediction of these outcomes mobilises explanatory variables at project level, that are fully symmetrical: both partners in the project play the same role.

I will then systematically present the prediction of project outcomes at **organisation** level (§ 6.9), namely the prediction of **learning** (i.e. of capability improvement) due to the project, in key areas of capability of the focal organisation of **knowledge transfer** to the focal organisation during the project, and of compliance with the organisation's **cost budget**. The prediction of these outcomes mobilises explanatory variables at organisation level, that are asymmetrical: the capabilities of the focal organisation and of the partner organisation are treated separately.

I will delay the interpretation of these results to the following chapter (chap. 7).

6.1 Data collection outcome and yield

The data was collected from June to December 2008 inclusive (pilot phase), and from January to December 2009 inclusive (operational phase). Data collection was made in France (mainly) and in the United Kingdom (marginally) during the pilot phase, and in the United Kingdom, Germany and Finland in the operational phase, with Finland being investigated over the last three months.

Contact was made with a total of **514** project managers that were identified and contacted through the methods described above (§ 5.6.3).

I received **120 complete answers**, that is, matching pairs of answers from both partners in the same project. The overall **yield** of the data collection is thus **23.3%**. Considering that two organisations needed to be convinced in parallel for every complete answer (instead of only one for conventional data collection methodologies), the yield may be considered as reasonable.

In addition, I received 86 additional incomplete answers, that is, unmatched answers from one organisation only. Therefore, the total number of independent, unmatched answers was **326**.

The data collection yield in each target European country is exposed in the following table.

	Germany	*%*	**France**	*%*	**UK**	*%*	**Finland**	*%*	**All countries**	*%*
Fruitless contacts	108	*56,0*	103	*65,6*	78	*70,3*	19	*35,8*	**308**	*59,9*
One single answer	36	*18,7*	18	*11,5*	11	*9,9*	21	*39,6*	**86**	*16,7*
Full paired answers	49	*25,4*	36	*22,9*	22	*19,8*	13	*24,5*	**120**	*23,3*
Total contacts	193	*100,0*	157	*100,0*	111	*100,0*	53	*100,0*	**514**	*100,0*

Table 6.1.1: Data collection yield in the target countries

It may be observed that the data collection yields vary from one country to the other. However, if one assumes a binomial distribution law with parameter β=0.233, equal to the overall proportion of success in the whole sample, the cumulative probability for the number of full answers ("successes") to reach the values observed or those values even further away from the mean for each country is of 22% or above. Therefore, the deviations from the mean yield value may not be considered as statistically significant.

The yield of the **optional** section of the survey was **low**, as illustrated in the Table 6.1.2 below: only one-tenth of those that completed the main part of the survey carried on with one optional section.

Optional section of the survey	**Number of answers received**	**Relative yield** (compared to the number of organisations that provided an answer i.e. 326)	**Overall yield** (compared to the number of initial contacts, i.e. 514)
Demographic features of the Research Department / the Business Unit	53	*16,3%*	*10,3%*
Internal competencies of the Research Department / the Business Unit (Human Resources, General Management)	26	*8,0%*	*5,1%*
Structural, very stable features of the Business Unit	21	*6,4%*	*4,1%*
Set-up of the Project	37	*11,3%*	*7,2%*
Project operations	38	*11,7%*	*7,4%*
Relation to the region	33	*10,1%*	*6,4%*

Table 6.1.2: Yield of the optional section of the survey

This low yield is no surprise. My survey was rather long, and answering to the main part already was a very kind contribution from the respondents. The fact that only a minority took the time and dedication to answer the further part of the survey is a sign that the early decision I took of significantly shortening my survey, and to concentrate on the essential information that I was seeking, was appropriate.

Considering this low yield, I was not able to introduce data from this part of the survey into the models attempting to explain the outcomes of the R&D projects.

6.2 Quantitative description of the observation sample

6.2.1 Distribution of responses according to nationality

The distribution of the full (i.e. paired) answers received among the target European countries is the following:

Country of the initial contact	**Number of full answers**	***% of total***
Germany	49	*40,8%*
France	36	*30,0%*
United Kingdom	22	*18,3%*
Finland	13	*10,8%*
All countries	**120**	***100,0%***

Table 6.2.1: Number of full answers per country of the initial contact

The projects however could be international, and involve organisations from different countries. Therefore, the distribution of the countries where the respondents were located differs from that of the initial contacts, and is the following:

Country of the respondent	**Number of responses**	***% of total***
Germany	97	*40,4%*
France	67	*27,9%*
United Kingdom	35	*14,6%*
Finland	24	*10,0%*
Other countries (Austria, Belgium, Czech Republic, Denmark, the Netherlands, Poland, Portugal, United States of America)	17	*7,1%*
All countries	**240**	***100,0%***

Table 6.2.2: Number of respondents per country

The proportion of **international** projects in the sample, i.e. of projects involving partner organisations located in different countries, is **21.67%**, which means that the sample contains a significant proportion of international projects.

6.2.2 Quantitative description of the organisations

The **legal statuses** of the respondent organisations were almost evenly distributed between private firms (119 respondents) and public R&D organisations (121 respondents). The results should therefore be representative for R&D led in both types of organisations, that intervene, with complementary roles, in the process of industrial innovation.

The sizes of the organisations were distributed as follows:

Total number of employees in the organisation	**Number of respondents**	***%***
1 to 10	13	*5,4%*
11 to 49	34	*14,2%*
50 to 249	67	*27,9%*
250 to 2000	46	*19,2%*
> 2000	80	*33,3%*
Total	**240**	***100,0%***

Table 6.2.3: Number of respondents per size of the organisation

The sample contains a relatively homogeneous representation of organisations of various sizes, from the small SME to the large group.

As regards the stable features of the organisation, as proposed by Teissier du Cros (1976), the distributions are the following.

Typical team size of a R&D project (number of employees involved)	**Number of respondents**	***%***
< 5	106	*46,3%*
5 to 10	91	*39,7%*
11 to 50	27	*11,8%*
51 to 200	2	*0,9%*
> 200	3	*1,3%*
Total answers	**229**	***100,0%***
No answer provided	*11*	

Table 6.2.4: Number of respondents per size of the typical R&D project

The **team sizes** of the typical R&D projects of the respondent organisations are **small**, the vast majority of respondent organisations (86%) manage projects with **10 employees or less**. This may be related to the industry of electronics, which handles rather small devices, and therefore mobilises smaller teams than the automotive or the aeronautics industries. It may also be related to the fact that co-operative projects tend to be early-stage, pre-competitive. Being considered as risky, they mobilise smaller teams than the development teams for commercial products. Since the survey addressed the part of the organisation surrounding the respondent, it may be the s/he answered for the unit in charge of this pre-competitive R&D, that structurally involves smaller teams, for the same reasons as above.

Typical duration of a R&D project (months)	**Number of respondents**	*%*
< 3	2	*0,9%*
3to 6	8	*3,5%*
7 to 12	23	*10,2%*
13 to 36	164	*72,6%*
> 36	29	*12,8%*
Total answers	**226**	***100,0%***
No answer provided	*14*	

Table 6.2.5: Number of respondents per duration of the typical R&D project

The **durations** of the typical R&D projects of the respondent organisations are **long**, the vast majority of respondent organisations (72.6%) manage projects between one and three years in length. This may also be related to the early stage nature of co-operative R&D. In order for such projects to lead to a meaningful result, in an uncertain environment, some time is necessary.

Quality Assurance requirements in the organisation (expressed as the potential consequences of a product failure)	**Number of respondents**	*%*
No human damage, material damage <100 €	22	*26,8%*
No human damage, material damage 100 - 10 000 €	42	*51,2%*
Wounded people, material damage 10 - 1 000 k€	12	*14,6%*
1 - 100 dead people, material damage 1 - 100 M€	6	*7,3%*
>100 dead people, material damage > 100 M€	0	*0,0%*
Total answers	**82**	***100,0%***
No answer provided	*158*	

Table 6.2.6: Number of respondents per Quality Assurance requirement level

The **Quality Assurance requirements** of the respondent organisations appears as being rather low. This is coherent with the electronics industry, which is little safety-driven (as opposed to the civil aviation, aerospace, defence, nuclear energy or rail transport). However, the low response rate to this item may also evidence that the question itself was difficult to understand (although the relation to the Quality Assurance requirements was present in the wording of the item). Considering the high number of non-answers, I **discarded** this item in the models predicting co-operative R&D project outcomes.

6.2.3 Quantitative description of the projects

The respondents were asked to rate the **project** that was the purpose of the survey, in terms of technical risk estimated *ex ante* and of public financial support.

***Ex ante* risk level of the project**	**Number of respondents**	*%*
Low-risk project, straightforward development from existing knowledge	13	*5,6%*
Medium-risk project, minor uncertainties that only challenge development cost or duration	81	*34,9%*
High-risk project, major uncertainties that challenge its very feasibility	102	*44,0%*
Highly exploratory research, with very limited visibility on potential outcomes	36	*15,5%*
Total answers	**232**	***100,0%***
No answer provided	*8*	

Table 6.2.7: Number of respondents per estimated *ex ante* risk level of the project

The projects being investigated are mainly considered as **medium** or **high-risk**, with a significant proportion (15.5%) that is even considered as "highly exploratory". This is coherent with what may be expected from early-stage R&D.

Public financial support to the project: Fraction of the project budget being paid for by public bodies (%)	**Number of respondents**	*%*
<10	20	*8,9%*
10 to 25	13	*5,8%*
25 to 75	138	*61,3%*
>75	54	*24,0%*
Total answers	**225**	***100,0%***
No answer provided	*15*	

Table 6.2.8: Number of respondents per level of public financial support to the project

The projects being investigated are financially **strongly supported** by public bodies, with a level of support beyond 25% in 85% of cases.

6.3 Validation of aggregated scales

As described above (§ 5.7.2), some of my variables are the result of the aggregation of answers received on several items of the survey: (1) the position of the organisation on the dimensions describing the organisational 'world views'; (2) the overall capability within a given area; (3) the concrete outcomes of the project; (4) the knowledge creation of the project; (5) the improvement of capabilities within a given area, and (6) the knowledge transfer during the project.

I therefore validated the unidimensionality of the obtained scales, using the classical Cronbach (1951) Alpha coefficient. For each scale, only the fraction of the items that maximised the value of the Cronbach alpha coefficient was retained. These coefficients are computed over the whole number of independent answers received (i.e. 326), in order to maximise the validity of the result: indeed, it is not necessary to have answers from both partners on the same project to assess this unidimensionality of scales on variables that are provided by one organisation only.

Underlying variable	**# of items retained / total items**	**Nmin - Nmax**	**Cronbach's Alpha for retained items**
Organisational "character": Mode of perception of information	9/9	253 - 287	0.66
Organisational "character": Behaviour in the outside world	9/9	226 - 298	0.57
Family model: Liberty vs. Authority	7/9	187 - 293	0.6
Family model: Equality vs. Inequality	*7/9*	*148 - 254*	*0.35*
Aggregated organisational capability: Strategic Marketing	4/4	321 - 323	0.99
Aggregated organisational capability: Management of R&D operations	14/14	299 - 318	0.97
Aggregated organisational capability: Legal & IP management	4/4	316 - 320	0.97
Aggregated organisational capability: Physics	4/4	316 -318	0.90
Aggregated organisational capability: Hardware design	6/6	307 - 317	0.87
Aggregated organisational capability: Software design	8/8	297 - 311	0.94
Aggregated organisational capability: Systems design	3/3	306 - 311	0.96
Aggregated organisational capability: Manufacturing technologies	11/11	310 -316	0.97
Concrete outcomes: Technological milestones (as described in § 5.5)	*4/4*	*326 - 326*	*0.30*
Concrete outcomes: Commercial milestones *(as described in § 5.5)*	4/5	326 - 326	0.56
Knowledge creation	*3/5*	*326 - 326*	*0.32*
Aggregated capability improvement: Strategic Marketing	4/4	35 - 38	0.87
Aggregated capability improvement: Management of R&D operations	14/14	203 - 221	0.89
Aggregated capability improvement: Legal & IP management	4/4	65 - 68	0.91
Aggregated capability improvement: Physics	4/4	109 - 115	0.61
Aggregated capability improvement: Hardware design	6/6	118 - 126	0.72
Aggregated capability improvement: Software design	8/8	140 - 148	0.81
Aggregated capability improvement: Systems design	3/3	142 - 146	0.78
Aggregated capability improvement: Manufacturing technologies	11/11	73 - 79	0.84
Knowledge transfer	*3/3*	*326 -326*	*-0.58*

Table 6.3.1: Cronbach's Alpha coefficient for aggregated variables

As may be seen in Table 6.3.1, the unidimensionality of the constructs is correct for most of the variables considered, with values of the Cronbach alpha coefficient reaching values of 0.56 or above. The literature initially recommended to have a threshold value of 0.5 to 0.6, for preliminary research (Nunnally, 1967), and moved then to a threshold value of 0.7, without further justification (Nunnally, 1978). However, considering that I am at the initial stages of the validation of these variables, I believe that they be kept aggregated. In addition, regarding the aggregation of commercial milestones (Cronbach Alpha = 0.56), the number of projects where each milestone was reached is extremely low (from 5 to 15 in a total of 120), so that constructing an aggregated variable makes sense in order to have a higher level of signal, with more cases when one milestone at least was attained.

However, some variables display a low, or even a very low, value of the Cronbach alpha coefficient. These are:

- Family model: Equality vs. Inequality
- Aggregation of technical milestones
- Knowledge creation
- Knowledge transfer.

As a result, I discarded the "Equality vs. Inequality" variable as potential explanatory variable, and considered each of the individual components of the "Technical milestones", of "Knowledge creation" and of "Knowledge transfer" as separate outcomes of the project, without attempting to aggregate them.

One reason why the "Equality vs. Inequality" variable proved to have disappointing unidimensionality features may be that this dimension is strongly connoted morally. In contemporary democratic societies, explicitly claiming the value of inequality among people is very difficult. I had attempted in the items of the survey to touch that point, without however directly mentioning it. I obviously have not managed to reach a satisfactory result: the design of a survey that reaches the beliefs and values of respondents and organisations about equality and inequality among humans remains to be done.

6.4 Common control variables

The control variables, common to all predictive models of my research, are the following:

- the **geographic distance** between the locations of project partners (*DistGeo*), computed as a L_1 distance, following the procedures described in § 5.7.2. I considered this variable because of the vast literature on the effects of geographic proximity on inter-organisational co-operation, that I presented earlier (§ 1.4.3)
- the difference in **nationality** (*DistNation*) between the project partners, taking the value 0 for partners established in the same country, and the value 1 otherwise. I considered this variable because it is one of the only operationalisations of 'cognitive distance' in the literature that I have found on the subject (§1.4.4)
- the distance in **legal status** (*DistLegalStatus*), taking the value 0 if both organisations are private firms or if both are non-profit R&D organisations, and the value 1 otherwise. I use this variable as a simple proxy of the 'logic of belonging' presented in § 1.4.4: the public sector (respectively the private sector) is a broad entity in which a sense of 'belonging' may be developed, and within which common behavioural logics may be expected, due to the specific nature of constraints that are present in each. It is

also often believed in the literature that "*the difference between non-profit and for-profit institutions tend to be more fundamental than differences among various types of for-profit institutions*" (Rothaermel and Deeds, 2006, p.435)

- the distance in the **size** of the partner organisations (*DistSize*), expressed as the absolute value of the difference in the conventional numeric values of the five pre-defined classes of number of employees defined in § 5.7.1. I use this variable because several cases of co-operation difficulties presented in the literature on co-operative R&D involve the archetypal opposition between the large corporation, considered as heavy and formal, and the supposedly innovative, nimble and adaptive SME, and attribute the difficulties to differences in size (Doz and Hamel, 1998, Table 6.2, p.152; Brouthers et al., 1995; Alvarez and Barney, 2001).
- the level of **public support** received for the project (*PublicSupport*), on the four-step scale described in § 5.7.1, averaged over the answers received from both partners. Since I have no other information on the project than the one being provided by the respondents (because even the identity of the project was unknown to me for confidentiality reasons described in § 5.6.3), taking the mean level between both answers received appears as being the best estimate considering the information available. I introduce this variable because one may expect that a project that receives external financial support may have greater probability of success than one that would be left on the only means of the partners.
- the level of **technical risk** estimated *ex ante* for the project (*TechRisk*), on the four-step scale described in § 5.7.1, averaged over the answers received from both partners, for the same reason as above. I have introduced this variable because one may also expect the outcomes of an R&D project to depend upon the technical risk level of the venture: the riskier the project, the larger the uncertainty on the outcomes, and the higher the probability of them being negative
- the level of **strategic compatibility** (*MotivStrategicCompatible*) is the mean of the opinions received from respondents in both organisations on their strategic compatibility-based motivation for selecting that specific partner for the project, over the three-point scale described in § 5.7.1. I included this variable because of the recommendations made in the existing literature on partner selection that emphasise this consideration (Doz and Hamel, 1998; Brouthers et al., 1995; Bamford and Gomes-Casseres, 2002).

The Spearman (rank-based) correlation matrix between these control variables is given in the Table 6.4.1 below.

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Name of variable	DistGeo	Dist Nation	DistSize	Dist Legal Status	Public Support	TechRisk	Motiv Strategic Compatible
DistGeo	**3.6625** ***(7.7522)***						
DistNation	0,608 *** *(1.59e-13)*	**0.2166** ***(0.4137)***					
DistSize	0,0569 *(0.5371)*	0,1681 ° *(0.06649)*	**1.2166** ***(0.9454)***				
Dist LegalStatus	-0,0740 *(0.4219)*	-0,1167 *(0.2042)*	-0,0098 *(0.9152)*	**0.6083** ***(0.4901)***			
Public Support	-0,1196 *(0.1950)*	-0,0301 *(0.7455)*	0,0487 *(0.5991)*	-0,1180 *(0.2012)*	**2.9873** ***(0.7659)***		
TechRisk	0,1054 *(0.2519)*	-0,0273 *(0.7674)*	-0,0419 *(0.6494)*	0,0053 *(0.954)*	0,1700 ° *(0.06462)*	**2.6916** ***(0.6520)***	
Motiv Strategic Compatible	0,0305 *(0.7429)*	-0,0646 *(0.4870)*	0,0769 *(0.4077)*	-0,0189 *(0.8394)*	0,0141 *(0.88)*	-0,0089 *(0.924)*	**2.4830** ***(0.5102)***

Table 6.4.1: Descriptive statistics of the control variables intervening in the models: **mean value, *(standard deviation)*** and Spearman correlations *(p-value)*.
*Confidence levels: *** : p value ≤1‰; ** : p value ≤1%; * : p value ≤5%; °: p value ≤ 10%*

As may be seen in the table, the correlations between the control variables are statistically non significant. The exceptions, that could somewhat be anticipated, are that: (1) the geographic distance (*DistGeo*) and the difference in nationality (*DistNation*) are positively (and very significantly) correlated, (2) the difference in size (*DistSize*) and the difference in nationality (*DistNation*) are positively (and weakly) correlated, which may mean that international projects tend to join organisations of different sizes, and (3) public support (*PublicSupport*) and technical risk (*TechnicalRisk*) are positively (and weakly) correlated, which means that organisations focus the public support on those projects considered *ex ante* as more risky, which is the very purpose of this support.

6.5 Explanatory variables introduced by the research

The independent, potentially explanatory, variables that I have introduced in my research, in addition to the control variables described in § 6.4, and that will be used in my prediction models may be divided into **symmetrical** and **asymmetrical** variables. The symmetrical variables describe the situation at project level, and consider both partners identically. Asymmetrical variables on the other hand consider the project from the position of one partner only.

6.5.1 Symmetrical explanatory variables, at project level

The 23 **symmetrical** variables that I introduced in my research may be sub-divided into five categories:

1. the **cognitive distance** between the organisational **'world views'** of project partners (3 variables),
2. the **cognitive distance** between the **structural features** (team size, project duration) of the project partners (2 variables),
3. the **cognitive distance** between the **capabilities** of project partners (8 variables),
4. the **combined capability** of the project partners (8 variables) and

5. two **initial conditions** of the project: (a) the level of **previous successful experience** in the dyad made of the two partners considered and (b) the level of **disagreement** between project partners as to who is the **leader** in the project.

The distance between the organisational 'world views' of project partners is the absolute value of the difference between the scores obtained by each partner along the dimensions where the answers to the survey may be aggregated (as per § 6.3):

- Mode of perception of information (*DistSN*)
- Behaviour in the outside world (*DistJP*)
- Authority vs. Liberty (*DistLib*).

The cognitive distance between the capabilities of the project partners, in each of the scientific & technical areas and in each of the innovation management areas, is designated as *DistXXX*, with XXX the acronym of the capability area specified in § 5.5, are computed as exposed in § 5.7.2.

The **distance** between organisational capabilities or 'world views' accounts for phenomena described verbally as **'compatibility'**, when the underlying assumption is that the cognitive distance should be kept low for organisations to be understand each other, and as **'complementarity'**, when reciprocally the assumption is that the source of creativity lies in the difference between partners. When considering the distance between capabilities, the overlap between them plays no role.

The combined capability of the project partners in each of the scientific & technical areas and in each of the innovation management areas, is designated as *CombXXX*, with XXX the acronym of the capability area, are computed as exposed in § 5.7.2. The **combined** capability (whatever the algorithm used to compute it) accounts for the **commonalities** between the partners, their overlap, with the underlying assumption that the strengths of the partners, even if they are identical in nature, supplement and support each other, and augment the basis for mutual understanding in the co-operation.

A visual illustration of the respective meanings of distance between organisational capabilities and of combined capabilities is provided in the Figure 6.5.1 below. When studying cognitive **distance** only, the attention focuses on the difference between the capabilities of both partners, i.e. the area surrounded by a thick black line, whatever the size of the overlap (the zone with the criss-crossed shading). On the other hand, when considering the **combined** capability, the attention focuses on the overlap. To what extent the areas of capabilities specific to A or to B are included in the combined capability depends on the algorithm used (among those of § 5.7.2).

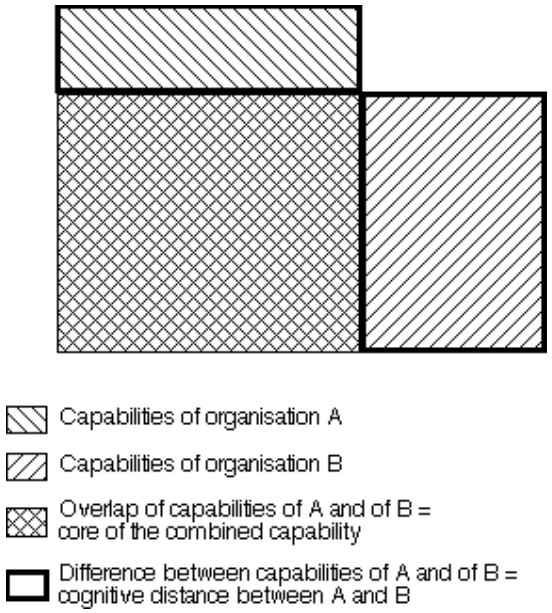

Figure 6.5.1: Illustration of the meanings of distance between capabilities and of combined capability

The level of previous successful experience in the dyad was computed as the mean of answers received from both organisations on their motivation for selecting that specific partner in the project (*MotivPreviousExperience*), along the three-point scale described in § 5.7.1.

The disagreement as to which organisation is the project leader is a variable taking the value '1' if both partners claim that they led the project, or if both claim that their partner did. It takes the value '0' otherwise.

6.5.2 Asymmetrical explanatory variables, at organisational level

The 18 **asymmetrical** variables that I introduced in my research may be sub-divided into three categories:

1. the **capability level** of the **focal organisation**, designated simply with the acronym of the capability area, computed as exposed in § 5.7.2
2. the **capability level** of the **partner**, designated as *PartXXX*, with XXX the acronym of the capability area, , computed as exposed in § 5.7.2, and
3. the level at which the **motivation** to select the partner was that it was expected to have general management capabilities (*MotivGeneralCompetence*) or to have scientific & technical capabilities (*MotivTechCompetence*), using the three-levels scale exposed in § 5.7.1.

These variables will be used to explain the asymmetrical **learning** processes taking place during the co-operative R&D project. The capability level of the focal organisation itself may have an influence on learning, because this capability may be understood as a domain-specific 'absorptive capacity' (Cohen and Levinthal, 1990). The capability level of the partner organisation may have an influence on learning, since one may expect that knowledge transmission is better when the 'teacher' itself has a good level of capability. Finally, the motivations for selecting a partner based on its expected level of capability may influence learning as they are a sign for a desire to actually do so, and benefit of the opportunity of the project to actually learn from the partner.

I will provide descriptive statistics and correlations between those (very numerous) variables only if they are significant as explanatory factors in my regression models.

6.6 Common methods and presentation templates

6.6.1 General procedure to select the most significant independent variables

In all the regression models of my research, the most significant variables were identified by using the following procedure.

I start with a full model incorporating all possible independent variables. I then eliminate the independent variable that is the least significant (i.e. having the highest p-value). I then compute a next model with all the variables of the previous model, less the one just eliminated. I then eliminate the least significant variable again, and repeat the procedure, until the variables remaining all have a significance level better than p = 5%.

6.6.2 Presentation template

In each of the sections describing a regression model, I will first present descriptive statistics of the variable describing the outcomes.

For each variable describing an outcome of the project, I will then present three regression models:

1. the model containing the control variables (§ 6.4) only
2. the model containing all control variables and the most significant explanatory variables
3. the model containing the most significant explanatory variables only, that can be either control variables or variables introduced by my research (§ 6.5).

Finally, I will display the Spearman (rank-based) correlation matrix between the significant variables and between these and the control variables. In this matrix, the shaded cells highlight the correlation between the most significant variables (those intervening in Model 3). A possible consequence of a correlation between significant variables, called multicolinearity, is that the variance given for the regression coefficients may be over-estimated, leading to rejecting as non-significant some variables that otherwise would be. Reciprocally, it means that the the coefficients that are retained in the models are certain to be significant.

My comments on correlations will be restricted to those significant correlations between the most significant variables, in gray-shaded cells in the tables.

6.7 Summary of the models predicting co-operative R&D project outcomes

In this section, I provide a tabular summary of the regression model results that I will detail in the next sections (§ 6.8 and 6.9). The interpretation of results will be provided in the next chapter (chap. 7).

In the tables, I summarise the results of the regression models with the most significant variables (Model 3 of the general template exposed above § 6.6.2):

- Table 6.7.1 summarises the prediction of **project milestone achievement** at project level,
- Table 6.7.2 the prediction of **knowledge creation** and the compliance with **schedule** at project level,
- Table 6.7.3 the prediction of **capability modification** at organisation level,
- Table 6.7.4 summarises the prediction of **knowledge transfer** and the compliance with project **cost budget** at organisation level.

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Explanatory variables		**Achievement of project milestones**				
		Scientific Publications	Patents	Lab Demonstrators	Functional Prototypes	Aggregation of 4 commercial milestones
Variables introduced by the research	DistSN		- *			
	DistJP			+ *		
	DistPhys				- *	
	DistHard					- *
	CombStratMkt	- **				+ ***
	CombLegalIP		+ **			
	CombSyst				+ *	
	CombPhys	+ ***				
	CombHard		+ **			
	CombManuf				+ *	
Controls	DistGeo					
	DistNation					
	DistSize					
	DistLegalStatus	+ *				
	PublicSupport					
	TechRisk					
	MotivStrategicCompatible					

Table 6.7.1: Summary of models predicting the achievement of project milestones at project level.
"+" means "*positive influence*", "-" means "*negative influence*"
Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

Explanatory variables		**Knowledge creation**					**Compliance with project schedule**
		Scientific	Technical	Marketing	Dead end	Unforeseen opportunities	
Variables introduced by the research	DistSN			+ *			
	DistJP						+ *
	DistTeamSize					- *	
	DistStratMkt						- *
	DistRDMgmt						+ *
	CombStratMkt	- *		+ *			
	CombPhys	+ **					
	CombHard		+ *				
	MotivPrevExperience					- **	
	DisagLeader			- *			
Controls	DistGeo						
	DistNation						- *
	DistSize						
	DistLegalStatus						
	PublicSupport						
	TechRisk				+ **		
	MotivStrategicCompatible						

Table 6.7.2: Summary of models predicting knowledge creation and compliance with schedule at project level.
"+" means "*positive influence*", "-" means "*negative influence*"
Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

Explanatory variables		**Modification of capability level**							
		Strategic Marketing	Management of R&D operations	Legal & IP	Systems design	Physics	Hardware design	Software design	Manufacturing technologies
Variables introduced by the research	DistSN	- *		- **			- **		- **
	DistLib					+ *			
	Capability of Partner				+ *	+ **		+ **	
	Capability of focal organisation					+ **	+ **	+ **	+ **
	MotivPreviousExperience			- *					
	MotivGeneralCompetence	+ *		+ *					
Controls	DistGeo								
	DistNation								
	DistSize								
	DistLegalStatus								
	PublicSupport					+ *		+ *	
	TechRisk								
	MotivStrategicCompatible								

Table 6.7.3: Summary of models predicting the modification of capabilities at organisation level.
"+" means "*positive influence*", "-" means "*negative influence*"
Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

Explanatory variables		**Knowledge transfer**			**Compliance with cost budget**
		Scientific	Technical	Marketing	
Variables introduced by the research	Capability of Partner: Strategic Marketing	- **	+ **	+ ***	
	Capability of Partner: Systems design				- *
	Capability of Partner: Physics	+ ***			
	Capability of focal organisation: Systems design	+ *			
	Capability of focal organisation: Manufacturing technologies			- *	
	MotivTechCompetence		+ ***		
Controls	DistGeo				
	DistNation				
	DistSize				
	DistLegalStatus				
	PublicSupport				
	TechRisk		- *		
	MotivStrategicCompatible				

Table 6.7.4: Summary of models predicting knowledge transfer and compliance with cost budget at organisation level.
"+" means "*positive influence*", "-" means "*negative influence*"
Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

6.8 Prediction of outcomes at project level

In a first series of models, I have attempted to predict, for the co-operative R&D projects of my sample, the outcomes at project level, in which the partner organisations play symmetric roles.

In this section, I will first present the dependent variables, that describe various sorts of outcomes at the project level (§ 6.8.1). I will then expose in § 6.8.2 the regression models that I developed, and that predict these outcomes, using both the control variables (§ 6.4) and those among the symmetrical variables introduced by my research (§ 6.5.1) that prove to be statistically significant.

6.8.1 Dependent variables

The dependent variables describe the outcomes of the co-operative R&D project, and are the following.

The variables *ScientificPublication*, *Patents*, *LabDemo* and *FunctionalPrototype* represent the attainment of **technical milestones** in the stage-gate process described in § 5.5, with an obvious meaning. These milestones cannot be aggregated into a single variable (§ 6.3). In order to obtain a result at project level, I have computed for each milestone, the mean value of the answers received from both partners.

The variable *ConcreteOutputCommercial* aggregates four **commercial milestones** in the stage-gate process described in § 5.5 (Industrial prototype – meeting environment, production & cost requirements; Pilot production; Commercial launch & full-scale production; Commercial success). It was considered as reasonably unidimensional in § 6.3, specifically considering the very low number of projects in which these milestones were indeed reached. To compute this variable, 0.5 points are attributed each time one of the four commercial milestones has been reached by one of the partners in the project. The variable is the sum of points obtained by the project.

I consider the five fields of **knowledge creation** (scientific, technical, marketing, dead end, unforeseen opportunities), described in § 5.5, that can have been caused by the co-operative R&D project being investigated. These fields cannot be aggregated into a single variable (§ 6.3). In order to obtain a result at project level, I have computed for each field of knowledge creation, the mean value of the answers received from both partners.

The variable *ProjMgmtSchedule* represents one aspect of the project management performance: the **compliance** with the **project schedule**, averaged over the answers of both partners using the metric given in § 5.7.1. Since it is an information shared by both partners, when the answer from one partner was missing, it was replaced by the answer from the other partner.

The relations that I investigate in this section between independent, potentially explanatory variables, and the dependent variables are described in the Figure 6.8.1 hereafter.

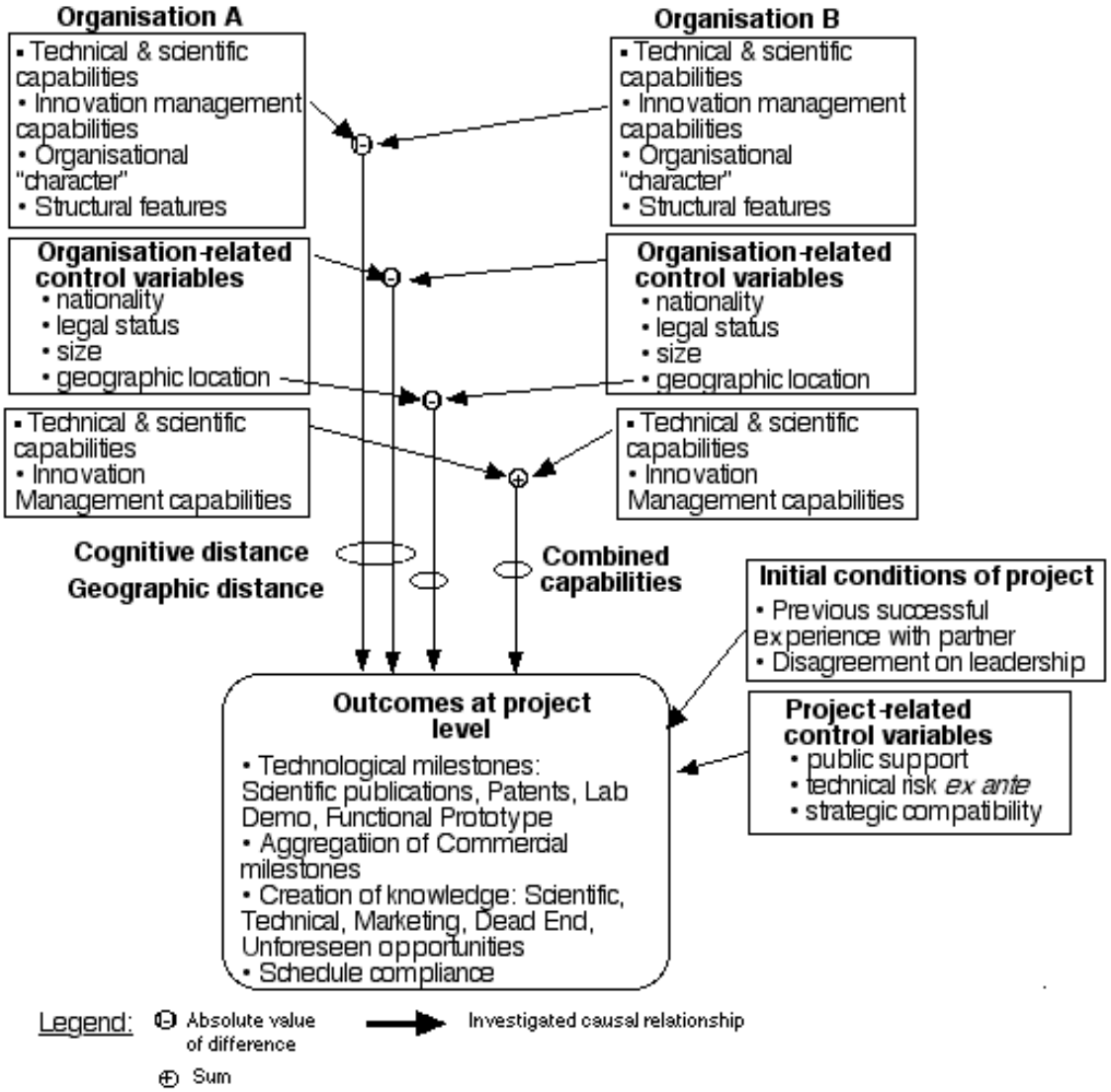

Figure 6.8.1: Relations between the investigated variables at project level

6.8.2 Regression models

6.8.2.1 Models predicting Scientific Publications

The variable *ScientificPublications* is the average of answers received from both partners on the attainment of this technical milestone (§ 6.8.1).

Descriptive statistics of this variable are provided in the Table 6.8.1 hereafter:

***ScientificPublications*:** Average achievement of technical milestone: "Scientific publications"			
Number of observations	120		
Number of discrete levels	3		
Mean value	0.7875		
Standard deviation	0.3283		
Technical milestone - Scientific publications: average number of positive answers	0	0.5	1
Number of projects	11	29	80

Table 6.8.1: Descriptive statistics of the variable *ScientificPublications*: average achievement of technical milestone "Scientific Publications"

In order to predict this variable, I have used **Ordered Probit** regression. This method is recommended when the number of possible values for the dependent variable is small, but yet strictly superior to 2. Since *ScientificPublications* may take three distinct values, I am in the case of application of this method.

(the space below is deliberately left blank)

The results of the three regression models of my general template (§ 6.6.2) are displayed in the Table 6.8.2 hereafter.

Name of variable	**Model 1: Control variables only**	**Model 2: Controls + most significant variables**	**Model 3: Most significant variables**
(Intercept 0-1)	1.3561 *(0,1116)*	0,3456 *(0,7022)*	-1,2660 *** *(0,0001)*
(Intercept 1-2)	2.3600 ** *(0,0063)*	1,4485 *(0,1123)*	-0,2323 *(0,4479)*
CombStratMkt		-0,5432 ** *(0,0036)*	-0,5158 ** *(0,0026)*
CombPhys		0,3483 ** *(0,0097)*	0,4153 *** *(0,0009)*
DistGeo	0,0120 *(0,5424)*	0,0216 *(0,3062)*	
DistNation	-0,1756 *(0,6133)*	-0,4365 *(0,2482)*	
DistSize	-0,1145 *(0,3553)*	-0,0870 *(0,5001)*	
DistLegalStatus	0,4575 ° *(0,0569)*	0,5249 * *(0,0371)*	0,4795 * *(0,0468)*
PublicSupport	0,3673 * *(0,0176)*	0,2250 *(0,1699)*	
TechRisk	0,3501* *(0,0500)*	0,2028 *(0,2904)*	
MotivStratCompat	0,2510 *(0,2870)*	0,2729 *(0,2716)*	
Degrees of freedom	109	107	115
AIC (Akaike information criterion): the smaller the value, the better the fit	200.01	189.43	186.30

Table 6.8.2: Ordered Probit regression models for the average achievement of technical milestone Scientific Publications (*ScientificPublications*): coefficients *(p values)* and significance levels

Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

The final Model 3 incorporating the most significant variables improves the fit of the regression (measured by the Akaike Information Criterion - AIC), as compared to Model 1 with the control variables only. The improvement of Model 3 compared to Model 2 with all control variables is also meaningful.

The variables that have a significant contribution to the specific project outcome designated as the "achievement of technical milestone: **Scientific Publication** (*ScientificPublication*)" are the following:

- the **combined** capability of partners in **Strategic Marketing** (*CombStratMkt*) has a **negative**, very significant influence on project outcome

- the **combined** capability of partners in **Physics** (*CombPhys*) has a **positive**, highly significant influence on project outcome
- the difference in **legal status** between private firms and non-profit research organsiations (*DistLegalStatus*) has a **positive**, significant influence on project outcome.

The Spearman (rank-based) correlation matrix of the significant variables and of the control variables is provided in the Table 6.8.3 hereafter.

Name of variable	CombStratMkt	CombPhys
CombStratMkt	**1.1635** ***(0.7006)***	
CombPhys	0,0277 *(0.7637)*	**1.4312** ***(1.0775)***
DistGeo	0,0263 *(0.7752)*	0,1027 *(0.2643)*
DistNation	-0,1987* *(0.02957)*	-0,0345 *(0.7083)*
DistSize	0,0477 *(0.6051)*	0,0100 *(0.9138)*
DistLegalStatus	0,1469 *(0.1093)*	-0,0254 *(0.7828)*
PublicSupport	-0,2059 * *(0.02468)*	0,1945 * *(0.03399)*
TechRisk	-0,1053 *(0.2521)*	0,3131 *** *(0.0004969)*
Motiv StrategicCompatible	0,1101 *(0.2352)*	0,1408 *(0.1282)*

Table 6.8.3: Descriptive statistics of the control and significant variables intervening in the model predicting the achievement of technical milestone - Scientific Publication (*ScientificPublication)*: **mean value, *(standard deviation)*** and Spearman correlations *(p-value)*.
*Confidence levels: *** : p value ≤1‰; ** : p value ≤1%; * : p value ≤5%; °: p value ≤ 10%*

None of the variables intervening in Model 3 (shaded cells) are significantly correlated to one another.

6.8.2.2 Models predicting Patents

The variable *Patents* is the average of answers received from both partners on the attainment of this technical milestone (§ 6.8.1).

Descriptive statistics of this variable are provided in the Table 6.8.4 hereafter:

***Patents*:** Average achievement of technical milestone: "Patents"			
Number of observations	120		
Number of discrete levels	3		
Mean value	0.3625		
Standard deviation	0.3993		
Technical milestone - Scientific publications: average number of positive answers	0	0.5	1
Number of projects	59	35	26

Table 6.8.4: Descriptive statistics of the variable *Patents*: average achievement of technical milestone "Patents"

In order to predict this variable, I have used **Ordered Probit** regression, for the same reasons as above (§ 6.8.2.1).

The results of the three regression models of my general template (§ 6.6.2) are displayed in the Table 6.8.5 hereafter.

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Name of variable	**Model 1: Control variables only**	**Model 2: Controls + most significant variables**	**Model 3: Most significant variables**
(Intercept 0-1)	0,8642 *(0,2790)*	0,4490 *(0,6158)*	0,6767 * *(0,0300)*
(Intercept 1-2)	1,7104 * *(0,0340)*	1,3942 *(0,1223)*	1,5932*** *(1,32e-06)*
DistSN		-0,7193 * *(0,0338)*	-0,6875 * *(0,0299)*
CombLegalIP		0,3208 * *(0,0277)*	0,3600 ** *(0,0087)*
CombHard		0,3921 * *(0,0104)*	0,3981 ** *(0,0057)*
DistGeo	-0,0432 *(0,1384)*	-0,0349 *(0,2911)*	
DistNation	0,0774 *(0,8209)*	0,0341 *(0,9255)*	
DistSize	-0,0003 *(0,9977)*	-0,0523 *(0,6762)*	
DistLegalStatus	-0,0413 *(0,8529)*	-0,1477 *(0,5316)*	
PublicSupport	-0,1385 *(0,3512)*	-0,0783 *(0,6277)*	
TechRisk	0,3895 * *(0,0240)*	0,2449 *(0,1822)*	
MotivStratCompat	0,1522 *(0,7057)*	-0,1257 *(0,6057)*	
Degrees of freedom	109	101	108
AIC (Akaike information criterion): the smaller the value, the better the fit	251.59	232.10	223.35

Table 6.8.5: Ordered Probit regression models for the average achievement of technical milestone Patents (*Patents*): coefficients *(p values)* and significance levels
Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

The final Model 3 incorporating the most significant variables improves the fit of the regression (measured by the Akaike Information Criterion - AIC), as compared to Model 1 with the control variables only and compared to Model 2 with all significant and control variables.

The variables that have a significant contribution to the specific project outcome designated as the "achievement of technical milestone: **Patents** (*Patents*)" are the following:

- the **distance** along the dimension of "**Mode of perception**" between the partners' organisational 'world views' (*DistSN*) has a **negative**, significant influence on project outcome
- the **combined** capability of partners in **Legal & IP management** (*CombLegalIP*) has a **positive**, very significant influence on project outcome

- the **combined** capability of partners in **Hardware design** (*CombHard*) has a **positive**, very significant influence on project outcome.

The Spearman (rank-based) correlation matrix of the significant variables and of the control variables is provided in the Table 6.8.6 hereafter.

Name of variable	DistSN	CombLegalIP	CombHard
DistSN	**0.5142** ***(0.3576)***		
CombLegalIP	0,0139 *(0.8835)*	**1.4562** ***(0.8143)***	
CombHard	0,0657 *(0.489)*	0,2731 ** *(0.0025)*	**1.310** ***(0.7826)***
DistGeo	-0,2500** *(0.0075)*	-0,0967 *(0.2933)*	-0,0599 *(0.5157)*
DistNation	-0,1188 *(0.2103)*	-0,1702 ° *(0.0630)*	-0,1701 ° *(0.06324)*
DistSize	-0,1716 ° *(0.0692)*	-0,0935 *(0.3099)*	0,0326 *(0.7238)*
DistLegalStatus	0,0836 *(0.3786)*	0,0313 *(0.7346)*	0,0910 *(0.3228)*
PublicSupport	-0,2337 * *(0.0127)*	-0,1122 *(0.2246)*	-0,0451 *(0.626)*
TechRisk	-0,1329 *(0.1606)*	0,1331 *(0.1472)*	0,1740 ° *(0.05738)*
Motiv StrategicCompatible	0,0650 *(0.494)*	0,2380 ** *(0.0094)*	0,1855 * *(0.04437)*

Table 6.8.6: Descriptive statistics of the control and significant variables intervening in the model predicting the achievement of technical milestone - Patents (*Patents)*: **mean value, *(standard deviation)*** and Spearman correlations *(p-value)*.
*Confidence levels: *** : p value ≤1‰; ** : p value ≤1%; * : p value ≤5%; °: p value ≤ 10%*

The combined capabilities in Hardware design and in Legal & IP management are significantly and positively correlated. I would interpret this as an indication that large organisations, which have a broad technical portfolio covering the full range of Hardware design, would also tend to have good capabilities in legal issues.

6.8.2.3 Models predicting Lab Demonstrators

The variable *LabDemo* is the average of answers received from both partners on the attainment of this technical milestone (§ 6.8.1).

Descriptive statistics of this variable are provided in the Table 6.8.7 hereafter:

***LabDemo*:** Average achievement of technical milestone: "Lab Demonstrator"			
Number of observations	120		
Number of discrete levels	3		
Mean value	0.6958		
Standard deviation	0.3508		
Technical milestone - Scientific publications: average number of positive answers	0	0.5	1
Number of projects	15	43	62

Table 6.8.7: Descriptive statistics of the variable *LabDemo*: average achievement of technical milestone "Lab Demonstrator"

In order to predict this variable, I have used **Ordered Probit** regression, for the same reasons as above (§ 6.8.2.1).

The results of the three regression models of my general template (§ 6.6.2) are displayed in the Table 6.8.8 hereafter.

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Name of variable	**Model 1: Control variables only**	**Model 2: Controls + most significant variables**	**Model 3: Most significant variables**
(Intercept 0-1)	-1,5411 ° *(0,0641)*	-0,9766	-0,8315 *** *(4,45e-05)*
(Intercept 1-2)	-0,4062 *(0,6237)*	0,1648	0,2826 *(0,1349)*
DistJP		0,9903 * *(0,0102)*	0,8633 * *(0,0196)*
DistGeo	0,0173 *(0,3475)*	0,0234 *(0,2167)*	
DistNation	-0,1337 *(0,6884)*	-0,2200 *(0,5352)*	
DistSize	0,0983 *(0,3961)*	0,0796 *(0,5096)*	
DistLegalStatus	-0,0703 *(0,7534)*	-0,1190 *(0,6130)*	
PublicSupport	-0,2673 ° *(0,0909)*	-0,3014 ° *(0,0681)*	
TechRisk	0,1366 *(0,4146)*	0,1500 *(0,4018)*	
MotivStratCompat	-0,0023 *(0,9917)*	0,1112 *(0,6458)*	
Degrees of freedom	109	102	109
AIC (Akaike information criterion): the smaller the value, the better the fit	239.80	224.79	216.42

Table 6.8.8: Ordered Probit regression models for the average achievement of technical milestone Lab Demonstrator (*LabDemo*): coefficients *(p values)* and significance levels
Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

The final Model 3 incorporating the most significant variables improves the fit of the regression (measured by the Akaike Information Criterion - AIC), as compared to Model 1 with the control variables only and compared to Model 2 with all significant and control variables.

The variable that has a significant contribution to the specific project outcome designated as the "achievement of technical milestone: **Lab Demonstrator** (*LabDemo*)" is the following:

- the **distance** along the dimension of "**Behaviour in the outside world**" between the partners' organisational 'world views' (*DistJP*) has a **positive**, significant influence on project outcome.

The Spearman (rank-based) correlation matrix of the significant variable and of the control variables is provided in the Table 6.8.9 hereafter.

Name of variable	DistJP
DistJP	**0.4166** ***(0.3276)***
DistGeo	-0,0057 *(0.9521)*
DistNation	0,0766 *(0.4218)*
DistSize	0,0537 *(0.5736)*
DistLegalStatus	0,0545 *(0.5684)*
PublicSupport	0,0193 *(0.8402)*
TechRisk	0,0372 *(0.6968)*
Motiv StrategicCompatible	-0,1518 *(0.1101)*

Table 6.8.9: Descriptive statistics of the control and significant variables intervening in the model predicting the achievement of technical milestone - Lab Demonstrator (*Labdemo)*: **mean value, *(standard deviation)*** and Spearman correlations *(p-value)*.
*Confidence levels: *** : p value ≤1‰; ** : p value ≤1%; * : p value ≤5%; °: p value ≤ 10%*

None of the variables intervening in Model 3 (shaded cells) are significantly correlated to one another.

6.8.2.4 Models predicting Functional prototypes

The variable *FunctionalPrototype* is the average of answers received from both partners on the attainment of this technical milestone (§ 6.8.1).

Descriptive statistics of this variable are provided in the Table 6.8.10 hereafter:

***FunctionalPrototype*:** Average achievement of technical milestone: "Functional prototype"			
Number of observations	120		
Number of discrete levels	3		
Mean value	0.5416		
Standard deviation	0.3973		
Technical milestone - Scientific publications: average number of positive answers	0	0.5	1
Number of projects	33	44	43

Table 6.8.10: Descriptive statistics of the variable *FunctionalPrototype*: average achievement of technical milestone " Functional prototype "

In order to predict this variable, I have used **Ordered Probit** regression, for the same reasons as above (§ 6.8.2.1).

The results of the three regression models of my general template (§ 6.6.2) are displayed in the Table 6.8.11 hereafter.

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Name of variable	**Model 1: Control variables only**	**Model 2: Controls + most significant variables**	**Model 3: Most significant variables**
(Intercept 0-1)	-0,7817 *(0,3119)*	-0,2170 *(0,8031)*	-0,1458 *(0,6318)*
(Intercept 1-2)	0,2160 *(0,7794)*	0,8660 *(0,3202)*	0,8762 ** *(0,0047)*
DistPhys		-0,2954 * *(0,0308)*	-0,2743 * *(0,0347)*
CombSyst		0,3225 ** *(0,0063)*	0,2291 * *(0,0381)*
CombManuf		0,4059 ** *(0,0085)*	0,3318 * *(0,0204)*
DistGeo	0,0129 *(0,4180)*	0,0184 *(0,2563)*	
DistNation	-0,4727 *(0,1372)*	-0,6036 ° *(0,0659)*	
DistSize	-0,0244 *(0,8283)*	0,0238 *(0,8378)*	
DistLegalStatus	-0,1343 *(0,5300)*	-0,3580 *(0,1136)*	
PublicSupport	0,0759 *(0,5920)*	0,1255 *(0,4003)*	
TechRisk	0,0917 *(0,5648)*	0,1752 *(0,2915)*	
MotivStratCompat	-0,1900 *(0,3671)*	-0,3488 *(0,1193)*	
Degrees of freedom	109	106	115
AIC (Akaike information criterion): the smaller the value, the better the fit	271.38	261.18	259.77

Table 6.8.11: Ordered Probit regression models for the average achievement of technical milestone Functional Prototype (*FunctionalPrototype*): coefficients *(p values)* and significance levels

Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

The final Model 3 incorporating the most significant variables improves the fit of the regression (measured by the Akaike Information Criterion - AIC), as compared to Model 1 with the control variables only and (less strongly) compared to Model 2 with all significant and control variables.

The variables that have a significant contribution to the specific project outcome designated as the "achievement of technical milestone: **Functional Prototype** (*FunctionalPrototype*)" are the following:

- the **distance** between the partners' organisational capabilities in **Physics** (*DisPhys*) has a **negative**, significant influence on project outcome

- the **combined** capability of partners in **Systems design** (*CombSyst*) has a **positive**, significant influence on project outcome
- the **combined** capability of partners in **Manufacturing technologies** (*CombManuf*) has a **positive**, significant influence on project outcome.

In order to test Nooteboom's (2000; 2007; 2005; 1999) hypothesis that the effect of cognitive distance in technical fields have a inverted-U shape on project outcome, I have tested the effect of the square of the cognitive distance in Physics (*DistPhys*) on the achievement of Functional Prototypes (FunctionalPrototype), when restricting the sample to the 56 projects where the technical risk was considered as "High" or as "Exploratory research" (*TechRisk* ≥ 3). The model (not displayed), shows no effect of the squared variable *DistPhys*.

The Spearman (rank-based) correlation matrix of the significant variables and of the control variables is provided in the Table 6.8.12 hereafter.

Name of variable	DistPhys	CombSyst	CombManuf
DistPhys	**0.9416** ***(0.8456)***		
CombSyst	-0.1738 ° *(0.0577)*	**1.9173** ***(0.9844)***	
CombManuf	0,4094*** *(3.44e-06)*	-0,1737 ° *(0.0578)*	**0.9445** ***(0.7852)***
DistGeo	0,1014 *(0.2703)*	-0,1053 *(0.2524)*	0,1132 *(0.2184)*
DistNation	-0,0530 *(0.5655)*	-0,0567 *(0.5385)*	-0,0519 *(0.5735)*
DistSize	0,0033 *(0.9714)*	-0,0193 *(0.8341)*	-0,0472 *(0.609)*
DistLegalStatus	-0,0139 *(0.8801)*	0,1093 *(0.2348)*	0,0930 *(0.3122)*
PublicSupport	-0,0619 *(0.5039)*	-0,2342 * *(0.0103)*	0,0108 *(0.907)*
TechRisk	0,1873 * *(0.0405)*	-0,1519 ° *(0.0977)*	0,1691 ° *(0.0647)*
Motiv StrategicCompatible	0,0667 *(0.4728)*	0,0544 *(0.5583)*	0,1798 ° *(0.0513)*

Table 6.8.12: Descriptive statistics of the control and significant variables intervening in the model predicting the achievement of technical milestone - Funtional Prototype (*FunctionalPrototype)*: **mean value, *(standard deviation)*** and Spearman correlations *(p-value)*.
*Confidence levels: *** : p value ≤1‰; ** : p value ≤1%; * : p value ≤5%; °: p value ≤ 10%*

The distance between partner's capabilities in Physics and the combined capabilities in Manufacturing technologies are significantly and positively correlated. I would interpret this as an indication that organisations involved in manufacturing have very contrasted capabilities in the science underlying their activity, namely Physics, and thus engage in partnerships with those that may complement them.

6.8.2.5 Models predicting the commercial milestones

The variable *ConcreteOutputCommercial* is the aggregation of variables describing the achievement of four commercial milestones: (1) Industrial prototype, (2) Pilot Production, (3) Commercial launch, (4) Commercial success.

The contingency table of this variable and descriptive statistics are given in Table 6.8.13 hereafter.

***ConcreteOutputCommercial*:** aggregation of commercial milestones					
Number of observations	120				
Number of discrete levels	5				
Mean value	0.3041				
Standard deviation	0.4906				
Number of commercial milestones reached (averaged over the two partners in the project)	0	0.5	1	1.5	2
Number of projects	76	26	10	5	3

Table **6.8.13**: Descriptive statistics of the variable *ConcreteOutputCommercial*: aggregation of four commercial milestones

In order to predict this variable, I have used **Ordered Probit** regression. This method is recommended when the number of possible values for the dependent variable is small, but yet strictly superior to 2. Since *ConcreteOutputCommercial* takes five distinct values, I am in the case of application of this method.

When following the general methodology exposed in § 6.6.1, the remaining variables are those presented under Model 3 in the Table 6.8.14 hereafter. However, as may be seen in Table 6.8.15, these variables are highly correlated with one another. This is why I continued the procedure of variables elimination, taking away the least significant variable among those of Model 3, and continuing until I reached again a situation in which all remaining variables had a significance level better than p value = 5 %. This is the situation of Model 4, where only two variables remain as being significant. The intermediate Model 2 is made by assembling the remaining significant variables from Model 4 and the control variables (§ 6.4).

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Name of variable	**Model 1: Control variables only**	**Model 2: Controls + most significant variables**	**Model 3: Variables retained following general procedure**	**Model 4: Most significant variables**
(Intercepts) - -4 values	*(not displayed)*	*(not displayed)*	*(not displayed)*	*(not displayed)*
DistPhys			-0,3980 * *(0,0244)*	
DistHard		-0,4791** *(0,0088)*	-0,4506 * *(0,0277)*	-0.3661 * *(0,0306)*
CombStratMkt		0,6965*** *(1,39e-04)*	0,8218*** *(9,11e-06)*	0,7108*** *(4,12e-05)*
CombHard			0,5633 * *(0,0109)*	
CombSoft			-0,3428 * *(0,0318)*	
CombManuf			-0,4075 * *(0,0282)*	
DistGeo	0,0229 *(0,1714)*	0,0154 *(0,3670)*		
DistNation	-0,4201 *(0,2309)*	-0,2953 *(0,4348)*		
DistSize	0,2339 ° *(0,0560)*	0,2299 ° *(0,0646)*		
DistLegalStatus	0,1370 *(0,5551)*	0,0856 *(0,7198)*		
PublicSupport	-0,2925 ° *(0,0581)*	-0,2529 *(0,1208)*		
TechRisk	0,0281 *(0,8723)*	0,1196 *(0,5114)*		
MotivStrategicCompatible	-0,0405 *(0,8553)*	-0,0994 *(0,6651)*		
Degrees of freedom	107	105	109	114
AIC (Akaike information criterion): the smaller the value, the better the fit	262.35	249.02	242.70	246.53

Table 6.8.14: Ordered Probit regression models for the aggregation of commercial milestones (*ConcreteOutputCommercial*): coefficients *(p values)* and significance levels
Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

As may be seen from the values of the Akaike Information Criterion (AIC), the final Model 4 incorporating the most significant variables and Model 2 that incorporates all control variables, including those that are not significant, improve the level of fit compared to the Model 1 with control variables only.

The variables that have a significant contribution to the specific project outcome designated as the "aggregation of four **commercial milestones** (*ConcreteOutputCommercial*)" are the following:

- the **distance** between the partners' capabilities in **Hardware design** (*DistHard*) has a **negative**, significant influence on project outcome
- the **combined** capability of partners in **StrategicMarketing** (*CombStratMkt*) has a **positive**, highly significant influence on project outcome.

In order to test the hypothesis that the effect of cognitive distance in technical fields have a inverted-U shape on project outcome, I have tested the effect of the square of the cognitive distance in Hardware design (*DistHard*) on the aggregation of commercial milestones (*ConcreteOutputCommercial*), when restricting the sample to the 56 projects where the technical risk was considered as "High" or as "Exploratory research" ($TechRisk \geq 3$). The model (not displayed), shows no effect of the squared variable *DistHard*.

The Spearman (rank-based) correlation matrix of the significant variables and of the control variables is provided in the Table 6.8.15 hereafter, with the same conventions for the shaded cells as above.

(the space below is deliberately left blank)

Name of variable	DistPhys	DistHard	Comb StratMkt	CombHard	CombSoft	Comb Manuf
DistPhys	**0.9416** ***(0.8456)***					
DistHard	0,3267*** *(0.0002)*	**0.9798** ***(0.7165)***				
Comb StratMkt	0,1789 ° *(0.0505)*	0,3737*** *(2.61e-05)*	**1.1635** ***(0.7006)***			
CombHard	0,4611*** *(1.15e-07)*	0,5615*** *(2.53e-11)*	0,3205*** *(0.0003)*	**1.31** ***(0.7826)***		
CombSoft	-0,2726** *(0.0027)*	0,1762 ° *(0.0552)*	0,0718 *(0.4378)*	0,1851* *(0.0439)*	**1.5341** ***(0.8708)***	
CombManuf	0,4094*** *(3.44e-06)*	0,1821* *(0.0465)*	0,3641*** *(4.36e-05)*	0,5147*** *(1.81e-09)*	-0,1887 * *(0.0399)*	**0.9445** ***(0.7852)***
DistGeo	0,1014 *(0.2703)*	-0,0225 *(0.8076)*	0,0263 *(0.7752)*	-0,0599 *(0.5157)*	-0,2127 * *(0.0202)*	0,1132 *(0.2184)*
DistNation	-0,0530 *(0.5655)*	-0,2277* *(0.0123)*	-0,1987* *(0.02957)*	-0,1701 ° *(0.0632)*	-0,2234 * *(0.0145)*	-0,0519 *(0.5735)*
DistSize	0,0033 *(0.9714)*	0,0122 *(0.8947)*	0,0477 *(0.6051)*	0,0326 *(0.7238)*	-0,0752 *(0.4165)*	-0,0472 *(0.609)*
Dist LegalStatus	-0,0139 *(0.8801)*	0,1157 *(0.2081)*	0,1469 *(0.1093)*	0,0910 *(0.3228)*	0,1751 ° *(0.0568)*	0,0930 *(0.3122)*
Public Support	-0,0619 *(0.5039)*	-0,1870* *(0.0416)*	-0,2059 * *(0.02468)*	-0,0451 *(0.626)*	-0,1903 * *(0.0390)*	0,0108 *(0.907)*
TechRisk	0,1873 * *(0.0405)*	0,0402 *(0.6625)*	-0,1053 *(0.2521)*	0,1740 ° *(0.0573)*	-0,0866 *(0.3493)*	0,1691 ° *(0.0647)*
Motiv Strategic Compatible	0,0667 *(0.4728)*	0,0987 *(0.2875)*	0,1101 *(0.2352)*	0,1855 * *(0.0443)*	0,0394 *(0.673)*	0,1798 ° *(0.0513)*

Table 6.8.15: Descriptive statistics of the control and significant variables intervening in the model predicting the aggregation of four commercial milestones (*ConcreteOutputCommercial)*: **mean value, *(standard deviation)*** and Spearman correlations *(p-value)*.
*Confidence levels: *** : p value ≤1‰; ** : p value ≤1%; * : p value ≤5%; °: p value ≤ 10%*

The variables intervening in Model 3 are very significantly correlated to one another. This is why the elimination procedure was pursued until reaching Model 4. The two variables intervening in Model 4 (*DistHard* and *CombStratMkt*) are strongly and positively correlated to one another (shaded cell). However, since they have opposite effects in the prediction model, I have decided to keep them.

6.8.2.6 Models predicting the creation of scientific knowledge

The contingency table of the variable expressing the creation of scientific knowledge (*KnowCreateScientific*) and descriptive statistics are given in Table 6.8.16 hereafter.

***KnowCreateScientific*:** Creation of scientific knowledge			
Number of observations	120		
Number of discrete levels	3		
Mean value	0.6666		
Standard deviation	0.3450		
Creation of scientific knowledge: average number of positive answers	0	0.5	1
Number of projects	15	50	55

Table 6.8.16: Descriptive statistics of the variable *KnowCreateScientific*: creation of scientific knowledge

In order to predict the creation of scientific knowledge, I have used **Ordered Probit** regression. This method is recommended when the number of possible values for the dependent variable is small, but yet strictly superior to 2. Since the mean value of the binary information about whether this type of knowledge was created may take three distinct values (when both partners agree on there having been no knowledge creation, when one contends there was while the other doesn't, and when they agree that there was), I am in the case of application of this method.

The results of the three regression models of my general template (§ 6.6.2) are displayed in the Table 6.8.17 hereafter.

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Name of variable	**Model 1: Control variables only**	**Model 2: Controls + most significant variables**	**Model 3: Most significant variables**
(Intercept 0-1)	0.9807 *(0.2196)*	0.1175 *(0.8886)*	-1.2297 *** *(1.381e-05)*
(Intercept 1-2)	2.3159 * *(0.0224)*	1.5561 *(0.1226)*	0.1361 *(0.5918)*
CombStratMkt		-0.4857 ** *(0.0060)*	-0.3723 * *(0.0187)*
CombPhys		0.2612 * *(0.0186)*	0.3152 ** *(0.0024)*
DistGeo	0.0146 *(0.4068)*	0.0249 *(0.1834)*	
DistNation	-0.0404 *(0.9026)*	-0.3012 *(0.3930)*	
DistSize	-0.0031 *(0.9582)*	0.0349 *(0.7660)*	
DistLegalStatus	0.0945 *(0.6686)*	0.1592 *(0.4838)*	
PublicSupport	0.0578 *(0.6944)*	-0.0958 *(0.5382)*	
TechRisk	0.3767 * *(0.0254)*	0.2696 *(0,1248)*	
MotivStrategicCompatible	0.3620 ° *(0.0956)*	0.4029 ° *(0.0714)*	
Degrees of freedom	109	107	116
AIC (Akaike information criterion): the smaller the value, the better the fit	240.79	232.20	228.90

Table 6.8.17: Ordered Probit regression models for the creation of scientific knowledge: coefficients *(p values)* and significance levels
Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

As may be seen from the values of the Akaike Information Criterion (AIC), the final Model 3 incorporating the most significant variables improves the level of fit compared to both the Model 1 with control variables only, and compared to Model 2 that incorporates all control variables, including those that are not significant.

The variables that have a significant contribution to the specific project outcome designated as the "**creation** of **scientific** knowledge (*KnowCreateScientific*)" are the following:

- the **combined** capability of partners in **StrategicMarketing** (*CombStratMkt*) has a **negative**, highly significant influence on project outcome
- the **combined** capability of partners in **Physics** (*CombPhys*) has a **positive**, highly significant influence on project outcome.

The Spearman (rank-based) correlation matrix of the significant variables and of the control variables was already provided earlier in Table 6.8.3.

6.8.2.7 Models predicting the creation of technical knowledge

The contingency table of the variable expressing the creation of technical knowledge (*KnowCreateTechnical*) and descriptive statistics are given in Table 6.8.18 hereafter.

***KnowCreateTechnical*:** Creation of technical knowledge			
Number of observations	120		
Number of discrete levels	3		
Mean value	0.8666		
Standard deviation	0.2488		
Creation of technical knowledge: average number of positive answers	0	0.5	1
Number of projects	3	26	91

Table 6.8.18: Descriptive statistics of the variable *KnowCreateTechnical*: creation of technical knowledge

In order to predict the creation of technical knowledge, I have used **Ordered Probit** regression, for reasons identical to those above.

The results of the three regression models of my general template (§ 6.6.2) are displayed in the Table 6.8.19 hereafter.

(the space below is deliberately left blank)

Name of variable	**Model 1: Control variables only**	**Model 2: Controls + most significant variables**	**Model 3: Most significant variables**
(Intercept 0-1)	-2.3912 * *(0,014)*	-2,5191 * *(0,0142)*	-1,5050 *** *(1,36e-06)*
(Intercept 1-2)	-1.1109 *(0,2458)*	-1,0988 *(0,2698)*	-0,1718 *(0,4832)*
CombHard		0,6224 ** *(0,0018)*	0,4312 * *(0,0156)*
DistGeo	0.0343 *(0,2758)*	0,0443 *(0,1824)*	
DistNation	-0.3747 *(0,3212)*	-0,3159 *(0,4228)*	
DistSize	0.0263 *(0,8432)*	0,0297 *(0,8296)*	
DistLegalStatus	0,2176 *(0,3934)*	0,1576 *(0,5494)*	
PublicSupport	0,1870 *(0,2574)*	0,2001 *(0,2354)*	
TechRisk	-0,1946 *(0,3216)*	-0,2918 *(0,1466)*	
MotivStrategicCompatible	-0,2446 *(0,3430)*	-0,4585 ° *(0,0926)*	
Degrees of freedom	109	108	117
AIC (Akaike information criterion): the smaller the value, the better the fit	161.36	152.48	151.65

Table 6.8.19: Ordered Probit regression models for the creation of technical knowledge: coefficients *(p values)* and significance levels
Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

As may be seen from the values of the Akaike Information Criterion (AIC), the final Model 3 incorporating the most significant variables improves, but only modestly, the level of fit compared to both the Model 1 with control variables only, and compared to Model 2 that incorporates all control variables, including those that are not significant.

The variable that has a significant contribution to the specific project outcome designated as the "**creation** of **technical** knowledge (*KnowCreateTechnical*)" is the following:

- the **combined** capability of partners in **Hardware design** (*CombHard*) has a **positive**, highly significant influence on project outcome.

The Spearman (rank-based) correlation matrix of the significant variable *CombHard* and of the control variables was already provided in the Table 6.8.6 above.

6.8.2.8 Models predicting the creation of marketing knowledge

The contingency table of the variable expressing the creation of marketing knowledge (*KnowCreateMarketing*) and descriptive statistics are given in Table 6.8.20 hereafter.

***KnowCreateMarketing*:** Creation of marketing knowledge			
Number of observations	120		
Number of discrete levels	3		
Mean value	0.2458		
Standard deviation	0.3240		
Creation of marketing knowledge: average number of positive answers	0	0.5	1
Number of projects	71	39	10

Table 6.8.20: Descriptive statistics of the variable *KnowCreateMarketing*: creation of marketing knowledge

In order to predict the creation of marketing knowledge, I have used **Ordered Probit** regression, for reasons identical to those above.

The results of the three regression models of my general template (§ 6.6.2) are displayed in the Table 6.8.21 hereafter.

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Name of variable	**Model 1: Control variables only**	**Model 2: Controls + most significant variables**	**Model 3: Most significant variables**
(Intercept 0-1)	0,3279 *(0,6884)*	1,7681 ° *(0,0730)*	0,9255** *(0,0012)*
(Intercept 1-2)	1,4747 ° *(0,0652)*	3,0943 ** *(0,0023)*	2,1170 *** *(7,62e-11)*
DistSN		0,8717 * *(0,0109)*	0,7495 * *(0,0203)*
DisagLeader		-0,6441 * *(0,0360)*	-0,6389 * *(0,0316)*
CombStratMkt		0,4160 * *(0,0178)*	0,3914 * *(0,0159)*
DistGeo	0,0129 *(0,4668)*	-0,0017 *(0,9287)*	
DistNation	-0,5099 *(0,1538)*	-0,1220 *(0,7519)*	
DistSize	0,0822 *(0,4936)*	0,1066 *(0,4016)*	
DistLegalStatus	-0,1001 *(0,6618)*	-0,1100 *(0,6538)*	
PublicSupport	-0,1541 *(0,3128)*	0,0580 *(0,7382)*	
TechRisk	0,2087 *(0,2414)*	0,2792 *(0,1470)*	
MotivStrategicCompatible	-0,0057 *(0,9792)*	-0,0810 *(0,7335)*	
Degrees of freedom	109	101	108
AIC (Akaike information criterion): the smaller the value, the better the fit	221.06	204.38	193.75

Table 6.8.21: Ordered Probit regression models for the creation of marketing knowledge: coefficients *(p values)* and significance levels
Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

As may be seen from the values of the Akaike Information Criterion (AIC), the final Model 3 incorporating the most significant variables improves very strongly the level of fit compared to both the Model 1 with control variables only, and compared to Model 2 that incorporates all control variables, including those that are not significant.

The variables that have a significant contribution to the specific project outcome designated as the "**creation** of **marketing** knowledge (*KnowCreateMarketing*)" are the following:

- the **distance** along the dimension of "**Mode of perception**" between the partners' organisational 'world views' (*DistSN*) has a **positive**, significant influence on project outcome
- the **disagreement** among partners as to which organisation is the **leader** of the project (*DisagLeader*) has a **negative**, significant influence on project outcome

- the **combined** capability of partners in **StrategicMarketing** (*CombStratMkt*) has a **positive**, significant influence on project outcome.

The Spearman (rank-based) correlation matrix of the significant variables and of the control variables is provided in the Table 6.8.22 hereafter. Only the variable expressing the disagreement regarding who the leader is (*DisagLeadeer*) is displayed, since the other significant variables, the distance along the dimension of 'Mode of perception' (*DistSN*) and the combined capability in Strategic Marketing (*CombStratMkt)*, already were presented separately earlier (§ 6.8.2.1 and 6.8.2.2). This is why only the correlation between these two variables is present in the table.

Name of variable	DistSN	DisagLeader	Comb StratMkt
DistSN	**0.5142** ***(0.3576)***		
DisagLeader	0,1292 *(0.1725)*	**0.225** ***(0.4193)***	
CombStratMkt	0,1153 *(0.224)*	-0,1449 *(0.1144)*	*(see § 6.8.2.1)*
DistGeo	*(see § 6.8.2.2)*	0,0339 *(0.7132)*	*(see § 6.8.2.1)*
DistNation	*(see § 6.8.2.2)*	0,0557 *(0.5456)*	*(see § 6.8.2.1)*
DistSize	*(see § 6.8.2.2)*	0,0214 *(0.8161)*	*(see § 6.8.2.1)*
DistLegalStatus	*(see § 6.8.2.2)*	0,1870 * *(0.0408)*	*(see § 6.8.2.1)*
PublicSupport	*(see § 6.8.2.2)*	-0,0224 *(0.8089)*	*(see § 6.8.2.1)*
TechRisk	*(see § 6.8.2.2)*	0,0177 *(0.8475)*	*(see § 6.8.2.1)*
MotivStrategic Compatible	*(see § 6.8.2.2)*	0,0028 *(0.9759)*	*(see § 6.8.2.1)*

Table 6.8.22: Descriptive statistics of the control and significant variables intervening in the model predicting the creation of marketing knowledge (*KnowCreateMarketing)*: **mean value, *(standard deviation)*** and Spearman correlations *(p-value)*.
Confidence levels: *** : p value ≤1‰; ** : p value ≤1%; * : p value ≤5%; °: p value ≤ 10%

None of the variables intervening in Model 3 (shaded cells) are significantly correlated to one another.

6.8.2.9 Models predicting the creation of knowledge: identification of dead ends

The contingency table of the variable expressing the creation of knowledge in the identification of dead ends (*KnowCreateDeadEnd*) and descriptive statistics are given in Table 6.8.23 hereafter.

***KnowCreateDeadEnd*:** Creation of knowledge: identification of dead ends			
Number of observations	120		
Number of discrete levels	3		
Mean value	0.1666		
Standard deviation	0.3063		
Creation of knowledge - identification of dead ends: average number of positive answers	0	0.5	1
Number of projects	89	22	9

Table 6.8.23: Descriptive statistics of the variable *KnowCreateDeadEnd*: creation of knowledge - identification of dead ends

In order to predict the creation of the knowledge that the direction being investigated is a dead end, I have used **Ordered Probit** regression, for reasons identical to those above.

The results of the regression models of my general template (§ 6.6.2) are displayed in the Table 6.8.24 hereafter. Since the most significant variable is one of the control variables, there is no point in having an intermediary Model 2 that would contain the control variables and the most significant ones.

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Name of variable	**Model 1: Control variables only**	**Model 3: Most significant variables**
(Intercept 0-1)	3,2041 ** *(0,0014)*	2.2561 *** *(0.0002)*
(Intercept 1-2)	3,9795 *** *(6,90e-05)*	3.099 *** *(1.50e-06)*
DistGeo	-0,0007 *(0,9702)*	
DistNation	0,0955 *(0,7988)*	
DistSize	0,0085 *(0,9408)*	
DistLegalStatus	0,6181 * *(0,0284)*	
PublicSupport	-0,2011 *(0,2504)*	
TechRisk	0,6819 ** *(0,0020)*	0.5807 ** *(0.0047)*
MotivStrategicCompatible	0,3937 *(0,1284)*	
Degrees of freedom	109	117
AIC (Akaike information criterion): the smaller the value, the better the fit	174.42	171.75

Table 6.8.24: Ordered Probit regression models for the creation of knowledge - identification of a dead end: coefficients *(p values)* and significance levels
Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

As may be seen from the values of the Akaike Information Criterion (AIC), the final Model 3 incorporating the most significant variables improves moderately the level of fit compared to the Model 1 with control variables only.

The variable having a significant contribution to the specific project outcome designated as the "**creation** of knowledge - identification of a **dead end** (*KnowCreateDeadEnd*)" is the following:

- the level of **technical risk** of the project (*TechRisk*) has a **positive**, highly significant influence on project outcome.

The Spearman (rank-based) correlation matrix of the control variables was provided above in § 6.4.

6.8.2.10 Models predicting the creation of knowledge: discovery of unforeseen opportunities

The contingency table of the variable expressing the creation of knowledge in the discovery of new, unforeseen opportunities (*KnowCreateOpportunities*) and descriptive statistics are given in Table 6.8.25 hereafter.

KnowCreateOpportunities: Creation of knowledge: discovery of new, unforeseen opportunities			
Number of observations	120		
Number of discrete levels	3		
Mean value	0.4708		
Standard deviation	0.3626		
Creation of knowledge - identification of dead ends: average number of positive answers	0	0.5	1
Number of projects	35	57	28

Table 6.8.25: Descriptive statistics of the variable *KnowCreateOpportunities*: discovery of new, unforeseen opportunities

In order to predict the discovery of a new, unforeseen opportunities, which is another form of knowledge creation, I have used **Ordered Probit** regression, for reasons identical to those above.

The results of the three regression models of my general template (§ 6.6.2) are displayed in the Table 6.8.26 hereafter.

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Name of variable	**Model 1: Control variables only**	**Model 2: Controls + most significant variables**	**Model 3: Most significant variables**
(Intercept 0-1)	-0,3271 *(0,6710)*	-1,0115 *(0,2436)*	-1,7094 ** *(0,0001)*
(Intercept 1-2)	0,9870 *(0,2022)*	0,3922 *(0,6488)*	-0,3742 *(0,3630)*
DistTeamSize		-0,3537 * *(0,0250)*	-0,3577 * *(0,0220)*
MotivPreviousExperience		-0,4197 * *(0,0128)*	-0,3591 ** *(0,0261)*
DistGeo	-0,0207 *(0,2260)*	-0,0196 *(0,2550)*	
DistNation	0,3185 *(0,3146)*	0,1976 *(0,5420)*	
DistSize	0,0531 *(0,6320)*	-0,0117 *(0,9212)*	
DistLegalStatus	0,2550 *(0,2334)*	0,3755 *(0.1016)*	
PublicSupport	-0,0689 *(0,6292)*	0,0188 *(0,9016)*	
TechRisk	0,2147 *(0,1868)*	0,3241 ° *(0.0682)*	
MotivStrategicCompatible	-0,1354 *(0,5122)*	-0,0972 *(0,6582)*	
Degrees of freedom	109	97	104
AIC (Akaike information criterion): the smaller the value, the better the fit	260.52	232.97	227.04

Table 6.8.26: Ordered Probit regression models for the creation of knowledge - discovery of unforeseen opportunities (*KnowCreateOpportunities*): coefficients *(p values)* and significance levels

Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

As may be seen from the values of the Akaike Information Criterion (AIC), the final Model 3 incorporating the most significant variables improves (very strongly) the level of fit compared to the Model 1 with control variables only, and (more modestly) compared to Model 2 that incorporates all control variables, including those that are not significant.

The variables that have a significant contribution to the specific project outcome designated as the "**creation** of knowledge - discovery of unforeseen opportunities (*KnowCreateOpportunities*)" are the following:

- the **distance** between the typical **team sizes** for R&D projects of both partners (*DistTeamSize*) has a **negative**, significant influence on project outcome
- the existence of a **prior positive experience** between the partners in the project, operationalised as the degree by which this consideration motivated them to choose

this specific partner in the project (*MotivPrevExperience*) has a **negative**, significant influence on project outcome.

The Spearman (rank-based) correlation matrix of the significant variables and of the control variables is provided in the Table 6.8.27 hereafter.

Name of variable	DistTeamSize	MotivPrevious Experience
DistTeamSize	**0.7363** ***(0.6996)***	
MotivPrevious Experience	-0,1147 *(0.237)*	**2.2991** ***(0.6949)***
DistGeo	-0,0364 *(0.7061)*	-0,1568 ° *(0.0912)*
DistNation	-0,0416 *(0.6657)*	-0,1100 *(0.2379)*
DistSize	0,0350 *(0.7163)*	0,0280 *(0.7646)*
DistLegalStatus	-0,0145 *(0.8805)*	0,0767 *(0.4109)*
PublicSupport	-0,0235 *(0.8072)*	0,0283 *(0.762)*
TechRisk	-0,0381 *(0.693)*	0,1134 *(0.2236)*
MotivStrategic Compatible	0,0130 *(0.8935)*	0,0941 *(0.3131)*

Table 6.8.27: Descriptive statistics of the control and significant variables intervening in the model predicting the creation knowledge - discovery of unforeseen opportunities (*KnowCreateOpportunities)*: **mean value, *(standard deviation)*** and Spearman correlations *(p-value)*.
Confidence levels: *** : p value ≤1‰; ** : p value ≤1%; * : p value ≤5%; °: p value ≤ 10%

None of the variables intervening in Model 3 (shaded cells) are significantly correlated to one another.

6.8.2.11 Models predicting the compliance with schedule

The variable *ProjMgmtSchedule* represents the compliance with the project schedule, averaged over the answers from both partners.

The contingency table of this variable and descriptive statistics are given in Table 6.8.28 hereafter.

***ProjMgmtSchedule*:** Compliance with project schedule								
Number of observations	120							
Number of discrete levels	8							
Mean value	3.7875							
Standard deviation	0.7850							
Compliance level (averaged over the two partners in the project)	1	2	2,5	3	3,5	4	4,5	5
Number of projects	1	5	3	20	20	41	16	14

Table **6.8.28**: Descriptive statistics of the variable *ProjMgmtSchedule*: compliance with project schedule

In order to predict this variable, I have used **Ordered Probit** regression. This method is recommended when the number of possible values for the dependent variable is small, but yet strictly superior to 2. Since *ProjMgmtSchedule* takes eight distinct values, I am in the case of application of this method.

The results of the three regression models of my general template (§ 6.6.2) are displayed in the Table 6.8.29 hereafter.

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Name of variable	**Model 1: Control variables only**	**Model 2: Controls + most significant variables**	**Model 3: Most significant variables**
(Intercepts) - -7 values	*(not displayed)*	*(not displayed)*	*(not displayed)*
DistJP		0,6199 ° *(0,0523)*	0,6651 * *(0,0315)*
DistStratMkt		-0,2951 * *(0,0131)*	-0,2231 * *(0,0385)*
DistRDMgmt		0,3962 ** *(0,0089)*	0,3588 * *(0,0143)*
DistGeo	-0,0029 *(0,8484)*	0,0001 *(0,9928)*	
DistNation	-0,4257 *(0,1467)*	-0,7069 * *(0,0255)*	-0,5914 * *(0,0192)*
DistSize	0,1282 *(0,2180)*	0,2005 ° *(0,0643)*	
DistLegalStatus	-0,2350 *(0,2342)*	0,1475 *(0,5106)*	
PublicSupport	-0,1065 *(0,4164)*	-0,2741 * *(0,0463)*	
TechRisk	0,0818 *(0,5808)*	0,0584 *(0,7090)*	
MotivStrategicCompatible	-0,1103 *(0,5672)*	-0,1731 *(0,3961)*	
Degrees of freedom	104	95	101
AIC (Akaike information criterion): the smaller the value, the better the fit	433.97	399.49	395.13

Table 6.8.29: Ordered Probit regression models for the compliance with project schedule (*ProjMgmtSchedule*): coefficients *(p values)* and significance levels
Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

As may be seen from the values of the Akaike Information Criterion (AIC), the final Model 3 incorporating the most significant variables and Model 2 that incorporates all control variables, including those that are not significant, strongly improve the level of fit compared to the Model 1 with control variables only.

The variables that have a significant contribution to the specific project outcome designated as the "compliance with project **schedule** (*ProjMgmtSchedule*)" are the following:

- the **distance** along the dimension of "**Behaviour in the outside world**" between the partners' organisational 'world views' (*DistJP*) has a **positive**, significant influence on project outcome
- the **distance** between the partners' capabilities in **Strategic Marketing** (*DistStratMkt*) has a **negative**, significant influence on project outcome
- the **distance** between the partners' capabilities in **Management of R&D operations** (*DistRDMgmt*) has a **positive**, significant influence on project outcome

- the difference between the **nationalities** of partners (*DistNation*) has a **negative**, significant influence on project outcome.

The Spearman (rank-based) correlation matrix of the significant variables and of the control variables is provided in the Table 6.8.30 hereafter.

Name of variable	DistJP	DistStratMkt	DistRDMgmt
DistJP	**0.4166** ***(0.3276)***		
DistStratMkt	0,0038 *(0.9679)*	**1.0562** ***(0.9671)***	
DistRDMgmt	0,0658 *(0.4905)*	0,1860 * *(0.0419)*	**1.1333** ***(0.7069)***
DistGeo	-0,0057 *(0.9521)*	-0,0336 *(0.7156)*	-0,0119 *(0.897)*
DistNation	0,0766 *(0.4218)*	-0,2260 * *(0.0130)*	0,0140 *(0.8792)*
DistSize	0,0537 *(0.5736)*	0,0015 *(0.9874)*	-0,0206 *(0.8235)*
Dist LegalStatus	0,0545 *(0.5684)*	0,4004 *** *(5.873e-06)*	-0,0762 *(0.4082)*
Public Support	0,0193 *(0.8402)*	-0,1095 *(0.2358)*	-0,0065 *(0.9442)*
TechRisk	0,0372 *(0.6968)*	-0,1248 *(0.1744)*	-0,0764 *(0.407)*
Motiv Strategic Compatible	-0,1518 *(0.1101)*	-0,0810 *(0.3833)*	-0,0534 *(0.566)*

Table 6.8.30: Descriptive statistics of the control and significant variables intervening in the model predicting the compliance with project schedule (*ProjMgmtSchedule)*: **mean value, *(standard deviation)*** and Spearman correlations *(p-value)*.
*Confidence levels: *** : p value ≤1‰; ** : p value ≤1%; * : p value ≤5%; °: p value ≤ 10%*

The distance between the partners' capabilities in Strategic Marketing are significantly correlated to both the distance in Management of R&D operations and with the difference in nationality. I would interpret the former, positive, correlation as the consequence of these two sets of capabilities being management capabilities, and thus more represented in private firms. I would consider the latter, negative, correlation as a consequence of organisations seeking partners with features close to theirs when taking the additional risk of working with organisations abroad.

6.9 Prediction of project outcomes at organisation level

In a second series of models, I have attempted to predict, for the co-operative R&D projects of my sample, the outcomes at **organisation** level, in which the issue is to understand the outcome of the project for each of the partners involved. In this section, the partner organisations play asymmetrical roles: it may happen that in a given project, one partner benefits while the other does not.

In this section, I will first present the variables of my models (§ 6.9.1): the dependent variables, that describe various sorts of outcomes at the organisation level, and the independent, potentially explanatory, variables. I will then briefly expose in § 6.9.2 the methods that I use to select the regression algorithm, and finally present in § 6.9.3 the regression models that I developed, and that predict these outcomes, using both the control variables (§ 6.4) and those among the variables introduced by my research (§ 6.5) that prove to be statistically significant.

6.9.1 Variables of the regression models

6.9.1.1 Dependent variables

The dependent variables in my regression models are:

- the variables describing the **modification** of the focal organisation **capability** caused by the co-operative R&D project being investigated, in each of the scientific & technical areas and in each of the innovation management areas that the organisation considered as part of its 'core' competence. The degree at which the capability was modified is designated as *ModifXXX*, with XXX the acronym of the capability area specified in § 5.5. Its conventional numeric value in each sub-field is expressed in a six-levels scale (§ 5.7.1), while the aggregated value (valid as per § 6.3) is computed and normalised to be in the [0 1] interval as per § 5.7.2

- the three fields of **knowledge transfer** (scientific, technical, marketing), described in § 5.5, caused by the co-operative R&D project being investigated. These are binary variables. They cannot be aggregated into a single variable (as per § 6.3)
- the variable *ProjMgmtCostBudget* describing the **compliance** with project **cost budget**, as seen by the focal organisation, which is a part of project management performance.

Since I consider the modification of capabilities at organisation level, the full population of my sample is equal to the number of organisations involved in the co-operative R&D projects being investigated, that is **240 organisations** (i.e. the double of the number of projects).

However, only the modification of those areas of capabilities considered as 'core' by the respondent were asked in the survey. Therefore, the number of observations for these variables is significantly lower than the full sample of organisations.

6.9.1.2 Independent, potentially explanatory variables

The dependent variables that the models attempt to predict are **learning** processes, in which the focal organisation improves its capabilities, or receives knowledge transferred from its partner, during the project. The potentially explanatory variables that I will explore hereafter, in addition to the common control variables (§ 6.4), are therefore: (1) symmetrical variables (among those exposed in § 6.5.1) that may have an influence on the communication between

partners during the learning process and (2) the asymmetrical variables (exposed and justified in § 6.5.2). The symmetrical variables that I consider may have an influence on learning are (1) the cognitive distance in 'world views', (2) the cognitive distance in structural features of the organisations and (3) the initial conditions of the project.

The control variables at project level (*PublicSupport*, *TechRisk* and *MotivStrategicCompatible*) are directly taken from the answers to the survey provided by the focal organisation. In contrast to § 6.8, the mean value with the answer from the partner is not computed.

The relations that I investigate in this section between independent, potentially explanatory variables, and the dependent variables are described in the Figure 6.9.1 hereafter.

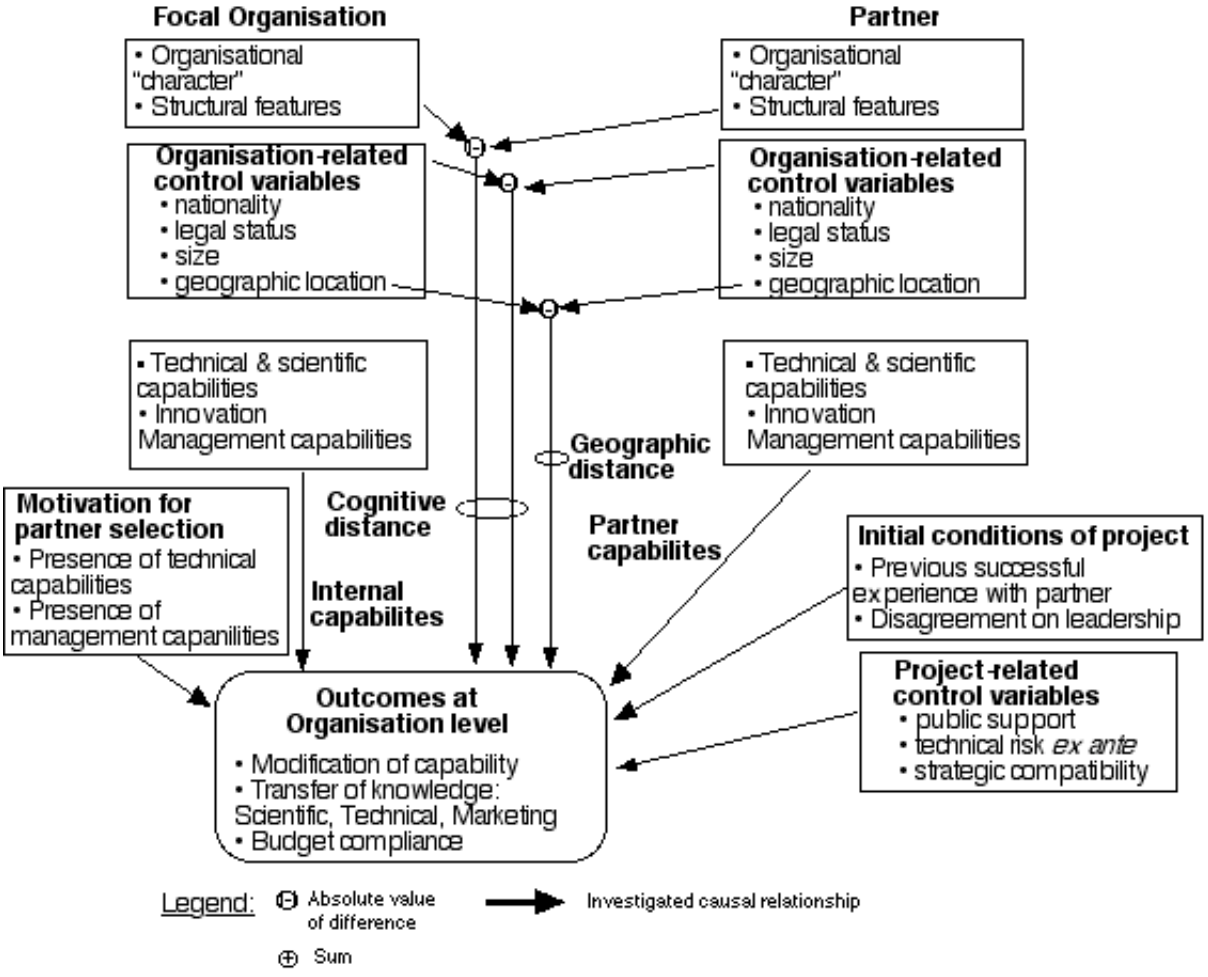

Figure 6.9.1: Relations between the investigated variables at organisation level

6.9.2 Method to choose the regression algorithm

The variables describing the aggregated modification of capabilities take a number of discrete possible values. When the number of possible values is small (10 or below), and significantly below the number of observations, I choose an Ordered Probit regression. In the other cases,

the number of possible values becomes close to the number of observations, and I choose an Ordinary Least Squares linear regression method.

6.9.3 Regression models

6.9.3.1 Models predicting the modification of capability in Strategic Marketing

The variable *ModifStratMkt* describes the aggregated modification of capability in **Strategic Marketing** for the focal organisation.

The histogram of this variable is given in Figure 6.9.2 hereafter.

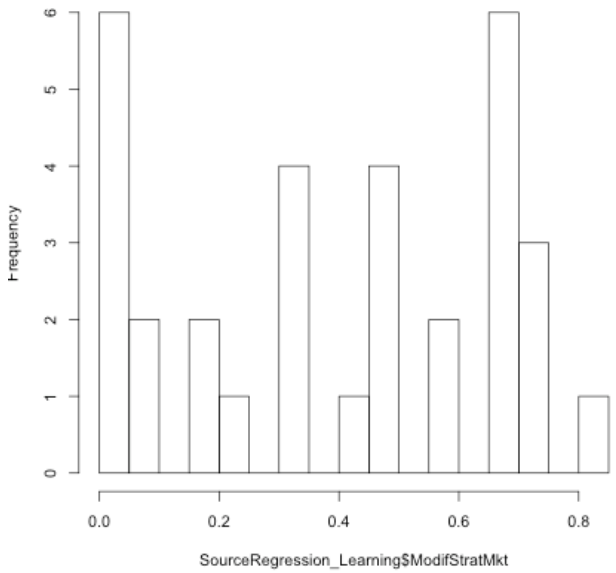

Figure 6.9.2: Histogram of the variable *ModifStratMkt*: aggregated modification of capability in Strategic Marketing

The descriptive statistics of this variable are given in Table 6.9.1 hereafter.

***ModifStratMkt*:** aggregated modification of capability in Strategic Marketing	
Number of observations	32
Number of discrete levels	12
Mean value	0.3984
Standard deviation	0.2781

Table 6.9.1: Descriptive statistics of the variable *ModifStratMkt*: aggregated modification of capability in Strategic Marketing

The number of observations of *ModifStratMkt* is equal to 32. Therefore, the fully rigorous method described in § 6.6.1 cannot be used, because the number of potentially explanatory variables in the initial steps of the procedure (equal to 17) would be too close to the number of observations. I have therefore chosen a simplified procedure, in which the initial model, from which I progressively eliminate candidate explanatory variables, is set up by gathering the

eight variables that have proven to be significant in predicting the other forms of capability modification or of knowledge transfer, and that I have summarised above (§ 6.7). I then proceeded using the standard elimination method of § 6.6.1.

There are 12 possible discrete levels for this variable, and 32 observations. This is why I chose a linear, **Ordinary Least Squares**, regression.

The results of the three regression models of my general template (§ 6.6.2) are displayed in the Table 6.9.2 hereafter.

Name of variable	**Model 1: Control variables only**	**Model 2: Controls + most significant variables**	**Model 3: Most significant variables**
(Intercept)	-0,1993 *(0,6053)*	0.0848 *(0.8172)*	0.30390 * *(0.0386)*
DistSN		-0.2739 ° *(0.0601)*	-0.2339 * *(0.0473)*
MotivGeneralCompetence		0.0907 *(0.2014)*	0.1319 * *(0.0245)*
DistGeo	0,0093 *(0,7537)*	0.0090 *(0.3146)*	
DistNation	0,1598 *(0,4458)*	-0.0116 *(0.9531)*	
DistSize	-0,0767 *(0,1539)*	-0.0600 *(0.2201)*	
DistLegalStatus	-0,0287 *(0,7938)*	-0.0242 *(0.8225)*	
PublicSupport	0,1486 * *(0,0347)*	0.0540 *(0.4797)*	
TechRisk	0,1119 *(0,1649)*	0.0620 *(0.4113)*	
MotivStrategicCompatible	0,0147 *(0,8720)*	0.0381 *(0.6533)*	
Degrees of freedom	21	18	27
Adjusted R^2	0.0795	0.2376	0.2581
Shapiro-Wilk test of normality of residuals: p-value	0.4461	0.4579	0.8497

Table 6.9.2: Linear regression models for the aggregated modification of capability in Strategic Marketing (*ModifStratMkt*): coefficients *(p values)* and significance levels
Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

The final Model 3 incorporating the most significant variables considerably improves the explanatory power of the regression, as compared to Model 1 with the control variables only: the Adjusted R^2 metric (a measure of the amount of the variance being explained by the model) increases from 0. 0795 to 0. 2581. The improvement of explanatory power of Model 3 compared to Model 2 is modest.

The Shapiro-Wilk normality test applied to the residuals of all three models are high: we should not reject the hypothesis that the residuals are indeed normal.

The variables that have a significant contribution to the project outcome at organisation level designated as the "modification of **Strategic Marketing** capabilities" (*ModifStratMkt*)" are the following:

- the **distance** along the dimension of "**Mode of perception**" between the partners' organisational 'world views' (*DistSN*) has a **negative**, significant influence on project outcome
- the level of **motivation** to select this specific partner because of its **innovation management** capabilities (*MotivGeneralCompetence*) has a **positive**, significant influence on project outcome.

The Spearman (rank-based) correlation matrix of the significant variables and of the control variables is provided in the Table 6.9.3 hereafter. Only the values involving the variable *MotivGeneralCompetence* are provided, since those for *DistSN* were already given in § 6.8.2.8.

Name of variable	MotivGeneral Competence
MotivGeneral Competence	**1.9733** ***(0.7957)***
DistSN	0,0440 *(0.5223)*
DistGeo	0,0933 *(0.1633)*
DistNation	0,0571 *(0.3939)*
DistSize	-0,0873 *(0.192)*
DistLegalStatus	-0,0494 *(0.461)*
PublicSupport	-0,0011 *(0.987)*
TechRisk	-0,0556 *(0.4108)*
MotivStrategic Compatible	0,1370 * *(0.0437)*

Table 6.9.3: Descriptive statistics of the control and significant variables intervening in the model predicting the aggregated modification of Strategic Marketing capabilities (*ModifStratMkt)*: **mean value, *(standard deviation)*** and Spearman correlations *(p-value)*.
*Confidence levels: *** : p value ≤1‰; ** : p value ≤1%; * : p value ≤5%; °: p value ≤ 10%*

None of the variables intervening in Model 3 (shaded cells) are significantly correlated to one another.

6.9.3.2 Models predicting the modification of capability in Management of R&D operations

The variable *ModifRDMgmt* describes the aggregated modification of capability in **Management of R&D operations** for the focal organisation.

The histogram of this variable is given in Figure 6.9.3 hereafter.

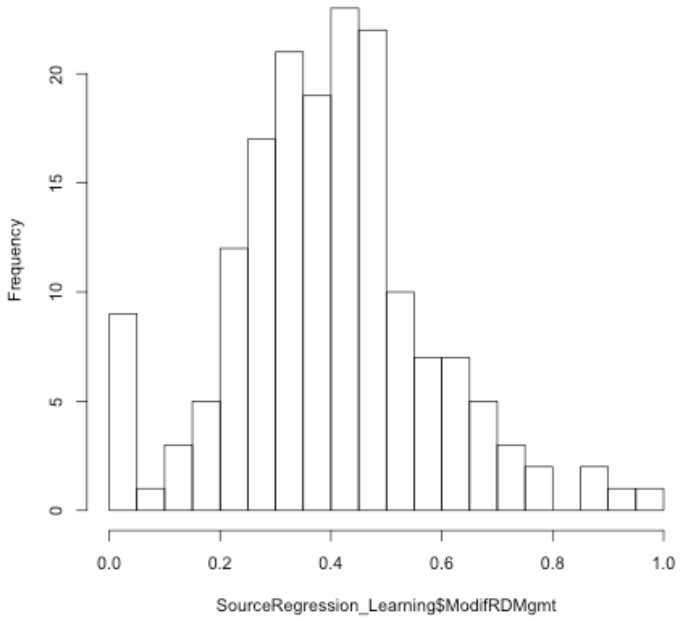

Figure 6.9.3: Histogram of the variable *ModifRDMgmt*: aggregated modification of capability in Management of R&D operations

The descriptive statistics of this variable are given in Table 6.9.4 hereafter.

***ModifRDMgmt*:** aggregated modification of capability in Management of R&D operations	
Number of observations	170
Number of discrete levels	21
Mean value	0.3962
Standard deviation	0.1833

Table 6.9.4: Descriptive statistics of the variable *ModifRDMgmt*: aggregated modification of capability in Management of R&D operations

There are 21 possible discrete levels for this variable, and 170 observations. This is why I chose a linear, **Ordinary Least Squares**, regression.

I attempted to predict this project outcome using the dependent variables that I had introduced (§ 6.9.1.2), in addition to the control variables (§ 6.4). However, **no model** displays significant variables. This is why I only show the regression model containing the control variables in the Table 6.9.5 hereafter.

Name of variable	**Model 1: Control variables only**
(Intercept)	0.3097 ** *(0.0016)*
DistGeo	-0.0002 *(0.9148)*
DistNation	0.0113 *(0.8040)*
DistSize	-0.0176 *(0.2614)*
DistLegalStatus	-0.0070 *(0.8119)*
PublicSupport	0.0265 *(0.1546)*
TechRisk	-0.0077 *(0.6784)*
MotivStrategicCompatible	0.0181 *(0.3955)*
Degrees of freedom	146
Adjusted R^2	*(meaningless negative value)*
Shapiro-Wilk test of normality of residuals: p-value	0.1172

Table 6.9.5: Linear regression model for the aggregated modification of capability in Management of R&D operations (*ModifRDMgmt*): coefficients *(p values)* and significance levels

Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

The model incorporating the control variables only explains none of the variance, and the probability of having all coefficients being equal to zero is 75.53 %. I may therefore consider that I have **not** been able to predict the aggregated modification of capability in Management of R&D operations (*ModifRDMgmt*).

6.9.3.3 Models predicting the modification of capability in Legal & Intellectual Property (IP) management

The variable *ModiLegalIP* describes the aggregated modification of capability in **Legal & Intellectual Property (IP)** management for the focal organisation.

The histogram of this variable is given in Figure 6.9.4 hereafter.

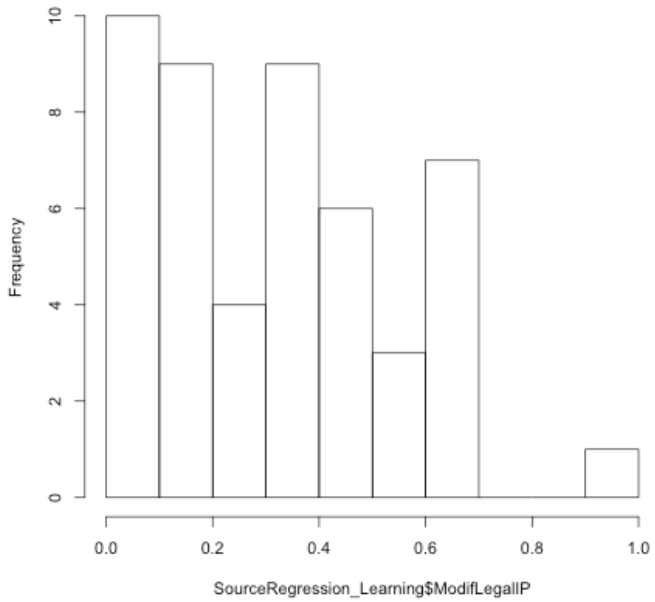

Figure 6.9.4: Histogram of the variable *ModifLegalIP*: aggregated modification of capability in Legal & IP management

The descriptive statistics of this variable are given in Table 0.6 hereafter.

***ModifLegalIP*:** aggregated modification of capability in Legal & IP management	
Number of observations	49
Number of discrete levels	10
Mean value	0.3197
Standard deviation	0.2395

Table 6.9.6: Descriptive statistics of the variable *ModifLegalIP*: aggregated modification of capability in Legal & IP management

There are 10 discrete levels for this variable, and 49 observations. This is why I chose an **Ordered Probit** regression.

The results of the three regression models of my general template (§ 6.6.2) are displayed in the Table 6.9.7 hereafter. Considering the high number of discrete levels, I have not displayed the values of the intercepts, that bring no additional information to the variables contributing to the prediction.

Name of variable	**Model 1: Control variables only**	**Model 2: Controls + most significant variables**	**Model 3: Most significant variables**
(Intercepts) - -9 values	*(not displayed)*	*(not displayed)*	*(not displayed)*
DistSN		-1.0918 * *(0.0282)*	-1.0972 ** *(0.0094)*
MotivPreviousExperience		-0.5884 * *(0.0186)*	-0.4479 * *(0.0316)*
MotivGeneralCompetence		0.4683 ° *(0.0652)*	0.5694 * *(0.0166)*
DistGeo	0.0617 *(0.4506)*	-0.0377 *(0.6800)*	
DistNation	-0.2673 *(0.6572)*	0.0695 *(0.9142)*	
DistSize	0.0148 *(0,9652)*	-0.0376 *(0.8474)*	
DistLegalStatus	-0.3916 *(0.2396)*	-0.4133 *(0.2582)*	
PublicSupport	0.2531 *(0.2824)*	0.1909 *(0.4932)*	
TechRisk	-0.0318 *(0.8894)*	-0.0401 *(0.8716)*	
MotivStrategicCompatible	0.2653 *(0.2922)*	0.3173 *(0.3018)*	
Degrees of freedom	31	24	33
AIC (Akaike information criterion): the smaller the value, the better the fit	218.14	194.62	195.48

Table 6.9.7: Ordered Probit regression models for the aggregated modification of capability in Legal & IP management (*ModifLegalIP*): coefficients *(p values)* and significance levels
Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

As may be seen from the values of the Akaike Information Criterion (AIC), the final Model 3 incorporating the most significant variables improves the level of fit compared to the Model 1 with control variables only. Comparison between the AIC values of Model 2 and of Models 1 and 3 is made difficult by the fact that the number of degrees of freedom differs significantly between them.

The variables that have a significant contribution to the project outcome at organisation level designated as the "modification of **Legal & IP** management capabilities" (*ModifLegalIP*)" are the following:

- the **distance** along the dimension of "**Mode of perception**" between the partners' organisational 'world views' (*DistSN*) has a **negative**, very significant influence on project outcome
- the existence of a **prior positive experience** between the partners in the project, operationalised as the degree by which this consideration motivated them to choose this specific partner in the project (*MotivPrevExperience*) has a **negative**, significant influence on project outcome

- the level of **motivation** to engage with the specific partner because of its **innovation management** capabilities (*MotivGeneralCompetence*) has a **positive**, significant influence on project outcome.

The Spearman (rank-based) correlation matrix of the significant variables and of the control variables is provided in the Table 6.9.8 hereafter. Only the values involving the correlation between the *MotivPrevExperience* and the other two non-control variables (*MotivGeneralCompetence* and *DistSN*) are provided, since those for *DistSN* were already given in § 6.8.2.8, those for *MotivPrevExperience* in § 6.8.2.1, and those for *MotivGeneralCompetence* in §6.9.3.1.

Name of variable	MotivGeneral Competence	DistSN
MotivGeneral Competence	*(see § 6.9.3.1)*	
DistSN	0,0440 *(0.5223)*	*(see § 6.8.2.8)*
MotivPrevious Experience	0,0924 *(0.1752)*	0,0556 *(0.4161)*
DistGeo	*(see § 6.9.3.1)*	*(see § 6.8.2.8)*
DistNation	*(see § 6.9.3.1)*	*(see § 6.8.2.8)*
DistSize	*(see § 6.9.3.1)*	*(see § 6.8.2.8)*
DistLegalStatus	*(see § 6.9.3.1)*	*(see § 6.8.2.8)*
PublicSupport	*(see § 6.9.3.1)*	*(see § 6.8.2.8)*
TechRisk	*(see § 6.9.3.1)*	*(see § 6.8.2.8)*
MotivStrategic Compatible	*(see § 6.9.3.1)*	*(see § 6.8.2.8)*

Table 6.9.8: Descriptive statistics of the control and significant variables intervening in the model predicting the aggregated modification of Legal & IP management capabilities (*ModifLegalIP)*: **mean value, *(standard deviation)*** and Spearman correlations *(p-value)*.
*Confidence levels: *** : p value ≤1‰; ** : p value ≤1%; * : p value ≤5%; °: p value ≤ 10%*

None of the variables intervening in Model 3 (shaded cells) are significantly correlated to one another.

6.9.3.4 Models predicting the modification of capability in Systems design

The variable *ModifSyst* describes the aggregated modification of capability in **Systems design** for the focal organisation.

The histogram of this variable is given in Figure 6.9.5 hereafter.

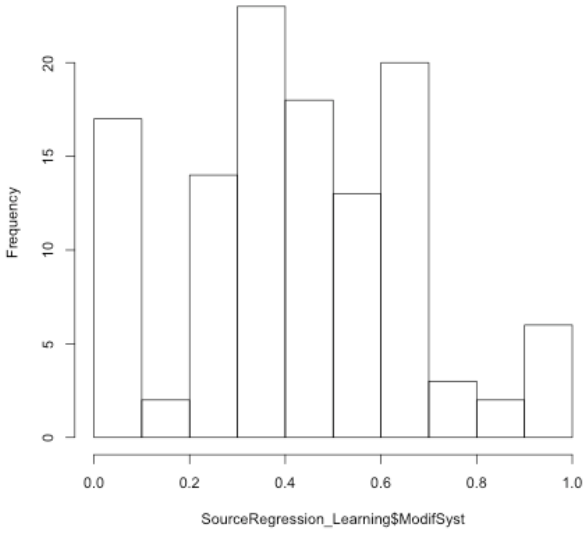

Figure 6.9.5: Histogram of the variable *ModifSyst*: aggregated modification of capability in Systems design

The descriptive statistics of this variable are given in Table 6.9.9 hereafter.

***ModifSyst*:** aggregated modification of capability in Systems design	
Number of observations	118
Number of discrete levels	10
Mean value	0.4209
Standard deviation	0.2650

Table 6.9.9: Descriptive statistics of the variable *ModifSyst*: aggregated modification of capability in Systems design

There are 10 discrete levels for this variable, and 118 observations. This is why I chose an **Ordered Probit** regression.

The results of the three regression models of my general template (§ 6.6.2) are displayed in the Table 6.9.10 hereafter. I have not displayed the values of the intercepts, for the same reasons as above.

Name of variable	**Model 1: Control variables only**	**Model 2: Controls + most significant variables**	**Model 3: Most significant variables**
(Intercepts) - -9 values	*(not displayed)*	*(not displayed)*	*(not displayed)*
PartSyst		0,1844 * *(0,0410)*	0.1878 * *(0.0224)*
DistGeo	-0.0116 *(0,4613)*	-0,0092 *(0,5654)*	
DistNation	0,3783 *(0,2352)*	0,3904 *(0,2210)*	
DistSize	-0,0007 *(0,9955)*	-0,0073 *(0,9519)*	
DistLegalStatus	-0,0928 *(0,6635)*	-0,0756 *(0,7236)*	
PublicSupport	0,0372 *(0,7664)*	0,0289 *(0,8182)*	
TechRisk	0,0025 *(0,9836)*	0,0348 *(0,7776)*	
MotivStrategicCompatible	0,0222 *(0,8870)*	-0,0180 *(0,9092)*	
Degrees of freedom	85	84	108
AIC (Akaike information criterion): the smaller the value, the better the fit	447.53	445.35	501.83

Table 6.9.10: Ordered Probit regression models for the aggregated modification of capability in Systems design (*ModifSyst*): coefficients *(p values)* and significance levels
Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

As may be seen from the values of the Akaike Information Criterion (AIC), the intermediate Model 2 incorporating all control variables, including those that are not significant, improves the level of fit compared to the Model 1 with control variables only. Comparison between the AIC values of Model 2 and Model 3 is made difficult by the fact that the number of degrees of freedom differs significantly between them.

The variable having a significant contribution to the project outcome at organisation level designated as the "modification of **Systems design** capabilities" (*ModifSyst*)" is the following:

- the capability level in **Systems design** of the **partner** (*PartSyst*) has a **positive**, significant influence on project outcome.

The Spearman (rank-based) correlation matrix of the significant variable and of the control variables is provided in the Table 6.9.11 hereafter.

Name of variable	PartSyst
PartSyst	**1.9173** ***(1.2282)***
DistGeo	-0,1110 ° *(0.0863)*
DistNation	-0,0529 *(0.4144)*
DistSize	-0,0241 *(0.7107)*
DistLegalStatus	0,0991 *(0.1256)*
PublicSupport	-0,1288 ° *(0.05367)*
TechRisk	-0,1857 ** *(0.0045)*
MotivStrategic Compatible	0,0650 *(0.331)*

Table 6.9.11: Descriptive statistics of the control and significant variables intervening in the model predicting the aggregated modification of System design capabilities (*ModifSyst)*: **mean value, *(standard deviation)*** and Spearman correlations *(p-value)*.
*Confidence levels: *** : p value ≤1‰; ** : p value ≤1%; * : p value ≤5%; °: p value ≤ 10%*

None of the variables intervening in Model 3 are significantly correlated to one another.

6.9.3.5 Models predicting the modification of capability in Physics

The variable *ModifPhys* describes the aggregated modification of capability in **Physics** for the focal organisation.

The histogram of this variable is given in Figure 6.9.6 hereafter.

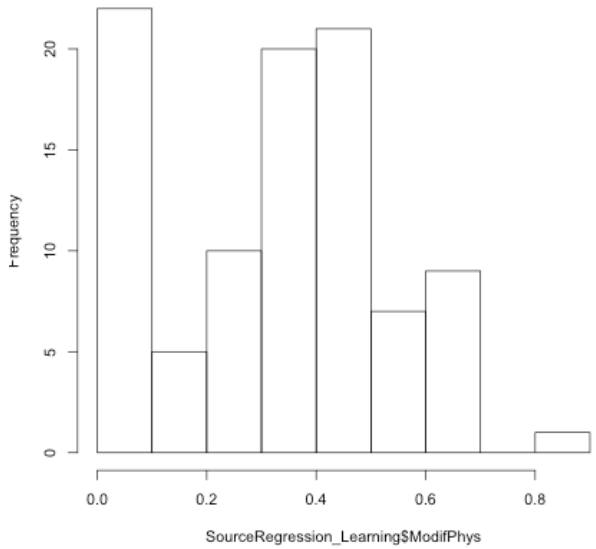

Figure 6.9.6: Histogram of the variable *ModifPhys*: aggregated modification of capability in Physics

The descriptive statistics of this variable are given in Table 6.9.12 hereafter.

***ModifPhys*:** aggregated modification of capability in Physics	
Number of observations	95
Number of discrete levels	10
Mean value	0.3263
Standard deviation	0.2213

Table 6.9.12: Descriptive statistics of the variable *ModifPhys*: aggregated modification of capability in Physics

There are 10 discrete levels for this variable, and 95 observations. This is why I chose an **Ordered Probit** regression.

The results of the three regression models of my general template (§ 6.6.2) are displayed in the Table 6.9.13 hereafter. Considering the high number of discrete levels, I have not displayed the values of the intercepts, that bring no additional information to the variables contributing to the prediction.

Name of variable	**Model 1: Control variables only**	**Model 2: Controls + most significant variables**	**Model 3: Most significant variables**
(Intercepts) - -9 values	*(not displayed)*	*(not displayed)*	*(not displayed)*
DistLib		0,7730 * *(0,0174)*	0.6446 * *(0.0270)*
PartPhys		0,3187 ** *(0,0084)*	0.3426 ** *(0.0033)*
Phys		0,3550 ** *(0,0059)*	0.3376 ** *(0.0074)*
DistGeo	-0,0027 *(0,8677)*	0,0058 *(0,7186)*	
DistNation	-0,0964 *(0,7682)*	-0,1480 *(0,6694)*	
DistSize	-0,1736 *(0,1320)*	-0,1322 *(0,2821)*	
DistLegalStatus	0,0810 *(0,7290)*	-0,0232 *(0,9280)*	
PublicSupport	0,4879 ** *(0,0067)*	0,3655 ° *(0,0650)*	0.4144 * *(0.0278)*
TechRisk	0,3466 * *(0,0341)*	0,1497 *(0,4140)*	
MotivStrategicCompatible	0,2316 *(0,2034)*	0,1247 *(0,5377)*	
Degrees of freedom	72	61	71
AIC (Akaike information criterion): the smaller the value, the better the fit	376.12	332.99	343.74

Table 6.9.13: Ordered Probit regression models for the aggregated modification of capability in Physics (*ModifPhys*): coefficients *(p values)* and significance levels
Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

As may be seen from the values of the Akaike Information Criterion (AIC), the final Model 3 with the most significant variables considerably improves the level of fit compared to the Model 1 with control variables only. Comparison between the AIC values of Model 2 and of Models 1 and 3 is made difficult by the fact that the number of degrees of freedom differs significantly between them.

The variables having a significant contribution to the project outcome at organisation level designated as the "modification of capabilities in **Physics** " (*ModifPhys*)" are the following:

- the **distance** along the dimension of **Liberty vs. Authority** between the partners' organisational 'world views' (*DistLib*) has a **positive**, significant influence on project outcome
- the capability level in **Physics** of the **partner** (*PartPhys*) has a **positive**, very significant influence on project outcome

- the capability level in **Physics** of the **focal organisation** (*Phys*) has a **positive**, very significant influence on project outcome
- the level of financial **public support** awarded to the co-operative R&D project (*PublicSupport*) has a **positive**, significant influence on project outcome.

The Spearman (rank-based) correlation matrix of the significant variable and of the control variables is provided in the Table 6.9.14 hereafter.

Name of variable	DistLib	PartPhys	Phys
DistLib	**0.4658** ***(0.3758)***		
PartPhys	-0,0319 *(0.6364)*	**1.4312** ***(1.2386)***	
Phys	-0,0319 *(0.6364)*	0,5603 *** *(<2e-16)*	**1.4312** ***(1.2386)***
DistGeo	-0,0313 *(0.6427)*	0,0903 *(0.1630)*	0,0903 *(0.1630)*
DistNation	-0,2060 ** *(0.0020)*	-0,0172 *(0.7905)*	-0,0172 *(0.7905)*
DistSize	-0,0935 *(0.1652)*	0,0157 *(0.8092)*	0,0157 *(0.8092)*
DistLegalStatus	-0,0477 *(0.4799)*	-0,0137 *(0.8323)*	-0,0137 *(0.8323)*
PublicSupport	-0,0295 *(0.6699)*	0,1593 * *(0.0168)*	0,1466 * *(0.0278)*
TechRisk	0,0294 *(0.6677)*	0,2341 *** *(0.0003)*	0,2473 *** *(0.0001)*
MotivStrategic Compatible	0,0564 *(0.4142)*	0,0510 *(0.4457)*	0,1450 * *(0.0292)*

Table 6.9.14: Descriptive statistics of the control and significant variables intervening in the model predicting the aggregated modification of Physics capabilities (*ModifPhys)*: **mean value, *(standard deviation)*** and Spearman correlations *(p-value)*.
*Confidence levels: *** : p value ≤1‰; ** : p value ≤1%; * : p value ≤5%; °: p value ≤ 10%*

The variable describing the capability in Physics of the partner organisation (*PartPhys*) is positively (and very significantly) correlated with the capability in Physics of the focal organisation (*Phys*). I interpret this as an indication that organisations select partners that have comparable levels of capability to theirs in the area of Physics. This correlation is not present for all capabilities: at the other extreme, the correlation between the capabilities of the focal organisation and of its partner in Strategic Marketing is 0.0359 (p-value = 0.5796).

The variable describing the level of public support to the project (*PublicSupport*) is positively (and significantly) correlated with the capabilities in Physics of the focal organisation (*Phys*) and of the partner organisation (*PartPhys*). I interpret this correlation as an indication that those co-operative R&D projects that involve early-stage, fundamental science such as physics, are considered as of higher risk. This higher risk justifies a higher level of public support (which is also evidenced by the weak correlation between technical risk and public support shown in § 6.4).

6.9.3.6 Models predicting the modification of capability in Hardware design

The variable *ModifHard* describes the aggregated modification of capability in **Hardware design** for the focal organisation.

The histogram of this variable is given in Figure 6.9.7 hereafter.

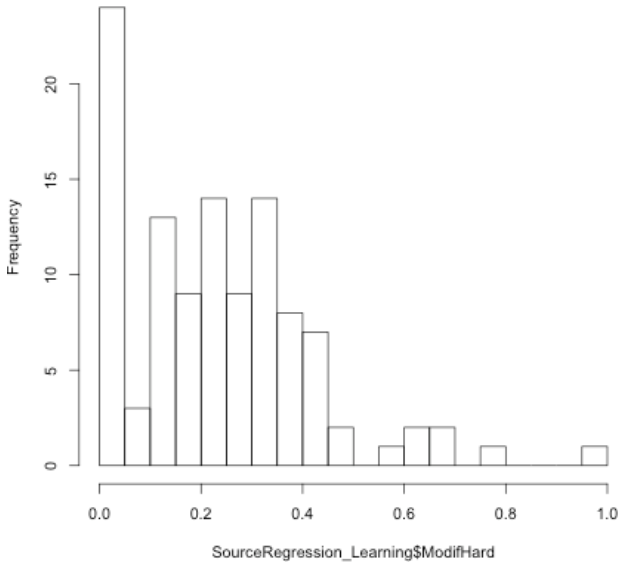

Figure 6.9.7: Histogram of the variable *ModifHard*: aggregated modification of capability in Hardware design

The descriptive statistics of this variable are given in Table 0.15 hereafter.

***ModifHard*:** aggregated modification of capability in Hardware design	
Number of observations	110
Number of discrete levels	14
Mean value	0.2318
Standard deviation	0.1937

Table 6.9.15: Descriptive statistics of the variable *ModifHard*: aggregated modification of capability in Hardware design

There are 14 discrete levels for this variable, and 110 observations. I chose a **linear**, Ordinary Least Squares, **regression**.

The results of the three regression models of my general template (§ 6.6.2) are displayed in the Table 6.9.16 hereafter.

Name of variable	**Model 1: Control variables only**	**Model 2: Controls + most significant variables**	**Model 3: Most significant variables**
(Intercept)	0.1323 *(0,282)*		0.1521 ** *(0.0018)*
DistSN		-0,1125 * *(0.0442)*	-0.1280 ** *(0.0078)*
Hard		0,0732 ** *(0.0012)*	0.0741 *** *(0.0005)*
DistGeo	-0.0008 *(0.770)*	0,0007 *(0.7841)*	
DistNation	0.0193 *(0.754)*	-0,0141 *(0.8073)*	
DistSize	0.0212 *(0.352)*	-0,0143 *(0.5374)*	
DistLegalStatus	0.0106 *(0.790)*	-0,0052 *(0.8903)*	
PublicSupport	0.0155 *(0.531)*	0,0073 *(0.7736)*	
TechRisk	0.0049 *(0.842)*	-0,0065 *(0.7858)*	
MotivStrategicCompatible	0.0049 *(0.868)*	-0,0031 *(0.9134)*	
Degrees of freedom	89	81	99
Adjusted R^2	*(meaningless negative value)*	0.0591	0.129
Shapiro-Wilk test of normality of residuals: p-value	0.01436	0.3392	0.0018

Table 6.9.16: Linear regression models for the aggregated modification of capability in Hardware design (*ModifHard*): coefficients *(p values)* and significance levels
Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

The final Model 3 incorporating the most significant variables considerably improves the explanatory power of the regression, as compared to Model 1 with the control variables only: the Adjusted R^2 metric jumps from 0.000 to 0.129. The improvement of explanatory power of Model 3 compared to Model 2 is also large.

The Shapiro-Wilk normality test applied to the residuals of Models 1 and 3 display rather low p-values: the hypothesis that the residuals are normal may be rejected with a limited probability of error. On the other hand, the residuals of Model 2 would be considered as normal, since the p-value of the Shapiro-Wilk test is high.

The variables having a significant contribution to the project outcome at organisation level designated as the "modification of capabilities in **Hardware design** " (*ModifHard*)" are the following:

- the **distance** along the dimension of "**Mode of perception**" between the partners' organisational 'world views' (*DistSN*) has a **negative**, very significant influence on project outcome
- the capability level in **Hardware design** of the **focal organisation** (*Hard*) has a **positive**, highly significant influence on project outcome.

The Spearman (rank-based) correlation matrix of the significant variable and of the control variables is provided in the Table 6.9.17 hereafter. Since the correlations between *DistSN* and the control variables were already given earlier (§ 6.8.2.8), only those with *Hard* are provided here.

Name of variable	Hard
Hard	**1.3160** ***(0.9210)***
DistSN	0,0903 *(0.1801)*
DistGeo	-0,0688 *(0.2922)*
DistNation	-0,1651* *(0.0111)*
DistSize	-0,0017 *(0.9794)*
DistLegalStatus	0,1036 *(0.1123)*
PublicSupport	-0,0870 *(0.1977)*
TechRisk	0,0851 *(0.2004)*
MotivStrategic Compatible	0,0918 *(0.1729)*

Table 6.9.17: Descriptive statistics of the control and significant variables intervening in the model predicting the aggregated modification of Hardware design capabilities (*ModifHard)*: **mean value, *(standard deviation)*** and Spearman correlations *(p-value)*.
*Confidence levels: *** : p value ≤1‰; ** : p value ≤1%; * : p value ≤5%; °: p value ≤ 10%*

None of the variables intervening in Model 3 (shaded cells) are significantly correlated to one another.

6.9.3.7 Models predicting the modification of capability in Software design

The variable *ModifSoft* describes the aggregated modification of capability in **Software design** for the focal organisation.

The histogram of this variable is given in Figure 6.9.8 hereafter.

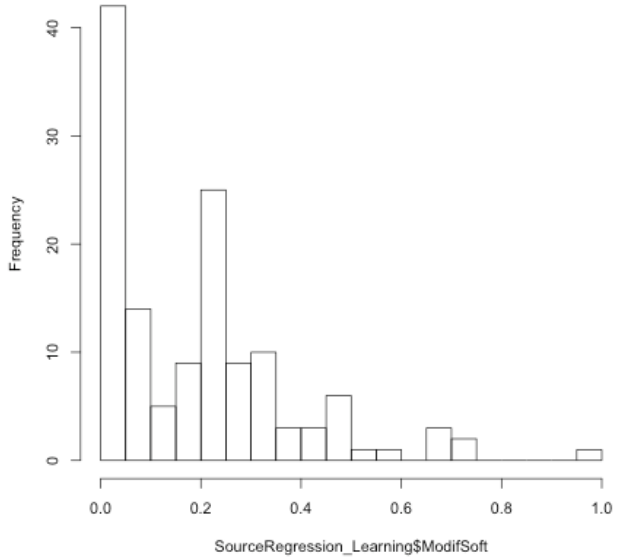

Figure 6.9.8: Histogram of the variable *ModifSoft*: aggregated modification of capability in Software design

The descriptive statistics of this variable are given in Table 6.9.18 hereafter.

***ModifSoft*:** aggregated modification of capability in Software design	
Number of observations	134
Number of discrete levels	19
Mean value	0.1946
Standard deviation	0.1927

Table 6.9.18: Descriptive statistics of the variable *ModifSoft*: aggregated modification of capability in Software design

There are 19 discrete levels for this variable, and 134 observations. I chose a linear, **Ordinary Least Squares**, regression.

The results of the three regression models of my general template (§ 6.6.2) are displayed in the Table 6.9.19 hereafter.

Name of variable	**Model 1: Control variables only**	**Model 2: Controls + most significant variables**	**Model 3: Most significant variables**
(Intercept)	0.0451 *(0.694)*	-0,0861 *(0,4450)*	-0.0839 *(0.2042)*
PartSoft		0,0561 ** *(0,0019)*	0.0483 ** *(0.0032)*
Soft		0,0421 * *(0,0293)*	0.0386 * *(0.0274)*
DistGeo	-0.0051 *(0.150)*	-0,0028 *(0,3859)*	
DistNation	0.0670 *(0.258)*	0,0372 *(0,5061)*	
DistSize	0.0176 *(0.368)*	0,0296 *(0,1214)*	
DistLegalStatus	0.0234 *(0.525)*	-0,0282 *(0,4416)*	
PublicSupport	0.0269 *(0.191)*	0,0303 *(0,1121)*	0.0405 * *(0.0190)*
TechRisk	-0.0049 *(0.816)*	-0,0156 *(0,4542)*	
MotivStrategicCompatible	0.0238 *(0.386)*	0,0150 *(0,5803)*	
Degrees of freedom	106	94	107
Adjusted R^2	*(meaningless negative value)*	0.1535	0.1617
Shapiro-Wilk test of normality of residuals: p-value	0.0008 ***	0.0009 ***	4.79e-05 ***

Table 6.9.19: Linear regression models for the aggregated modification of capability in Software design (*ModifSoft*): coefficients *(p values)* and significance levels
Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

The final Model 3 incorporating the most significant variables considerably improves the explanatory power of the regression, as compared to Model 1 with the control variables only: the Adjusted R^2 metric (a measure of the amount of the variance being explained by the model) jumps from 0.000 to 0.1617. The improvement of explanatory power of Model 3 compared to Model 2 is more modest.

The Shapiro-Wilk normality test applied to the residuals of these models display very low p-values: the hypothesis that the residuals are normal may be rejected with a very limited probability of error.

The variables having a significant contribution to the project outcome at organisation level designated as the "modification of capabilities in **Software design** " (*ModifSoft*)" are the following:

- the capability level in **Software design** of the **partner** (*PartSoft*) has a **positive**, very significant influence on project outcome
- the capability level in **Software design** of the **focal organisation** (*Soft*) has a **positive**, significant influence on project outcome
- the level of financial **public support** awarded to the co-operative R&D project (*PublicSupport*) has a **positive**, significant influence on project outcome.

The Spearman (rank-based) correlation matrix of the significant variable and of the control variables is provided in the Table 6.9.20 hereafter.

Name of variable	PartSoft	Soft
PartSoft	**1.5340** ***(1.0252)***	
Soft	0,4678 *** *(1.4e-13)*	**1.5340** ***(1.0252)***
DistGeo	-0,1929 ** *(0.0032)*	-0,1929 ** *(0.0032)*
DistNation	-0,1967 ** *(0.0026)*	-0,1967 ** *(0.0026)*
DistSize	-0,0510 *(0.4402)*	-0,0510 *(0.4402)*
DistLegalStatus	0,1880 ** *(0.0041)*	0,1880 ** *(0.0041)*
PublicSupport	-0,1472 * *(0.0302)*	-0,1690 * *(0.0126)*
TechRisk	-0,0619 *(0.3572)*	-0,0900 *(0.1803)*
MotivStrategic Compatible	0,0432 *(0.5252)*	0,0252 *(0.711)*

Table 6.9.20: Descriptive statistics of the control and significant variables intervening in the model predicting the aggregated modification of Software design capabilities (*ModifSoft)*: **mean value, *(standard deviation)*** and Spearman correlations *(p-value)*.
*Confidence levels: *** : p value ≤1‰; ** : p value ≤1%; * : p value ≤5%; °: p value ≤ 10%*

The variable describing the capability in Software design of the partner organisation (*PartSoft*) is positively (and very significantly) correlated with the capability in Software design of the focal organisation (*Soft*). I interpret this as an indication that organisations select partners that have comparable levels of capability to theirs in the area of Software design. The variable describing the level of public support (*PublicSupport*) is negatively and significantly correlated with *Soft* and *PartSoft*. I interpret this correlation as the fact that software projects are closer to the market, and thus less supported by public funding.

6.9.3.8 Models predicting the modification of capability in Manufacturing technologies

The variable *ModifManuf* describes the aggregated modification of capability in **Manufacturing technologies** for the focal organisation.

The histogram of this variable is given in Figure 6.9.9 hereafter.

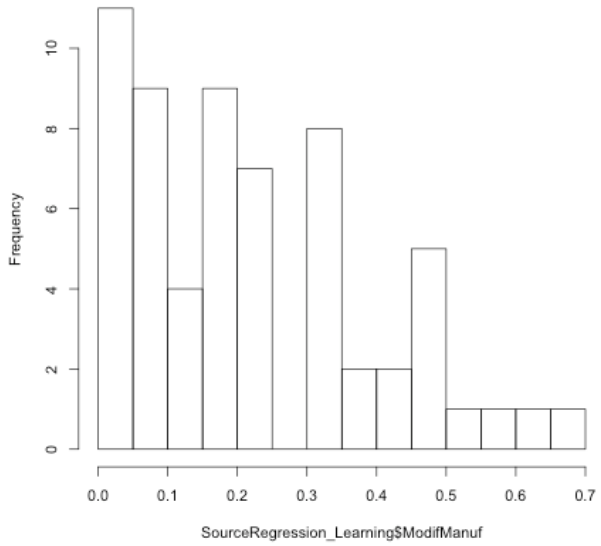

Figure 6.9.9: Histogram of the variable *ModifManuf*: aggregated modification of capability in Manufacturing technologies

The descriptive statistics of this variable are given in Table 6.9.21 hereafter.

***ModifManuf*:** aggregated modification of capability in Manufacturing technologies	
Number of observations	61
Number of discrete levels	20
Mean value	0.2155
Standard deviation	0.1779

Table 6.9.21: Descriptive statistics of the variable *ModifManuf*: aggregated modification of capability in Manufacturing technologies

There are 19 discrete levels for this variable, and 61 observations. I chose a linear, **Ordinary Least Squares**, regression.

The results of the three regression models of my general template (§ 6.6.2) are displayed in the Table 6.9.22 hereafter.

Name of variable	**Model 1: Control variables only**	**Model 2: Controls + most significant variables**	**Model 3: Most significant variables**
(Intercept)	-0,1072 *(0,5280)*	0,0972 *(0,6052)*	0,1953 *** *(0,0005)*
DistSN		-0,1818 * *(0,0136)*	-0,1851 ** *(0,0035)*
Manuf		0,0553 * *(0,0379)*	0,0594 ** *(0,0062)*
DistGeo	-0,0037 *(0,3710)*	-0,0043 *(0,2640)*	
DistNation	0,0856 *(0,2270)*	0,0457 *(0,5157)*	
DistSize	-0,0082 *(0,7680)*	-0,0239 *(0,4312)*	
DistLegalStatus	0,0409 *(0,4370)*	-0,0603 *(0,2808)*	
PublicSupport	0,0582 *(0,1100)*	0,0599 *(0,1454)*	
TechRisk	0,0058 *(0,8480)*	-0,0298 *(0,3394)*	
MotivStrategicCompatible	0,0411 *(0,2660)*	0,0324 *(0,4043)*	
Degrees of freedom	50	40	50
Adjusted R^2	*(meaningless negative value)*	0.1949	0.2001
Shapiro-Wilk test of normality of residuals: p-value	0.0184 *	0.0718 °	0.1781

Table 6.9.22: Linear regression models for the aggregated modification of capability in Manufacturing technologies (*ModifManuf*): coefficients *(p values)* and significance levels
Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

The final Model 3 incorporating the most significant variables considerably improves the explanatory power of the regression, as compared to Model 1 with the control variables only: the Adjusted R^2 metric jumps from 0.000 to 0.2001. The improvement of explanatory power of Model 3 compared to Model 2 is more modest.

The Shapiro-Wilk normality test applied to the residuals of Models 3 has a high p-value: rejecting the hypothesis that the residuals are normal could only be done with a high probability of error. We may then consider them as normal. This is less true of Model 2 and of Model 1.

The variables having a significant contribution to the project outcome at organisation level designated as the "modification of capabilities in **Manufacturing technologies**" (*ModifManuf*)" are the following:

- the **distance** along the dimension of "**Mode of perception**" between the partners' organisational 'world views' (*DistSN*) has a **negative**, very significant influence on project outcome
- the capability level in **Manufacturing technologies** of the **focal organisation** (*Manuf*) has a **positive**, very significant influence on project outcome.

The Spearman (rank-based) correlation matrix of the significant variable and of the control variables is provided in the Table 6.9.23 hereafter. Since the correlations between *DistSN* and the control variables were already provided earlier (§ 6.8.2.8), only those with *Manuf* are provided here.

Name of variable	Manuf
Manuf	**0.9225** ***(0.9504)***
DistSN	0,0406 *(0.5469)*
DistGeo	0,1037 *(0.1120)*
DistNation	-0,0337 *(0.6062)*
DistSize	-0,0224 *(0.7322)*
DistLegalStatus	0,0469 *(0.4732)*
PublicSupport	0,0179 *(0.7909)*
TechRisk	0,1217 ° *(0.0665)*
MotivStrategic Compatible	0,1181 ° *(0.0789)*

Table 6.9.23: Descriptive statistics of the control and significant variables intervening in the model predicting the aggregated modification of Manufacturing technologies (*ModifManuf)*: **mean value, *(standard deviation)*** and Spearman correlations *(p-value)*.
*Confidence levels: *** : p value ≤1‰; ** : p value ≤1%; * : p value ≤5%; °: p value ≤ 10%*

None of the explanatory variables display significant correlations with the others.

6.9.3.9 Models predicting the transfer of scientific knowledge to the focal organisation

The binary variable *KnowTransfScientific* describes whether **scientific knowledge** was **transferred** to the focal organisation during the co-operative R&D project being investigated.

The descriptive statistics of this variable are given in Table 6.9.24 hereafter.

***KnowTransfScientific*:** Transfer of scientific knowledge to the focal organisation		
Number of observations	240	
Number of discrete levels	2	
Mean value	0.55	
Was scientific knowledge transferred to the organisation during the co-operative R&D project ?	No	Yes
Number of organisations	108	132

Table 6.9.24: Descriptive statistics of the variable *KnowTransfScientific*: transfer of scientific knowledge to the focal organisation

I use **Logit** regression for the prediction of this binary variable.

The results of the three regression models of my general template (§ 6.6.2) are displayed in the Table 6.9.25 hereafter.

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Name of variable	**Model 1: Control variables only**	**Model 2: Controls + most significant variables**	**Model 3: Most significant variables**
(Intercept)	0,4258 *(0,6370)*	0,1395 *(0,8925)*	-0,3979 *(0,2941)*
PartStratMkt		-0,4128 ** *(0,0097)*	-0,4529 ** *(0,0016)*
PartPhys		0,4725 *** *(0,0005)*	0,4403 *** *(0,0004)*
Syst		0,3372 * *(0,0106)*	0,2725 * *(0,0223)*
DistGeo	0,0001 *(0,9970)*	0,0051 *(0,8375)*	
DistNation	0,2748 *(0,5240)*	0,1219 *(0,7946)*	
DistSize	-0,1693 *(0,2630)*	-0,1618 *(0,3153)*	
DistLegalStatus	0,0940 *(0,7450)*	0,1414 *(0,6455)*	
PublicSupport	0,1458 *(0,4190)*	0,1442 *(0,4638)*	
TechRisk	-0,0549 *(0,7550)*	-0,2615 *(0,1744)*	
MotivStrategicCompatible	-0,1718 *(0,4160)*	-0,1672 *(0,4573)*	
Degrees of freedom	203	200	236
AIC (Akaike information criterion): the smaller the value, the better the fit	303.61	284.89	302.11

Table 6.9.25: Logit regression models for the transfer of scientific knowledge (*KnowTransfScientific*): coefficients *(p values)* and significance levels
Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

The AIC measure of model fit is significantly improved in Model 2 that includes all variables compared to Model 1 with control variables only. The metric for Model 3 is difficult to compare, since the number of degrees of freedom in this last model is increased compared to the two previous ones.

The variables having a significant contribution to the project outcome at organisation level designated as the "**transfer** of **scientific** knowledge to the focal organisation" (*KnowTransfScientific*)" are the following:

- the capability level in **Strategic Marketing** of the **partner** (*PartStratMkt*) has a **negative**, very significant influence on project outcome
- the capability level in **Physics** of the **partner** (*PartPhys*) has a **positive**, highly significant influence on project outcome

- the capability level in **Systems design** of the **focal organisation** (*Syst*) has a **positive**, very significant influence on project outcome.

The Spearman (rank-based) correlation matrix of the significant variable and of the control variables is provided in the Table 6.9.26 hereafter.

Name of variable	PartStratMkt	PartPhys	Syst
PartStratMkt	**1.1635** ***(1.0007)***		
PartPhys	-0,0791 *(0.2221)*	**1.43125** ***(1.2386)***	
Syst	-0,0418 *(0.5191)*	-0,2408 *** *(0.0002)*	**1.9173** ***(1.2282)***
DistGeo	0,0057 *(0.9306)*	*(see §6.9.3.5)6.8.2.8*	-0,1110 ° *(0.08626)*
DistNation	-0,1189 ° *(0.06582)*	*(see § 6.9.3.5)*	-0,0529 *(0.4144)*
DistSize	0,0293 *(0.6519)*	*(see § 6.9.3.5)*	-0,0241 *(0.7107)*
DistLegalStatus	0,0543 *(0.4024)*	*(see § 6.9.3.5)*	0,0991 *(0.1256)*
PublicSupport	-0,0407 *(0.5433)*	*(see § 6.9.3.5)*	-0,1971 ** *(0.0029)*
TechRisk	-0,1033 *(0.1165)*	*(see § 6.9.3.5)*	-0,0643 *(0.3293)*
MotivStrategic Compatible	0,1024 *(0.1250)*	*(see § 6.9.3.5)*	-0,0192 *(0.7743)*

Table 6.9.26: Descriptive statistics of the control and significant variables intervening in the model predicting the transfer of scientific knowledge (*KnowTransfScientific*): **mean value, *(standard deviation)*** and Spearman correlations *(p-value)*.
*Confidence levels: *** : p value ≤1‰; ** : p value ≤1%; * : p value ≤5%; °: p value ≤ 10%*

The capability level of the focal organisation in Systems design (*Syst*) is negatively, and highly significantly, correlated to the capability level in Physics of the partner (*PartPhys*). I would interpret this correlation as a reluctance of those organisations that develop full systems to engage in co-operative R&D with organisations that have a specialised scientific knowledge.

6.9.3.10 Models predicting the transfer of technical knowledge to the focal organisation

The binary variable *KnowTransfTechnical* describes whether **technical knowledge** was **transferred** to the focal organisation during the co-operative R&D project being investigated.

The descriptive statistics of this variable are given in Table 6.9.27 hereafter.

***KnowTransfTechnical*:** Transfer of technical knowledge to the focal organisation		
Number of observations	240	
Number of discrete levels	2	
Mean value	0.7458	
Was technical knowledge transferred to the organisation during the co-operative R&D project ?	No	Yes
Number of organisations	61	179

Table 6.9.27: Descriptive statistics of the variable *KnowTransfTechnical*: transfer of technical knowledge to the focal organisation

I use **Logit** regression for the prediction of this binary variable.

The results of the three regression models of my general template (§ 6.6.2) are displayed in the Table 6.9.28 hereafter.

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Name of variable	**Model 1: Control variables only**	**Model 2: Controls + most significant variables**	**Model 3: Most significant variables**
(Intercept)	2,2638 * *(0,0386)*	-3,0044 ° *(0,0664)*	-3,6995 ** *(0,0039)*
PartStratMkt		0,5090 * *(0,0184)*	0,6086 ** *(0,0031)*
MotivTechCompetence		1,9220 *(2,10e-05)*	1,9460 *** *(8,15e-06)*
DistGeo	0,0149 *(0,6327)*	0,0148 *(0,6693)*	
DistNation	-0,1501 *(0,7654)*	-0,2266 *(0,6702)*	
DistSize	0,0784 *(0,6590)*	0,0630 *(0,7450)*	
DistLegalStatus	-0,3880 *(0,2683)*	-0,3078 *(0,4134)*	
PublicSupport	-0,1371 *(0,5344)*	-0,1540 *(0,5168)*	
TechRisk	-0,2634 *(0,2096)*	-0,4575 * *(0,0477)*	-0,4808 * *(0,0269)*
MotivStrategicCompatible	0,0710 *(0,7692)*	0,0160 *(0,9503)*	
Degrees of freedom	203	200	223
AIC (Akaike information criterion): the smaller the value, the better the fit	243.01	220.82	227.67

Table 6.9.28: Logit regression models for the transfer of technical knowledge (*KnowTransfTechnical*): coefficients *(p values)* and significance levels
Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

The AIC measure of model fit is significantly improved in Model 2 that includes all variables compared to Model 1 with control variables only. The metric for Model 3 is difficult to compare, since the number of degrees of freedom in this last model is increased compared to the two previous ones, however, the AIC metric is still strongly improved compared to the initial model.

The variables having a significant contribution to the project outcome at organisation level designated as the "**transfer** of **technical** knowledge to the focal organisation" (*KnowTransfTechnical*) are the following:

- the capability level in **Strategic Marketing** of the **partner** (*PartStratMkt*) has a **positive**, very significant influence on project outcome
- the level of **motivation** to select this specific partner because of its **technical capabilities** (*MotivTechCompetence*) has a **positive**, highly significant influence on project outcome

- the level of **technical risk** of the project (*TechRisk*) has a **negative**, significant influence on project outcome.

The Spearman (rank-based) correlation matrix of the significant variable and of the control variables is provided in the Table 6.9.29 hereafter. Since the correlations of *PartStratMkt* were already provided above (§ 6.9.3.9), only the correlations for *MotivTechCompetence* are provided.

Name of variable	Motiv TechCompetence
MotivTechCompetence	**2.8793** ***(0.3757)***
PartStratMkt	-0,0123 *(0.8518)*
DistGeo	0,0093 *(0.8882)*
DistNation	0,0394 *(0.5502)*
DistSize	-0,0343 *(0.6028)*
DistLegalStatus	-0,0905 *(0.1697)*
PublicSupport	-0,0132 *(0.8454)*
TechRisk	0,1594 * *(0.0162)*
MotivStrategic Compatible	0,0218 *(0.7465)*

Table 6.9.29: Descriptive statistics of the control and significant variables intervening in the model predicting the transfer of technical knowledge (*KnowTransfTechnical*): **mean value, *(standard deviation)*** and Spearman correlations *(p-value)*.
*Confidence levels: *** : p value ≤1‰; ** : p value ≤1%; * : p value ≤5%; °: p value ≤ 10%*

The level of motivation to select the partner for its technical capabilities (*MotivTechCompetence*) is positively, and significantly, correlated technical risk level estimated *ex ante* for the project (*TechRisk*). I interpret this correlation as an illustration that organisations, when they engage in a project that they consider as risky, tend to seek as partners the organisations whose technical capability they trust.

6.9.3.11 Models predicting the transfer of marketing knowledge to the focal organisation

The binary variable *KnowTransfMarketing* describes whether **marketing knowledge** was **transferred** to the focal organisation during the co-operative R&D project being investigated.

The descriptive statistics of this variable are given in Table 6.9.30 hereafter.

***KnowTransfMarketing*:** Transfer of marketing knowledge to the focal organisation		
Number of observations	240	
Number of discrete levels	2	
Mean value	0.2166	
Was marketing knowledge transferred to the organisation during the co-operative R&D project ?	No	Yes
Number of organisations	188	52

Table 6.9.30: Descriptive statistics of the variable *KnowTransfMarketing*: transfer of marketing knowledge to the focal organisation

I use **Logit** regression for the prediction of this binary variable.

The results of the three regression models of my general template (§ 6.6.2) are displayed in the Table 6.9.31 hereafter.

(the space below is deliberately left blank)

Name of variable	**Model 1: Control variables only**	**Model 2: Controls + most significant variables**	**Model 3: Most significant variables**
(Intercept)	-2,3738 *(0,0349)*	-3,5933 ** *(0,0038)*	-1,9622 *** *(1,51e-09)*
PartStratMkt		0,8529 *** *(8,93e-06)*	0,8252 *** *(7,89e-07)*
Manuf		-0,6019 * *(0,0138)*	-0,5138 * *(0,0229)*
DistGeo	0,0438 ° *(0,0847)*	0,0358 *(0,1795)*	
DistNation	-0,8870 *(0,1319)*	-0,5554 *(0,3792)*	
DistSize	0,1697 *(0,3475)*	0,1127 *(0,5629)*	
DistLegalStatus	0,4927 *(0,1763)*	0,4875 *(0,2116)*	
PublicSupport	0,0294 *(0,8965)*	0,0592 *(0,8076)*	
TechRisk	0,1745 *(0,4111)*	0,4129 ° *(0,0884)*	
MotivStrategicCompatible	0,0129 *(0,9598)*	-0,0238 *(0,9331)*	
Degrees of freedom	203	197	233
AIC (Akaike information criterion): the smaller the value, the better the fit	233.45	206.26	222.36

Table 6.9.31: Logit regression models for the transfer of marketing knowledge (*KnowTransfMarketing*): coefficients *(p values)* and significance levels
Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

The AIC measure of model fit is significantly improved in Model 2 that includes all variables compared to Model 1 with control variables only. The metric for Model 3 is difficult to compare, since the number of degrees of freedom in this last model is increased compared to the two previous ones, however, the AIC metric is still strongly improved compared to the initial model.

The variables having a significant contribution to the project outcome at organisation level designated as the "**transfer** of **marketing** knowledge to the focal organisation" (*KnowTransfMarketing*) are the following:

- the capability level in **Strategic Marketing** of the **partner** (*PartStratMkt*) has a **positive**, highly significant influence on project outcome
- the capability level in **Manufacturing technologies** of the **focal organisation** (*Manuf*) has a **negative**, significant influence on project outcome.

The Spearman (rank-based) correlation matrix of the significant variable and of the control variables was already provided above (§ 6.9.3.9 for *PartStratMkt* and § 6.9.3.8 for *Manuf*),.

Therefore, only the correlations between the significant variables is provided in the Table 6.9.32.

Name of variable	Manuf
PartStratMkt	0.1172 ° *(0.0721)*

Table 6.9.32: Descriptive statistics of the significant variables intervening in the model predicting the transfer of marketing knowledge (*KnowTransfMarketing*): Spearman correlations *(p-value)*.
*Confidence levels: *** : p value ≤1‰; ** : p value ≤1%; * : p value ≤5%; °: p value ≤ 10%*

6.9.3.12 Models predicting the compliance with cost budget

The variable *ProjMgmtCostBudget* represents the compliance with the project cost budget, considered separately for each organisation in the project.

The contingency table of this variable and descriptive statistics are given in Table 6.9.33 hereafter.

***ProjMgmtSchedule*:** Compliance with project schedule					
Number of observations	221				
Number of discrete levels	5				
Mean value	3.7875				
Standard deviation	0.7850				
Compliance level *(following numeric values of Table 5.7.3)*	1	2	3	4	5
Number of projects	1	5	31	132	51

Table 6.9.33: Descriptive statistics of the variable *ProjMgmtCostBudget*: compliance with project cost budget

In order to predict this variable, I have used **Ordered Probit** regression. This method is recommended when the number of possible values for the dependent variable is small, but yet strictly superior to 2. Since *ProjMgmtCostBudget* takes five distinct values, I am in the case of application of this method.

The results of the three regression models of my general template (§ 6.6.2) are displayed in the Table 6.9.34 hereafter.

Name of variable	**Model 1: Control variables only**	**Model 2: Controls + most significant variables**	**Model 3: Most significant variables**
(Intercepts) - -4 values	*(not displayed)*	*(not displayed)*	*(not displayed)*
PartSyst		-0,1349 * *(0,0471)*	-0.1459 * *(0.0184)*
DistGeo	-0,0078 *(0,5387)*	-0,0085 *(0,5080)*	
DistNation	-0,1113 *(0,6511)*	-0,1017 *(0,6802)*	
DistSize	-0,0329 *(0,7053)*	-0,0481 *(0,5832)*	
DistLegalStatus	-0,3189 ° *(0,0564)*	-0,2799 ° *(0,0969)*	
PublicSupport	0,0406 *(0,6868)*	0,0236 *(0,8164)*	
TechRisk	-0,1073 *(0,2986)*	-0,1430 *(0,1738)*	
MotivStrategicCompatible	0,0675 *(0,5729)*	0,0892 *(0,4591)*	
Degrees of freedom	188	187	215
AIC (Akaike information criterion): the smaller the value, the better the fit	420.31	418.35	458.41

Table 6.9.34: Ordered Probit regression models for the compliance with project cost budget (*ProjMgmtCostBudget*): coefficients *(p values)* and significance levels
Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

The final Model 3 incorporating the most significant variables has a much larger number of degrees of freedom than the other two: the Akaike Information Criteria (AIC) are difficult to compare. The improvement of Model 2 that incorporates all control variables, including those that are not significant, compared to the Model 1 with control variables only is only marginal.

The variable that has a significant contribution to the specific project outcome designated as the "compliance with project **cost budget** (*ProjMgmtCostBudget*)" is the following:

- the capability level in **Systems design** of the **partner** (*PartSyst*) has a **negative**, significant influence on project outcome.

The Spearman (rank-based) correlation matrix of the significant variables and of the control variables was provided earlier in Table 6.9.11.

I have in this chapter exposed the raw empirical results obtained from my research: the data collection yield and the prediction model for each category of project outcome. I am now in a position to interpret them, in the following chapter.

7 Interpretation of results

The regressions of the preceding chapter demonstrate two types of results: (1) those that would contradict or modify earlier literature, and (2) the positive contribution of my research to the understanding of co-operative R&D projects outcomes. I will interpret these two categories of results in the following sections (§ 7.1 and 7.2 respectively).

7.1 Results contradicting or modifying earlier literature

The results of my research that contradict or modify earlier literature are that many of the common control variables already identified by extant research (§ 6.4) have no effect on project outcomes. A final result is that the cognitive distance in technical fields does not display the inverted-U shape expected by Nooteboom (2007).

7.1.1 No influence of geographic distance

The first negative result is in contradiction with most of the literature on geographic proximity and local knowledge spill-overs (Feldman, 1994; Feldman, 2000; Audretsch and Feldman, 2004). Indeed, **geographic distance** (*DistGeo*) has no influence whatsoever on the outcomes of the co-operative R&D projects being investigated in my survey, whatever the nature of the outcome being considered. Direct encounters and face-to-face interactions that geographic proximity would foster seem to have no effect. This is coherent with earlier findings by Dyer et al. (2007).

The distribution of geographic distance between partners in the sample illustrates a predominance of interactions at short geographic distance, with a strong negative slope, and a small set of outliers - the trans-Atlantic projects (see Figure 7.1.1 below). All results on the absence of influence of geographic distance on project outcome hold even after forcing these outliers to remain under 15° of geographic distance.

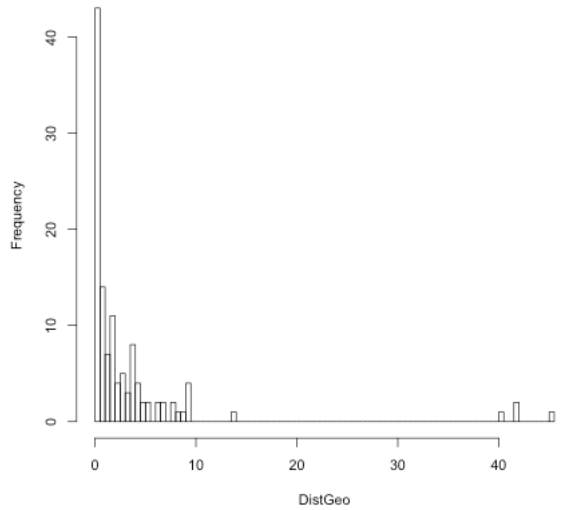

Figure 7.1.1: Distribution of geographic distance (unit: degrees of longitude and latitude. 1° is approx. 100 km)

My interpretation of the discrepancy between my results and the existing literature on geographic proximity is that earlier research has indeed observed a distribution of co-operative projects with geographic distance equivalent to mine. However, the authors may have over-interpreted this observation, by claiming that the quantitative predominance of

short-range interactions was the consequence of their higher efficiency (which my research tends to strongly question). I would simply interpret this distribution in **economic** terms: interactions at long geographic distance are more costly, in travel expenses and time, but also in information gathering (it is faster and cheaper to select a partner among the few serious candidates that lie within a regional 50 km radius, than among those situated within a continental 2 000 km radius), and transaction costs (due to language and legal issues).

Another interpretation of the fact that I do not observe any effect of geographic distance on the outcomes of the co-operative R&D projects that I consider, despite the literature on the favourable effects of geographic proximity on innovativeness, would be related to the distinction between 'local buzz' and 'global pipelines' (Bathelt et al., 2004). In the early, creative moments of the innovation process, the generation of ideas may indeed be fostered by short, dense, informal contacts and exchanges of thoughts and reflections, described as 'local buzz' by Bahtelt *et al.*, as one would expect them to happen in geographically dense concentrations of people active in the same industry, such as in permanent high-tech clusters or in trade fairs, who would then play the role of 'temporary clusters' (Maskell et al., 2006). My research however operates on formalised R&D contracts, that are more related to the 'global pipelines' described by Bathelt *et al.*. The numeric predominance of interactions at short geographical range that I observe could then be also interpreted by an **historical** argument in the innovation process. The initial idea of an innovation may often be born in the short-distance 'buzz'-like interaction mode with a given individual or organisation. Once the idea gets formalised and becomes a full-fledged R&D project, the natural and somewhat moral evolution would be to pursue the co-operation with that same individual or organisation, even if some better suited partners could be set up at the other end of a 'global pipeline'. The evolution could be considered as natural because the immediately available option of pursuing co-operation with the already known partner provides a 'satisficing' solution (Simon, 1979). It may also be considered a moral evolution because the paternity of the idea born in an informal discussion always is somewhat shared between the participants. If one of the participants deliberately abandoned the other to seek another co-operative R&D partner to exploit that idea, this move could righteously be considered as a form of robbery of creative capacity, even if no formal Intellectual Property Right could ever be attached to the creative idea born in the initial conversation.

7.1.2 Limited influence of the difference in nationality

Another contradiction to the existing literature on cognitive distance (Coenen et al., 2004; Gertler, 1995) is that the difference in **nationality** of the teams involved in the co-operative R&D project (*DistNation*) has an influence only on the compliance with project schedule: it is then negative, as could be expected.

My observation that nationality plays a limited role in project outocomes may be considered as surprising, since differences in nationality could impede the communication between co-operating teams, and therefore affect project outcome, for plain linguistic reasons, or because the differences in verbal and non-verbal communication, in working habits and conventions or in institutional and legal environments would lead to conflicting mutual expectations (Knoben and Oerlemans, 2006).

In addition, international projects are a minority, representing only 21.66 % of the projects in my sample, which could be interpreted as them being less efficient.

I would, as in § 7.1.1 above, interpret this contradiction between my research and earlier work as an over-interpretation of results by earlier scholars, and an attribution to cognitive causes of purely economic phenomena. Indeed, as shown in § 6.4, geographic distance and difference in nationality are positively and very significantly correlated.

I would also interpret this contradiction by the fact that I introduced new variables in my research to describe organisational 'world views' (§ 6.5), and thus the difference between organisations: the 'Mode of perception' (*DistSN*), the 'Behaviour in the outside world' (*DistJP*) and the 'Authority vs. Liberty' dimension (*DistLib*). As shown in Table 7.1.1 below, two of these variables are very significantly correlated with the geographic distance and with the difference in nationality.

Name of variable	DistSN	DistJP	DistLib
DistGeo	-0,2500** *(0.0075)*	-0,0057 *(0.9521)*	-0,0313 *(0.6427)*
DistNation	-0,1188 *(0.2103)*	0,0766 *(0.4218)*	-0,2060 ** *(0.0020)*

Table 7.1.1: Spearman correlation (*p-values*) of geographic distance and of difference in nationality with distances along components of 'world views' introduced by my research
Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

If they are alone in a regression model, the geographic distance (*DistGeo*) and the difference in nationality (*DistNation*) may appear in the earlier literature to have an influence on project outcome, while actually this is the effect of the variables describing 'world views' that are correlated with them. My research systematically placed the control variables in competition with those that I introduced, in the Model 2 of all sections in § 6.8 and 6.9 above. In all cases, the variables that contained the really meaningful information, and that appeared as significant in the regressions, were those that I introduced. However, in the absence of such variables, it is understandable that geographic distance and the difference in nationality be mistaken as being the explanatory variables.

7.1.3 Inverted or inexistent influence of the difference in legal status

Also in contradiction with the most usual common sense (Rothaermel and Deeds, 2006) and with the 'logic of belonging' (Torre and Rallet, 2005) describing a mode of cognitive proximity, the fact that the co-operating organisations belong or not to the seemingly contrasting worlds and institutional environments of non-profit R&D organisations and of private firms, i.e. the difference in their **legal status** (DistLegalStatus), plays no role either on the outcomes of the projects investigated in our survey, or if it does, on the opposite direction to the one expected: the influence on ScientificPublication is positive.

My interpretation of this result would be that the organisations that answered the survey have a good experience of the differences between these two institutional environments, and have learnt to cope with them. In the case of scientific publications, the positive influence of a difference in legal status may be interpreted by the fact that when a non-profit R&D organisation and a private firm co-operate, the allocation of the scientific results in academic journals is easily done in favour of the non-profit organisation.

7.1.4 No influence of the difference in size

Another contradiction with most expectations is that the differences in organisational **size** (*DistSize*) appear to play no role in the outcome of the co-operative R&D project, despite the differences in organisational culture between SMEs and large corporations claimed by earlier literature (Doz and Hamel, 1998; Alvarez and Barney, 2001).

My interpretation of this contradiction would simply be that the association between size and organisational features of organisations simply is not valid, specifically when including public R&D organisations in the sample. The authors that claim it rely on anecdotal evidence, but made no thorough assessment of it. I would therefore strongly question this association.

7.1.5 No influence of strategic compatibility

The level of **strategic compatibility** between partners, as evaluated by the respondents to the survey (*MotivStrategicCompatible*) plays no role either in the outcomes of the co-operative R&D projects being investigated, despite the strong recommendation in the literature arguing that it be essential to project success (Doz and Hamel, 1998; Brouthers et al., 1995; Bamford and Gomes-Casseres, 2002).

This may be the result of a selection bias: only those partners that were considered as strategically compatible were allowed to enter a co-operative R&D relationship. This hypothesis would be supported by the high mean value of the *MotivStrategicCompatible* variable (2.48 on a scale from 1 to 3 inclusive). It may also be that the co-operative R&D projects being investigated were at an pre-competitive enough stage of development for strategic compatibility issues not to influence the project operations.

7.1.6 No risk transfer to public bodies through public support

In what may appear as a satisfactory outcome for those public bodies funding co-operative R&D, the level of **public support** in the financing of the project (*PublicSupport*) has an effect only on the modification of capabilities in Physics and Software design, and then a positive one. In all other categories of co-operative R&D project outcome, the public support level has no significant influence.

This absence of effect is positive, since one could fear that private organisations take benefit of the existence of a public subsidy to engage in more risky, or second-grade R&D, effectively having the taxpayer paying for the potential losses, in a classical scheme of privatisation of gains and nationalisation of expenses. It appears from my empirical study that public support for co-operative R&D causes no bias in the project outcomes, and that the public funding plays its role of enabling a good-quality work that would otherwise not have taken place because of financial constraints.

7.1.7 Limited influence of technical risk level

Rather surprisingly, the anticipated level of **technical risk** (*TechRisk*) plays a role in project outcomes only in the prediction of a Dead End and of transfer of technical knowledge (see below § 7.2.3 and 7.2.4), although one could have anticipated that riskier projects are, on average, less successful than straightforward developments. This result would probably need to be completed by an analysis of the variance in the project outcomes, according to the level of anticipated risk.

7.1.8 No inverted-U shaped influence of cognitive distance in scientific & technical capabilities

Contradicting the previous work by Nooteboom (2007; 2005) and by Wuyts et al. (2005), but confirming Branstetter and Sakakibara (2002), the **cognitive distance** in scientific & technical capabilities between partners, when indeed significant to predict project outcomes (which is the case when predicting the achievement of technical milestone "Functional prototype" and of commercial milestones in § 6.8.2.4 and 6.8.2.5), has a **linear** (negative) influence, and displays no influence of a quadratic term, even when restricting the investigation to the 56 more exploratory projects (i.e. where the variable *TechRisk* ≥ 3). I do not therefore observe the inverted-U relation anticipated by Nooteboom in the case of exploratory co-operation.

Although the theoretical reasoning by Nooteboom and his followers appears reasonable, that cognitive distance be creative if small, but impedes communication when large, I do not observe it.

One reason of the difference in our results may lie in the difference in the experimental setting. Nooteboom, as mentioned earlier in § 1.4.4, measures the **average** distance in technological profiles (drawn from patent data) between a focal firm and its partners, and relates this distance to the innovativeness (measured again through patent data) of that same firm. He cannot attribute a specific patent to a specific alliance and therefore not either the cognitive distance to a specific partner to the innovative success of the alliance. The dyadic nature of the co-operative R&D co-operative relationship (that I maintain in my data) is therefore lost. In the same way, Wuyts et al. never have access directly to both cognitive distance and innovative output. In their experimental design, "*both tests are indirect, in opposite ways. In the first test, we had a direct measure of innovative output, but not of cognitive distance. In the second test the reverse applied: we had several measures of cognitive distance, but not of innovative output*" (p.298). My research may the first one in which both variables are simultaneously and directly integrated and investigated in the same data set.

7.1.9 No complementarity of scientific & technical capabilities

Although 78 % of my respondents have stated that the presence of specific scientific & technical knowledge with their potential partner is a “major” reason for co-operation, and despite the literature supporting that cognitive distance be creative, I have **not** found any **positive** influence of cognitive distance in scientific & technical capabilities on project outcomes.

My interpretation at this stage would be that the positive effects of cognitive distance (i.e. a complementarity of scientific & technical skills, where distance would have a positive effect on co-operation), if at all, would operate at much smaller scales of knowledge granularity than the one I used in my investigation. Indeed, in these very small fields of capabilities, mutual understanding would be assured by a common "*basic*" knowledge while the creativity would stem from the distance in "*specialised*" knowledge fields (Lane and Lubatkin, 1998).

Reaching a finer granularity in the description of scientific & technical capabilities would have been a challenge, though. Since I used a survey to collect data, I was restricted in the finesse of my enquiry, by two phenomena: (1) for considerations of confidentiality, the respondents could have been reluctant to reveal their capabilities in too great a detail and (2) this would have required that I know in advance, and with a very high level of detail, the full list of possible scientific & technical fields of activity of my sample, in order to list them

as survey items - which would have required consulting many specialists beforehand, which would have caused significant delay, and would have also significantly increased the time necessary to answer the survey, again at the expense of response yield.

7.2 Positive contribution of the research to the understanding of co-operative R&D projects outcomes

The positive contribution of my research to the understanding of co-operative R&D projects outcomes are the following. I will re-consider the raw results exposed above (§ 6.8 and 6.9, and summarised in § 6.7), and provide an interpretation for them. I will interpret the prediction of project milestones achievement (§ 7.2.1), of capability modification (§ 7.2.2), of knowledge creation (§ 7.2.3), and of knowledge transfer (§ 7.2.4) and of project management achievements (§ 7.2.5). I will then underline the effects of the motivation that an organisation has to select its specific partner (§ 7.2.6), and end up with the observations that I cannot directly interpret at this stage, and that may deserve further research (§ 7.2.7).

7.2.1 Interpretation of the prediction of project milestones achievement

7.2.1.1 Interpretation of the prediction of Scientific publications

The prediction of **Scientific publications** (§ 6.8.2.1) shows:

- a significant **negative** influence of the **combined** capabilities of project partners in **Strategic Marketing** (*CombStratMkt*)
- a significant **positive** influence of the **combined** capabilities of project partners in **Physics** (*CombPhys*)
- a significant **positive** influence of the **difference** in **Legal Status** of project partners (*DistLegalStatus*).

The positive influence of combined capability in "Physics", the fundamental science underlying the electronics industry, on an outcome that relates to scientific issues means that the self- and partner-**perception** of the organisation's capability is a **reliable predictor** of outcomes related to the same capability. This is a first empirical validation of the method I developed for the measurement of scientific & technical capabilities, that relies on the triangulated views of capabilities as perceived by the focal organisation and by its partner. This result is no tautology: the item in the survey on the organisation's capability referred to it in general, in all circumstances where it is mobilised, while that on the outcomes refer to the specific co-operative R&D project under consideration. The result of the regression model means that the dyads that perceive having a combined high level of permanent capability in Physics are also those that, statistically over my whole sample, published more scientific publications following the projects about which I interrogated them: the perceived permanent capability has a significant effect on the one-off circumstance of the specific project being studied.

The fact that the **combined** capability in Physics is significant, and not the distance in these capabilities, means (as interpreted above in § 6.5.1) that the **common component** of scientific & technical capabilities in the dyad is more important in the co-operative R&D project outcome than the differences between the partners. At a higher level of abstraction, what is common in the dyad is more important than what is different.

I would interpret the negative effect of combined (self- and partner-perceived) Strategic Marketing capabilities (*CombStratMkt*) on the achievement of Scientific publications as a

consequence of the conflict between fundamental research and application. Indeed, combined Strategic Marketing capabilities are the sign that both partners in the co-operative R&D project share a concern for direct applications, and for short-term returns. On the other hand, scientific publications are a fundamental, long-term and non-profit activity. Therefore, I can understand that when both organisations in the co-operative R&D project share a short-term, applied orientation, their common project generate few long-term, fundamental, general-interest achievements such as scientific publication. That a self- and partner perceived capability level be a reliable predictor of project outcomes again contributes to the validation of my measurement method. That the combined capability be significant (and not the distance in capability) is another illustration that what is common is more important than what is different: in this case, it is because no organisation in the dyad has a sufficient interest in long term issues (i.e. none of them has a small enough capability in Stategic Marketing) that the overall achievement of scientific publications is hindered.

The positive influence of the difference in Legal Status was interpreted earlier (§ 7.1.3).

7.2.1.2 Interpretation of the prediction of Patents

The prediction of the achievement of **Patents** (§ 6.8.2.2) shows:

- a significant **negative** influence of the **distance** along the dimension of "**Mode of perception**" (*DistSN*) of organisational 'world views'
- a significant **positive** influence of the **combined** capabilities of project partners in **Legal & IP management** (*CombLegalIP*)
- a significant **positive** influence of the **combined** capabilities of project partners in **Hardware design** (*CombHard*).

The negative influence of the distance along the cultural dimension of "Mode of perception" on the achievement of patents may be related to dissenting appreciations of the (technical and market) potential of technologies, and therefore of the relevance of patenting them. Indeed, organisations having a preference for "Sensing" consider immediate, hard facts as being the only ones being real and meaningful, while those with a preference for "Intuition" are more concerned with long-term, yet emerging trends. Therefore, the appreciation of the same invention would lead to a conflict regarding the need to patent it. The "Sensing" organisation would avoid patenting a forward-looking invention, because it doesn't perceive its long-term potential, while the "Intuitive" organisation would on the opposite favour it. Reciprocally, an "Intuitive" organisation would resist spending resources on a short-term, incremental invention for its supposed lack of ambition, while this is typically the sort of patents supported by a "Sensing" organisation.

The positive influence of combined capability in "Legal & IP management" capabilities (that include the wording of patents and patenting strategy) on achieving patents is another empirical validation of my method for measuring organisational capabilities via self- and partner perceptions. The fact that the combined capability (and not the distance in capabilities) is significant, is again an indication that commonality is more important than differences.

The positive influence of combined capability in "Hardware design" capabilities on achieving patents may be an indication that the determinant **technical** field in my sample of the electronics industry is Hardware design, and that Software design (although very present) is less a source of innovation. It may also be that Hardware innovations are easier to patent, and

easier to defend in trial, than those in Software, and therefore deserve better to be protected by patents.

7.2.1.3 Interpretation of the prediction of Lab demonstrators

The prediction of the achievement of **Lab demonstrators** (§ 6.8.2.3) shows:

- a significant **positive** influence of the **distance** along the dimension of "**Behaviour in the outside world**" (*DistJP*) of organisational 'world views'.

The positive influence on project outcome of distance along the cultural dimension of "Behaviour in the outside world" could be a surprise. Indeed, the "Behaviours" being described at the two opposing poles of this dimension of the organisational "character" are highly contrasted, and could very well lead to conflict. Organisations of the "P" type tend to believe that the world is essentially mobile, flexible, and in a constant process of change. They consider it as an endless repository of information, and would tend to delay any decision as much as possible, in order to maximise the chances that additional data could be gathered, under the motto "why should we decide today something that may become obsolete tomorrow?", at the risk of procrastination. They thus tend not to respect schedules and deadlines. Organisations of the "J" type on the other hand believe that the world is essentially stable and constant. They consider it as a locus of action and decision-making, and tend to take early decisions, under the motto "why should we delay to tomorrow a decision that could be taken today?", at the risk of precipitation. They set up accurate schedules, and respect them scrupulously. One could thus potentially anticipate that organisations contrasting along this dimension in the same project may engage in persistent conflict between those wanting to decide early and respect deadlines (of the "J" type), and those wanting to take more time to explore more options (of the "P" type).

The positive influence of the distance along this dimension on project outcomes that I observe in my research can on the other hand be interpreted as a synergetic effect of the co-operation between two types of organisations, respectively oriented towards "*exploration*" (preference for "P") and "*exploitation*" (preference for "J"), following March (1991). The interpretation from my empirical data seems to mean that contrasting organisations along this dimension of "Behaviour in the outside world" learn to work with one another, and to benefit from each other's qualities: the organisation of a "J" type benefits from the propensity of the partner organisation (of a "P" type) to look for more information and data – which may be highly beneficial in R&D activities that generally involve some form of uncertainty – while the organisation of a "P" type benefits from the capacity of its partner (of a "J" type) to take decisions and actually proceed in the work plan.

I would interpret the fact that this synergetic effect applies specifically to the achievement of "Lab demonstrators" as the result of this milestone being the one that requires the greatest amount of productive creativity. The issue is to integrate in a concrete, working artefact, a set of untried scientific & technical innovations. There is thus a need for both creativity and time to identify new solutions, but also of rigour and capacity to take timely decisions.

7.2.1.4 Interpretation of the prediction of Functional prototypes

The prediction of the achievement of **Functional prototypes** (§ 6.8.2.4) shows:

- a significant **negative** influence of the **distance** between the capabilities in **Physics** of project partners (*DistPhys*)

- a significant **positive** influence of the **combined** capabilities of project partners in **Systems design** (*CombSyst*)
- a significant **positive** influence of the **combined** capabilities of project partners in **Manufacturing technologies** (*CombManuf*).

The negative influence on project outcome of distance between the organisations' capabilities in Physics may be interpreted as the effect of a difference of mastery in the fundamental scientific substrate relevant for the electronics industry. Those organisations that have a high capability in Physics may be expected to have a stronger preoccupation for fundamental issues, at the opposite of those who have a lesser level of capability, and who would have a greater concern for applications and for reaching concrete market targets. This disagreement in priorities (in the 'axiologies') of the co-operating organisations would be specifically meaningful when the issue is that of achieving late-stage milestones such as "Functional prototypes" and would negatively impact this specific project outcome.

Systems design is the capacity to organise and assemble modules (material or immaterial) into a full operational artefact, taking fully into account engineering budgets (mass, power, dimensional tolerance) and performance targets. It is a capability that one would indeed expect to be mobilised to achieve "functional prototypes": while "lab demonstrators" prove the feasibility of a function, the "functional prototype" must prove that the function is attained at the right level of performance, and within set engineering budgets. I would thus interpret the positive influence of the combined capabilities in Systems design on the achievement of "functional prototypes" as a new illustration of the relevance of my measurement method for organisational capabilities. Following earlier interpretations, the fact that the combined capability is significant also means that what is most important is the commonalities between partners, rather than their differences. The same observations hold for capabilities in "Manufacturing technologies", that are mobilised to physically construct the prototype.

7.2.1.5 Interpretation of the prediction of commercial milestones

The prediction of the aggregation of the achievement of the four retained **commercial milestones**, that is (1) Industrial prototype, (2) Pilot Production, (3) Commercial launch, (4) Commercial success, (§ 6.8.2.5) shows:

- a significant **positive** influence of the **combined** capabilities of project partners in **Strategic Marketing** (*CombStratMkt*)
- a significant **negative** influence of the **distance** between the capabilities in **Hardware design** of project partners (*DistHard*).

The positive influence of combined capability in "Strategic marketing" (that include capabilities in the anticipation and definition of markets needs, and of their translation into technical terms) on reaching commercial milestones (that are related to introducing an innovation to the market) is again an empirical validation of my method for measuring organisational capabilities via self- and partner perceptions. The fact that the combined capability (and not the distance in capabilities) is significant, is again an indication that commonality is more important than differences. Finally, this result is good news for engineering and management schools. The techniques of Strategic Marketing appear to be indeed useful for co-operative R&D (i.e. involving external organisations), as much as they are for purely internal projects.

The negative influence on project outcome of distance between the organisations' capabilities in Hardware design may be interpreted as follows. Hardware design appears to be the technical capability that is most differentiating for the co-operative R&D projects of my sample (more than Software design or Manufacturing). Therefore, if the partner organisations differ too much along this variable, their capacity to bring the project to full fruition, through the final commercial milestones may be hampered by the difference between the really leading partner, that has this capacity to fully solve the remaining technical hurdles, and the follower.

7.2.2 Interpretation of the prediction of capability modification

The predictions of modifications of capabilities because of the co-operative R&D project (§ 6.9.3.1 to 6.9.3.8) show:

- a significant **positive** influence of the capability level of the **focal organisation** on the modification of that same capability in the fields of **Physics**, **Hardware** design, **Software** design and **Manufacturing** technologies, that is, in all **the scientific & technical** areas of capability being investigated in my research
- a significant **negative** influence of the **distance** along the dimension of "**Mode of perception**" (*DistSN*) of organisational 'world views' on the modification of capabilities in **Strategic Marketing**, **Legal & IP** management**, Hardware** design, and **Manufacturing** technologies
- a significant **positive** influence of the capability level of the **partner** on the modification of that same capability in the fields of **Systems** design, **Physics**, and **Software** design, that is, in all fields of capability where the distance along the dimension of "Mode of perception" of the organisational 'world view' (*DistSN*) has no influence
- a significant **positive** influence of the level of financial **public support** for the co-operative R&D project (*PublicSupport*) on the modification of capabilities in **Physics** and in **Software design**, that is, on the scientific & technical areas of capabilities among those where the capability of the partner plays a role
- a significant **negative** influence of the existence of a **previous**, positive **experience** with the partner, operationalised as the level of motivation to select this partner for this reason (*MotivPrevExperience*) on the modification of capability in **Legal & IP** management.

I would interpret the positive influence of the (self- and partner-perceived) scientific & technical capabilities of the focal organisation on its capacity to benefit from the co-operative R&D project to improve even more its capacity in the same area as an illustration of a **subjective 'absorptive capacity'** phenomenon (Cohen and Levinthal, 1990): the greater the perceived capability of an organisation in an area, the more it believes it learnt in that same area from co-operative R&D projects. Whether this subjective phenomenon also is confirmed with other methods would be the purpose of further research. This phenomenon triggers a positive feedback, self-reinforcing effect (Arthur, 1988) leading to an increased scientific & technical specialisation of organisations and an increased heterogeneity between them. This empirically evidenced specialisation process would reinforce the justification of the very existence of organisational capabilities in scientific & technical areas, in addition to the more general arguments developed above (chap. 2). It would also increase the justification of inter-organisational co-operation: if organisations tend to increase the specialisation of their

scientific & technical capabilities over time, then the need for co-operation with external, complementary organisations also increases, in an inter-organisational division of labour (Young, 1928).

The results summarised above tend to distinguish between two categories of capabilities, whose conditions of modification during a co-operative R&D project differ:

- capabilities of the focal organisation in **Strategic Marketing**, **Legal & IP** management, **Hardware** design, and **Manufacturing** technologies are believed to be increased during the co-operative R&D project if the distance in the 'Mode of perception' dimension of organisational 'world views' remains small
- capabilities of the focal organisation in **Systems** design, **Physics** and **Software** design are believed to be increased during the co-operative R&D project if the (self- and partner-perceived) capabilities of the partner organisation in the same area are high, and (in the latter two capabilities) if the public support for the project is large.

The first set of capabilities (Strategic Marketing, Legal & IP management, Hardware design, and Manufacturing), as may be seen in Table 7.2.1 below, is correlated to the 'Sensing' polarity of the 'Mode of perception' and to the 'J' polarity of the 'Behaviour in the outside world' dimensions of the 'world views', respectively. This association corresponds to a preference for the 'Introvert Sensing' psychic function, as described above (§ 4.5.1), which is associated to experiential, slow and progressive learning, and to a limited formalisation of knowledge.

Capability areas	**Spearman correlation** (*p-values*) over 240 organisations (*Smaller values of the score indicate a preference for 'Sensing' and for 'J', respectively => a negative correlation indicates a correlation of the capability with 'Sensing' and for 'J', respectively*)	
	'Mode of perception' dimension of 'world views'	'Behaviour in the outside world' dimension of 'world views'
Strategic Marketing	-0.1863 ** *(0.0044)*	-0.3077 *** *(1.85e-06)*
Management of R&D operations	0.1463 * *(0.0260)*	-0.1202 ° *(0.0686)*
Legal & IP management	0.0545 *(0.4086)*	-0.1670 * *(0.0109)*
Systems design	0.0419 *(0.5252)*	-0.0447 *(0.4985)*
Physics	0.0643 *(0.329)*	-0.0119 *(0.8564)*
Hardware design	-0.1156 ° *(0.0801)*	-0.2189 *** *(0.0008)*
Software design	-0.0503 *(0.4482)*	-0.0816 *(0.2192)*
Manufacturing technologies	-0.2360 *** *(0.0003)*	-0.3256 *** *(4.42e-07)*

Table 7.2.1: Spearman correlation (*p-values*) of organisational capabilities with the score along the 'Mode of perception' and 'Behaviour in the outside world' dimensions of 'world views'
Significance levels codes: ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

My interpretation of the conditions for the focal organisation's learning in these 'experiential' capability areas is then the following. If one organisation in the co-operative R&D project prefers the 'Intuition' polarity, attentive to "*the future, the big picture and the possibilities inherent in situations*" (Bridges, 2000), while the other prefers the 'Sensing' polarity, that focuses on "*the present, the details and the actuality of the situation*" that is, if the distance between the partners along this dimension of 'Mode of perception' is large, the transmission between them of experience will be difficult, because the organisations focus their attention on diverging aspects of phenomena, live and operate in different worlds of perception, in a different "*Umwelt*" (Uexküll, 1909). When one organisation describes a set of observations and its experience, along its 'Mode of perception', the other will only hardly perceive it, because it uses the opposite 'Mode of perception'. Therefore, experience-sharing between organisations will be difficult. In those capabilities correlated to the 'Introvert Sensing' psychic function (Strategic Marketing, Hardware design and Manufacturing technologies, and Legal & IP management to a lesser extent), where direct, hands-on experience is key to learning, the distance along the 'Mode of perception', by impeding the transmission of this very experience, will thus be an obstacle for learning and for the perceived improvement of capabilities. This difficulty in transmitting experience cannot be compensated for by a formalisation of knowledge, because this knowledge is highly experiential (which is detected by it being correlated to the Introvert Sensing psychic function).

On the other hand, the capabilities of the second group (Systems design, Physics and Software design) are not correlated to a specific psychic function, and specifically not to the 'Introvert Sensing' psychic function that requires experiential learning. They are thus easier to formalise and to transmit to others. This is the reason I would see why the (self- and partner-perceived) capability level of the partner plays a significant role in the focal organisation's perceived capability improvement in these areas: the perceived capability of the partner may be transmitted - and therefore received and assimilated - easily, in a subjective '**teaching**' effect. It may also be the reason why public support plays a role for the transmission of the two scientific and technical capabilities in this group: current procedures in the attribution of such financial aid is conditioned to the explicit planning of work. It is easier to provide such a planning to public financing bodies when the capability area involved is compatible with the formal exposition of knowledge.

I would interpret the empirical observation that the perceived improvement in Legal & IP management capability of the focal organisation is impaired by a previous experience with the same partner as the consequence of the fact that once the partners in the dyad have worked together once, they have learnt each other's legal requirements and procedures. These requirements and procedures are relatively stable. Therefore, once they have been learnt once for a specific partner, they believe that there is little more to learn from that same partner in the Legal & IP area. We therefore observe a **saturation** effect in the learning process of Legal & IP procedures.

Legal & IP management may therefore be considered as a privileged locus to observe "*partner-specific experience accumulation*" (Zollo et al., 2002, p.705). Indeed, according to Zollo *et al.* themselves, this experience accumulation specifically concerns the negotiations of legal agreements, in the wake of the focus on transaction costs and governance issues of previous research (Doz and Hamel, 1998; Williamson, 1979; Bamford and Gomes-Casseres, 2002; Anslinger and Jenk, 2004; Faems, 2006). However, our observation would tend to indicate that such an effect saturates rapidly after the first, or the first few, interactions between the same dyad of partners.

7.2.3 Interpretation of the prediction of knowledge creation

The predictions of **knowledge creation** during the co-operative R&D project (§ 6.8.2.6 to 6.8.2.10) show:

- a significant **positive** influence of the **combined** capabilities of project partners in **Physics** (*CombPhys*) on the **creation** of **scientific** knowledge
- a significant **positive** influence of the **combined** capabilities of project partners in **Hardware** design (*CombHard*) on the **creation** of **technical** knowledge
- a significant **positive** influence of the **combined** capabilities of project partners in **Strategic Marketing** (*CombStratMkt*) on the **creation** of **marketing** knowledge
- a significant **positive** influence of the degree of anticipated **technical risk** for the co-operative R&D project (*TechRisk*) on the creation of knowledge that the investigated path is a **dead end**
- a significant **negative** influence of the existence of a **previous**, positive **experience** with the partner, operationalised as the level of motivation to select this partner for this reason (*MotivPrevExperience*), on the discovery of **unforeseen opportunities**
- a significant **negative** influence of the **combined** capabilities of project partners in **Strategic Marketing** (*CombStratMkt*) on the **creation** of **scientific** knowledge
- a significant **positive** influence of the **distance** along the dimension of "**Mode of perception**" (*DistSN*) of organisational 'world views' on the **creation** of **marketing** knowledge
- a significant **negative** influence of the **disagreement** between partners as to which organisation **leads** the project (*DisagLeader*) on the **creation** of **marketing** knowledge.

I would interpret the first set of results rather simply. The main area of scientific capability for the electronics industry that I investigated is Physics; the main area of technical capability for the electronics industry is Hardware design; Strategic Marketing is the area of capability involved in the discovery of knowledge and information on the market of innovative products. I observe again (as in § 7.2.1) a confirmation of the validity of my method to measure organisational capabilities: the combined self- and partner-perceptions of capabilities in Physics, Hardware design and Strategic Marketing are reliable predictors of project outcomes that are logically related to them, respectively of the creation of scientific, technical and marketing knowledge.

I also observe (as in § 7.2.1) that the combined capability (and not the distance) is significant, which indicates a predominance of commonality phenomena over issues of inter-organisational differences.

I would interpret the following results also along a rather natural path. High technical risk in a project (*TechRisk*) means that the anticipated probability of failure is higher. It is therefore unsurprising that this feature of the co-operative R&D projects under observation leads to a greater possibility for the partners to learn that the path being investigated actually is a dead end. Finally, the fact of having already worked with a given partner, and of being motivated to select it as project partner because of successful previous experience (*MotivPrevExperience*), makes it better known. The organisation knows what to expect from an interaction. It is thus also straightforward that the potential for new, unforeseen opportunities be reduced when working with an already known partner. Good surprises stem

from novelty and from the unknown, including in the choice of partners in co-operative R&D projects. We have again an effect of rapid saturation of the knowledge creation potential from the interaction within a specific dyad.

I would interpret the negative effect of combined (self- and partner-perceived) Strategic Marketing capabilities (*CombStratMkt*) on the creation of scientific knowledge as above (§ 7.2.1.1).

As described above (§ 5.5), I understand 'Marketing knowledge' as knowledge about the receptivity of pilot customers, their willingness to pay and about the maturity of the need for the innovative product or service being developed during the co-operative R&D project. This understanding was specified in the survey itself, and therefore transmitted to respondents. I would consider that, in order to gather this information, both 'Intuition' and 'Sensing' psychic functions are necessary. A good mastery of 'Intuition' is required to anticipate and imagine the future product or service; a good mastery of 'Sensing' is necessary remain realistic and pragmatic as to what economic and monetary benefit the organisation will draw from this new activity. I would then interpret the favourable influence of the distance along the 'Mode of perception' dimension of 'world views' (*DistSN*), that is, between organisations preferring 'Intuition' and those preferring 'Sensing', on the creation of marketing knowledge as the consequence of the complementarity exposed above between these two psychic functions.

Finally, I would interpret the negative influence of disagreement about which organisation is the project leader (*DisagLeader*) on the creation of marketing knowledge as the consequence of the high stakes involved at this stage of the innovation. If the co-operative R&D project has made so much progress as to investigate the market potential for its technical outcome, the issue of how its economic benefits will be shared becomes highly relevant. At this stage, not agreeing on such a basic governance issue as to which organisation actually leads the co-operative project is the sign of a potential conflict that can very well impact the joint search for marketing knowledge.

7.2.4 Interpretation of the prediction of knowledge transfer

The predictions of **knowledge transfer** during the co-operative R&D project (§ 6.9.3.9 to 6.9.3.11) show:

- a significant **positive** influence of the capability level of the **partner** in **Physics** (*PartPhys*) on the **transfer** of **scientific** knowledge
- a significant, **positive** influence of the capability level of the **partner** in **Strategic marketing** (*PartStratMkt*) on the **transfer** of **marketing** knowledge
- a significant, **positive** influence of the capability level of the **focal organisation** in **Systems** design (*Syst*) on the **transfer** of **scientific** knowledge
- a significant **negative** influence of the capability level of the **partner** in **Strategic marketing** (*PartStratMkt*) on the **transfer** of **scientific** knowledge
- a significant **negative** influence of the level of **technical risk** (*TechRisk*) on the **transfer** of **technical** knowledge.

I would again interpret the first two results rather simply.

The main area of scientific capability for the electronics industry that I investigated is Physics, and this area of capability may be formalised and taught, as it does not rely on direct hands-on experience (§ 7.2.2). That the (self- and partner-perceived) capabilities of the

partner in Physics (*PartPhys*) be a reliable predictor of transfer to the focal organisation, during the co-operative R&D project, of a category of knowledge that logically relates to it, namely scientific knowledge, is a new confirmation of the validity of my measurement method of organisational capabilities. That the capabilities of the partner (Organisation B) are a predictor of the transfer of knowledge to the focal organisation (A), as perceived by the same Organisation A, demonstrates that this regression result is no tautology.

Similarly, Strategic Marketing is the area of capability involved in the discovery of knowledge and information on the market of innovative products. Although the capability itself is highly experiential and difficult to teach, by being related to the 'Introvert Sensing' psychic function (§ 7.2.2), the results of its usage, the market study on the perspectives of an innovative product, are easy to transmit. That the perceived partner's capability in Strategic Marketing (*PartStratMkt*) favours the transfer of marketing knowledge to the focal organisation is again a confirmation that the self- and partner perception of a capability is a reliable predictor of concrete outcomes related to it. In this scenario, the partner (Organisation B) makes the marketing study, by mobilising internally its own highly developed capabilities in Strategic Marketing (that are difficult to formalise and to teach), transmits the easily transmittable results of the study to the focal organisation (A), and the focal organisation considers this as valuable marketing data. That the (perceived) capability lies in one organisation, while the result of it appear in the other, underline the non-tautological nature of this result.

I would interpret the fact that a (self- and partner-perceived) good capability in Systems design of the focal organisation (*Syst*) favours its reception of scientific knowledge from its partner as a form of **'absorptive capacity'** (Cohen and Levinthal, 1990), although it is different in nature from what Cohen and Levinthal described. Indeed, Systems design is a highly integrative engineering capability, in which very varied fields of scientific & technical knowledge are jointly mobilised to develop a complete and coherent product, made of several complementary modules. Therefore, mastering this capability means that the organisation can integrate various types and various sources of knowledge, at a level sufficient to use them, and to incorporate the constraints and opportunities stemming from these different scientific & technical disciplines in a global design. This integration is easier when the knowledge is well-formalised, which is more often the case with scientific than with technical knowledge. Following this reasoning, I can understand that an organisation displaying a high level of capability in Systems design also has a good capacity to absorb well-formalised knowledge, such as scientific knowledge, that is being transferred from its partner. In this sense, Systems Design capacity is a form of **generic** 'absorptive capacity', that Cohen and Levinthal had not anticipated.

I would interpret the negative influence of the (self- and partner-perceived) partner capabilities in Strategic Marketing (*PartStratMkt*) on the transfer of scientific knowledge in two ways. On the one hand, as exposed above (§ 7.2.3), capabilities in Strategic Marketing would be a marker for short-term, applied orientation. If the partner organisation bears these features, it has little fundamental scientific knowledge present in-house, and therefore also little to transfer to partners. A second interpretation could be that those organisations with high capabilities in Strategic Marketing are also those most aware of the economic value of knowledge, because they know well how to leverage it on a market. They would therefore be more reluctant to transfer scientific knowledge, or more clever to prevent its leakage.

In these last two results, the fact that a perceived level of capabilities is a reliable predictor of a project outcome that is logically related to it is again an validation of my measurement method.

Finally, my interpretation of the observation that the transfer of technical knowledge is impaired by the risk level of the project would be that if organisations place themselves in a position of student in a learning relationship (which is also illustrated that they select their partner for its technical capabilities (see below § 7.2.6), they would minimise the risks of failure. Passive, asymmetrical learning is best assured in a secure environment.

7.2.5 Interpretation of project management achievements

7.2.5.1 Interpretation of the prediction of compliance with project schedule

The predictions of **compliance** with the project **schedule** (§ 6.8.2.11) show:

- a significant **positive** influence of the **distance** along the dimension of "**Behaviour in the outside world**" (*DistJP*) of organisational 'world views'
- a significant **negative** influence of the **distance** between the capabilities in **Strategic Marketing** of project partners (*DistStratMkt*)
- a significant **positive** influence of the **distance** between the capabilities in **Management of R&D operations** of project partners (*DistRDMgmt*)
- a significant **negative** influence of the **difference** in **nationality** between project partners (*DistNation*).

The positive influence of the difference in R&D Management capabilities (*DistRDMgmt*) on the compliance with project schedule could appear as a paradox, as much as that of distance along the dimension "Behaviour in the outside world" of the 'world views' (*DistJP*), of which I provided an interpretation above (§ 7.2.1.3). I would interpret this paradoxical result in the same way as for *DistJP*. One could argue that strong R&D Management capabilities on both sides of the partnership should foster the timely delivery of the project output (because it contains items relevant to project management in sub-fields *RDMgmt8* and *11* to *14*). I would however, in the light of this result, rather consider that such a configuration would lead to a project management that be too rigid for innovation to take place, and where the adherence to strict timelines would be done at the detriment of technical performance or of reliability in the design, ultimately leading to last-minute delays to fix what was left aside during the process. If the dyad contains one organisation that follows strong R&D Management guidelines, while the other is more flexible, then it seems that this contrast could be productive. The organisation more competent in R&D Management would push for orderliness and method, while the other would keep an eye on the unexpected and the thorough treatment of issues, even it takes more time than planned.

I would interpret the negative influence of the distance in Strategic Marketing capabilities as the expression of a conflict between the partners' 'world views' as regards the project's objective. A strong capability in Strategic Marketing could be interpreted as an orientation towards application and down-stream issues: if the weight given to these considerations is very different between partners, then their objectives may become so divergent as to cause delays in the overall schedule.

The negative influence of the difference in nationality on the compliance with project schedule may simply be interpreted as the result of plain communication and co-ordination issues (see above § 7.1.2).

7.2.5.2 Interpretation of the prediction of compliance with project cost budget

The predictions of **compliance** with the project **cost budget** (§ 6.9.3.12) show:

- a significant **negative** influence of the capability level of the **partner** in **Systems design** (*PartSyst*).

This result may appear as surprising, for one would not expect the high level of a partner's capabilities to have a negative influence on any project outcome. My interpretation however could shed light on this phenomenon. Systems design capabilities involve the accurate definition of specifications, specifically at interfaces. If a co-operative R&D project starts encountering difficulties, one easy means for an organisation to hold one's own budget could be to shift responsibilities and work towards the partner, by modifying one's deliverables or attempting to deliver less than what was originally thought of, and expecting the partner to compensate. However, if the partner has good Systems design capabilities, it defined the interface specifications between the members of the dyad with great accuracy (so that relying on ambiguities is less easy), and also knows very well the justification for each component of it. The partner will thus monitor compliance with the specification with a greater attention, and prevent any form of evasion from one's commitments, be it for the good cause of complying with one's own cost budget.

7.2.6 Effects of the source of motivation to select the partner: presence of capabilities

Some items of the survey referred to the nature of the motivation that the organisation had to select its specific partner in the co-operative R&D project, and more specifically to the level of motivation to select it that originated in the anticipated presence of capabilities in the partner. These anticipated capabilities in the partner that could motivate partner selection were either its general innovation management capabilities (*MotivGeneralCompetence*) or its scientific & technical capabilities (*MotivTechCompetence*).

As was evidenced above (§ 6.9.3.1, 6.9.3.3 and 6.9.3.10):

- the level of **motivation** for having selected that specific partner for its general **innovation management** capabilities (*MotivGeneralCompetence*) has a significant, **positive** effect on the modification of capabilities in **Strategic Marketing** and in **Legal & IP** management
- the level of **motivation** for having selected that specific partner for its **technical** capabilities (*MotivTechCompetence*) has a significant, **positive** effect on the **transfer** of **technical** knowledge.

I would interpret these rather straightforward results mainly as an illustration that the organisations in my sample have some capability to detect the specific capabilities of a potential partner, and that they are indeed able to leverage the co-operative R&D project to reach some of their capability acquisition goals. However, the modification of innovation management capabilities due to the anticipated presence of such capabilities in the partner organisation only applies to Strategic Marketing and Legal & IP management. The Management of R&D operations, which may appear as an important management capability for innovative organisations, is not affected. This would mean that these capabilities are indeed more difficult to acquire or to modify.

7.2.7 Unexplained observations

Despite my reflections, there are some observations from the statistical exploitation of my data that I have remained unable to account for. They would deserve being investigated in further research, potentially using qualitative methods to understand the underlying active

mechanisms. These results that remain so far not explained, and the attached unresolved questions that I have identified, are the following:

- the **distance** along the dimension of "**Liberty vs. Authority**" (*DistLib*) of organisational 'world views' has a significant **positive** influence on the **modification of capabilities** in **Physics**. Why does this dimension of 'world views' have an effect on Physics only? Why does the distance between liberal and authoritarian organisations prove to be productive?
- the **distance** along the dimension of "Team size" (*DistTeamSize*) has a significant **negative** influence on the discovery of **unforeseen opportunities**. The team size would affect the working habits of organisations, specifically the level of structure in the organisation. Why does it affect the discovery of new opportunities only?
- The capability level of the **focal organisation** in **Manufacturing technologies** (*Manuf*) has a significant, **negative** influence on the **transfer** of **marketing** knowledge. Why does a relatively inward-oriented capability such as Manufacturing technologies impede the transfer towards the organisation displaying it of an outward-oriented knowledge such as marketing?
- the capability level of the **partner** in **Strategic marketing** (*PartStratMkt*) has a significant, **positive** influence on the **transfer** of **technical** knowledge. Why does a management capability influence of the partner affect the reception of technical knowledge by the focal organisation?

I have reached the goal of the empirical part of my thesis, and provided an interpretation of most results obtained from the statistical exploitation of my empirical data. I can now summarise my overall results in the general conclusion, which is the purpose of the next and final Part 3.

Part 3: General conclusion

I have completed both the construction of my theoretical concepts of organisational capabilities and 'world views' (Part 1), and their incorporation into empirical research, by examining their influence on the outcomes of co-operative R&D projects (Part 2).

I am now in a position, in a final chapter, to conclude on the main contributions of my research, and to draw perspectives for further research, as well as for the improvement of practice (chap. 8).

8 Summary of results, limitations and further research

I will in this chapter summarise my results, distinguishing between my contributions to theory (§ 8.1) and my empirical observations and interpretations (§ 8.2). I will then acknowledge the limitations of my work (§ 8.3) and open perspectives for further research that could benefit from this thesis (§ 8.4).

8.1 Contributions to theory

Although they are not the core purpose of my doctoral research, I have developed during this work some auxiliary theoretical concepts that I believe have the potential to renew the study of organisations: (1) I have supported by theoretical arguments the stability of the organisation's 'world views' and 'purposive communication network' (chap. 2), (2) I provided a definition of organisational capabilities (§ 3.2), and (3) I have developed a unified model of organisational 'world views' (§ 4.4). I will draw some consequences of these results in the next three sections (§ 8.1.1, 8.1.2 and 8.1.3).

8.1.1 Stability of the organisation's 'world views' and 'purposive communication network'

In the reflections of chapter 2, I have argued that the research on the stable elements of organisations should focus on 'world views' - the combination of an ontology, a mission statement and an axiology - and on the purposive communication network. I have exposed why I believe that these features are stable, what processes make them stable, and that they are potentially universal and well-suited for observation. In that sense, they provide a path for research on the persistent organisational 'genes' that may be more fruitful than the 'routines' that were studied so far by the school of Evolutionary Economics. I have also supported by theoretical arguments the existence and the persistence of organisational capabilities and cultures, which may be helpful for the research on capabilities, in the framework of the Resource-Based View of the firm.

8.1.2 Definition of organisational capabilities

In section 3.2, I proposed a definition of 'organisational capabilities' as a capacity for the organisation to perform well a set of actions in a given context. This definition, although simple, has a potential to clarify a field of research that my earlier systematic review of literature (Zibell, 2007) has shown to be in a state of emergence and confusion of concepts.

8.1.3 Unified model of organisational 'world views'

In section 4.4, I have provided a unified model of 'world views', in a typology that contains four 'collective' polities and four 'individual' ones, based upon converging observations from economic sociology, historical anthropology and analytical psychology. Typologies have the purpose and ambition of condensing the differences within a population to a small number of parameters. My intention in developing this typological model therefore was to provide a tool that be simple and yet relevant to describe the ontology, the mission statement and the axiology of human groups.

By describing the world of perception in which the people live, the 'common superior principle' that they seek, and the nature of the higher 'worth' that they aim at reaching, I help anticipating their behaviour, provide a framework to understand their motivation, and explain the source of co-ordination within a 'polity' and of conflicts between them. This typology may

renew several domains of social and management sciences, according to the scale of the group for which the 'polity' is defined, as described in the Table 8.1.1 hereafter.

Scale of the human group at which the preference for a 'polity' / a 'world view' is defined	Nature of the **actions** and **decisions** being influenced by the belonging to a 'polity' / by the prevalent 'world view' in the group	**Discipline** of social or management science that could benefit from the integration of the typology of 'world views'
Individual	Consumer choices Vote	Marketing of consumer goods and charities Political science
Work team	Work motivation	Human Resource Management
Organisation	Fields of activity Mergers & Acquisitions	Strategic Management
Nation / Political entity	Economic policy	Political Economy

Table 8.1.1: Scale of human groups where the 'world views' model could apply and the disciplines of social and management science that could benefit from it

The 'world views' model could benefit Marketing of consumer goods and charities by enriching and diversifying the nature of motivations to mobilise from a potential consumer or donor. In the same manner, it could structure the analysis of political options offered to voters. Similarly, by its contribution to the understanding of what motivates work teams, the model could renew the nature of reward systems in organisations, and improve the adequacy of missions with the 'world views' of those in charge of implementing them. It could thus contribute to Human Resources Management in organisations. At the scale of the organisation as a whole, the model could help identify those activities that are suitable for the organisation, by being compatible with its 'world view', and thus those to acquire or to sell, to develop or to relinquish. The simplicity of the typology could also improve the anticipation of cultural conflicts upon Mergers & Acquisitions. As such it could contribute to Strategic Management. Finally, at the scale of the nation or of a coherent political entity, the model could help hierarchising priorities among collective goals to better fit the 'world views' present in the political entity, or to present a panel of varied policies, in order to adapt to the diversity of 'world views' present in heterogeneous entities (such as the European Union). The selection of innovation policies could benefit from knowing the mode of innovation preferred by the locally prevalent 'world view'. It would then contribute to Political Economy.

8.2 Empirical results

The main aim of my doctoral research was to evidence empirically those capability-based and cultural factors that influence the outcomes of co-operative R&D projects (§ 1.6.1). I have achieved the following tasks: (1) I validated empirically the relevance of the models of organisational 'world views' and of structural features of organisations that I had introduced, (2) I validated empirically my method to evaluate organisational capabilities and their relevance to predict project outcomes, (3) I provided empirical evidence for a deep reform of the research agenda on the economic geography of inter-organisational co-operation, and finally (4) I proposed and supported empirically some recommendations for practitioners co-operative R&D projects. This is the purpose of the following sections (§ 8.2.1 to 8.2.4).

8.2.1 Validation of models of organisational 'world views'

In my research, I have both validated the relevance of the model of 'world views' that I proposed in § 4.4, and (partially) the survey items used to evaluate them.

Indeed, as evidenced in sections 6.8 and 6.9 and summarised in chapter 7, the variables describing the distance along the dimensions of 'world views' that I retained (in § 4.5) and along one of the 'structural features' of the organisation (§ 5.5) that I proposed prove to be significant predictors of co-operative R&D project outcomes:

- the distance along the dimension of 'Mode of perception' (*DistSN*) has a significant influence on the achievement of patents, on the creation of marketing knowledge, on the modification of capabilities in Strategic Marketing, Legal & IP management, Hardware design and Manufacturing technologies (§ 6.8.2.2, 6.8.2.8, 6.9.3.1, 6.9.3.3, 6.9.3.6 and 6.9.3.8)
- the distance along the dimension of 'Behaviour in the outside world' (*DistJP*) has a significant influence on the achievement of lab demonstrators and on compliance with schedule (§ 6.8.2.3 and 6.8.2.11)
- the distance along the dimension of 'Liberty vs. Authority' (*DistLib*) has a significant (even if mysterious) influence on the modification of capabilities in Physics (§ 6.9.3.5)
- the distance between the typical team sizes of project partners (*DistTeamSize*) has a significant (and again yet unexplained) influence on discovery of new, unforeseen opportunities (§ 6.8.2.10).

I demonstrated empirically (§ 6.3) that the survey items that I have either re-used from earlier literature (Bridges, 2000) or developed entirely are unidimensional enough to be aggregated as representative of three underlying dimensions of 'world views': the 'Mode of perception', the 'Behaviour in the outside world' and 'Liberty vs. Authority'. On the other hand, the items that I had developed for the 'Equality vs. Inequality' dimension were proven not to be unidimensional: this would be the purpose of further investigation.

I have proven that these dimensions are relevant to describe organisational 'world views' and to predict the outcomes of co-operative R&D projects. I have in addition empirical evidence that these dimensions of cultural proximity are not perceived, even unconsciously, by practitioners. Indeed, had the practitioners a good perception of the relevant 'cultural proximity' with their partners, even if they were not able to formalise it explicitly, it would mean that my research on the relevant dimensions of this notion would be somewhat useless in practice, since relying on practitioner experience would be sufficient for decision-making. I had therefore asked the project managers of my sample about how much 'cultural proximity' motivated their choice of their partner (*MotivCulturalProximity*), without (deliberately) making the notion more explicit. I have investigated the Spearman (rank-based) correlation between this variable and the distance computed along the dimensions describing cultural distance, either that I introduced in my research or that are provided in earlier literature (§ 6.4). The results are provided in the Table 8.2.1 below.

Name of variable	Motiv CulturalProximity
Motiv CulturalProximity	**1.7226** ***(0.5811)***
DistSN	0.0469 *(0.6216)*
DistJP	-0.0659 *(0.4897)*
DistLib	0.0183 *(0.8486)*
DistTeamSize	0.0510 *(0.5979)*
DistProjDuration	0.2742 ** *(0.0044)*
Motiv PreviousExperience	0.1807 ° *(0.0511)*
DistGeo	-0.2682 ** *(0.0031)*
DistNation	-0.2355 ** *(0.0099)*
DistSize	-0.1061 *(0.2505)*
DistLegalStatus	0.0111 *(0.9042)*

Table 8.2.1: Descriptive statistics of the level of motivation to select the partner for 'cultural proximity' reasons (*MotivCulturalProximity*): **mean value, *(standard deviation)*** and Spearman correlations *(p-value)* with variables semantically related to it.
*Confidence levels: *** : p value ≤1‰; ** : p value ≤1%; * : p value ≤5%; °: p value ≤ 10%*

As may be seen, project managers that I surveyed in my research consider 'Cultural proximity' as a minor consideration when selecting a partner in co-operative R&D projects: the mean value of 1.7226 (on a scale from 1 "not relevant for selection" to 3 "major consideration for selection') is low. Although cultural dimensions prove to be significant determinants of project outcomes, as seen above, project managers tend to under-estimate its importance.

They also associate 'Cultural proximity' with geographic and national considerations only: the correlation between the motivation to select the partner for 'cultural proximity' (*MotivCulturalProximity*) is negatively and significantly correlated to geographic distance (*DistGeo*) and to the difference in nationality (*DistNation*). The negative correlation is explained by the fact that 'proximity' is the opposite of 'distance'. However, as shown above (§ 7.1), these variables have very limited influence on project outcomes. Project managers ansewering the survey also consider 'Cultural proximity' to be related to having had a positive previous experience with that partner (*MotivPreviousExperience*), but this may be an artefact due to having taken the same selection criterion in their earlier choice. On the other hand, the motivation to select the partner for 'cultural proximity' (*MotivCulturalProximity*) is correlated with none of the variables for 'world views' nor for structural features of the organisation that I demonstrated were relevant to predict project outcomes.

These results show that the project managers that I interrogated do not sufficiently integrate the cultural dimensions of the partner organisations when selecting their partners, and that they do not either have the tools to identify the relevant parameters of this cultural proximity. An instrument such as the one that I developed for this research can therefore be useful to improve partner selection in co-operative R&D projects.

8.2.2 Validation of metrics for organisational capabilities

Considering the rather disappointing result of my earlier systematic review of literature on the measurement of collective capabilities (Zibell, 2007), I have been led to develop my own method to assess the capability level of the organisations being surveyed (§ 5.6.1). The main features of this method are the following. In coherence with the definition that I provided (§ 3.2), I formulated capabilities in functional terms, by expressing them as actions that the organisation may want to undertake. I split organisational capabilities in broad functional areas, and for those that the organisation considered as being in its 'core' competence (Prahalad and Hamel, 1990), I went into greater detail of functional sub-fields and of comparison with competitors. I asked each organisation to evaluate its partner, on those capabilities that could be visible from the outside, and averaged for each organisation its self-evaluation with that of its partner, in a triangulation perspective, in order to reduce noise (§ 5.7.3).

Although it relies solely on the (self- and partner-) perception of capabilities, the result of this measurement method proved to be a relevant metric, valid as predictor of co-operative R&D project outcomes that are logically related to the capability being measured. Indeed, when using this method of measurement:

- the combined capabilities of project partners in Strategic Marketing (*CombStratMkt*), in Legal & IP management (*CombLegalIP*), Systems design (*CombSyst*), Physics (*CombPhys*), Hardware design (*CombHard*) and Manufacturing technologies (*CombManuf*) have a significant influence on the achievement of technical and of commercial project milestones, and on the creation of scientific, technical and marketing knowledge (§ 6.8.2.1 to 6.8.2.8)
- the distance between the capabilities of partners in Physics (*DistPhys*), has a significant influence on the achievement of functional prototypes and of commercial project milestones (§ 6.8.2.4 and 6.8.2.5), while the distance between capabilities in Strategic Marketing (*DistStratMkt*) and Management of R&D operations (*DistRDMgmt*) have a significant influence on the compliance with project schedule (§ 6.8.2.11)
- the capability levels of the partner in Strategic Marketing (*PartStratMkt*), Systems design (*PartSyst*), Physics (*PartPhys*) and Software design (*PartSoft*) have a significant influence on the transfer of scientific, technical and marketing knowledge, and on the modification of the focal organisation's capability level in Systems design, Physics, and Software design and on the compliance with cost budget (§ 6.9.3.4, 6.9.3.5, 6.9.3.7 , 6.9.3.9 to 6.9.3.12).
- the capability levels of the focal organisation in Systems design (*Syst*), Physics (*Phys*), Hardware design (*Hard*), Software design (*Soft*) and Manufacturing technologies (*Manuf*) have a significant influence on the transfer of scientific and marketing knowledge, and on the modification of the focal organisation's capability level in Physics, Hardware design, Software design and Manufacturing technologies (§ 6.9.3.5 to 6.9.3.9 and 6.9.3.11).

More generally, and as a conclusion of these first two sections,

I have demonstrated that my representation of organisations in a cognitive space made of **'world views'** and **organisational capabilities**:

1. is theoretically grounded
2. can be operationalised using the survey that I developed
3. is empirically validated in the specific setting of predicting the outcomes of European co-operative R&D projects.

8.2.3 Reform of the economic geography of inter-organisational co-operation

Generally, science progresses cumulatively. New results add upon existing ones, modify them marginally, and provide refinements that increase the predictive accuracy of models, or cover a broader set of marginal cases.

My research has taken into account variables that had previously been considered in the literature as potentially explanatory, my common control variables (§ 6.4): the geographic distance (*DistGeo*), the differences in nationality (*DistNation*), in size (*DistSize*), in legal status (*DistLegalStatus*) between the partner organisations, the level of public financial support (*PublicSupport*) and of technical risk of the project (*TechRisk*) and the level of strategic compatibility between partners (*MotivStrategicCompatible*). In each of the regression models (§ 6.8.2.1 to 6.9.3.12), I systematically placed these common control variables in competition with those emerging from my research (§ 6.5): this was the intermediary 'Model 2' (in the general presentation template described in § 6.6.2). However, in all these cases, and as I underscored above (§ 7.1), none of the control variables proved to remain significant when placed in competition with the explanatory variables introduced by my research. Instead of carefully building upon existing literature, in the cumulative view of science briefly exposed above, I am forced into the position of deeply renovating my area of research, which I could describe as the economic geography of inter-organisational co-operation (whose main results were summarised in § 1.4).

8.2.3.1 History, and not geography, as explanatory factor of high-tech clusters

Previous research (summarised in § 1.4.3) emphasises geographic distance as a meaningful parameter when explaining the co-location of innovative activities in small areas, generally referred to as 'high-tech clusters'. Geographic proximity, by fostering direct, face-to-face contacts, is meant to improve the efficiency of inter-organisational co-operation in R&D.

My research contradicts this view, since we have seen above that geographic distance (*DistGeo*) has no significant influence on the outcomes of co-operative R&D projects (§ 7.1.1). However, it opens the path for an alternative, **history-based** explanation for the existence of 'high-tech clusters'. Initially, organisations seek their first co-operation partners at short geographic distance, for reasons that I would interpret as purely based on economic **cost** or because the initial idea was born in a 'local buzz' interaction (§ 7.1.1). The cost reduction makes sense in the initial phases of co-operation experience: minimising costs reduces the potential impact of failure on the operations of the recently partnering organisation. In the same fashion, 'buzz'-like interactions generally start at short geographical range, locally (Bathelt et al., 2004). Once this first selection bias is taken in favour of short geographic distance, for reasons that have nothing to do with greater efficiency of co-operation at short geographic distance, it is maintained by pure inertia, and because it provides a 'satisficing' solution (Simon, 1979), even if the previous successful experience with a given partner has no

effect either on the outcomes of further co-operative R&D projects with that same partner (beyond a rather negative saturation effect on the learning of Legal & IP capabilities and on the possibility of knowledge creation in the shape of 'new, unforeseen opportunities').

8.2.3.2 'World views' and organisational capabilities, not institutions or nationality, at the core of a cognitive space

Previous research (summarised in § 1.4.4) attempts to enrich geographic distance by introducing the concept of 'cognitive distance' between organisations. However, the operationalisation of this potentially interesting concept had so far remained rather crude. It was limited to either nationality, a logic of 'belonging' to the same (network of) organisations.

My research would contradict these previous results. Indeed, neither the difference in nationality (*DistNation*), nor the difference between private firms and public R&D institutions (*DistLegalStatus*), nor the distance in size (*DistSize*), the last two parameters being very simple means to implement the 'logic of belonging', have any influence on co-operative R&D project outcomes (§ 7.1.2 to 7.1.3), the only exception being the influence of the difference in nationality on compliance with project schedule.

On the other hand, the parameters that I introduced in my research to describe the organisational 'world views' and capabilities prove to be subject to observation and measurement, and to have a significant influence on the prediction of co-operative R&D project outcomes. Placing organisations in a 'cognitive space' whose dimensions are the organisational 'world views' and capabilities appears therefore as being much more relevant to anticipate their co-operative behaviour and R&D performance than in one composed with nationality, legal status or size.

8.2.3.3 Commonalities between partner capabilities are more important than their differences

The previous research involving 'cognitive' dimensions of inter-organisational co-operation has focused on the distance between partnering organisations' scientific & technical capabilities as being the main determinant of co-operative success. The underlying assumption for focusing on this metric (should it have an inverted-U shaped or a linear influence on outcomes) is that what is different between partners is the most determinant phenomenon to predict co-operative success.

I observe this influence of the distance between organisational capabilities on project outcomes only rarely, when predicting the achievement of functional prototypes, of commercial milestones and compliance with project schedule (§ 6.8.2.4, 6.8.2.5 and 6.8.2.11).

In all the other cases that I studied in my empirical research, the method to consider the capabilities of both partners in the co-operative R&D project that proved to be a significant predictor of outcomes is the **combined** capability of partners, not the distance between their capabilities (§ 7.2.1 and 7.2.3). When considering capabilities, what is common between partners is more important to predict project outcomes than what is different, which is coherent with Dyer and Singh's (1998)views that the overlap of technical knowledge is essential for co-operative effectiveness.

8.2.3.4 Distance in organisational 'world views', not in capabilities, determines compatibility

My previous conclusion is that cognitive distance in capabilities only has a marginal effect on co-operative R&D project outcomes. However, cognitive distance between organisational 'world views', and specifically between the organisational 'characters', is a significant predictor of the outcomes of co-operative R&D projects (§ 6.8.2.2, 6.8.2.3, 6.8.2.8, 6.8.2.11, 6.9.3.1, 6.9.3.3, 6.9.3.6 and 6.9.3.8).

I would conclude that the core of the **compatibility** issue between organisations lies in that of their **'world views'**. I am thus able to empirically confirm, and to operationalise with accuracy, the practitioner-originated notion (§ 1.5.2) that "**compatibility of cultures**" is important for co-operative success. This notion, although it was broadly reproduced in the literature (§ 1.5.2), had not yet received any operationalisation, nor any empirical confirmation.

8.2.3.5 The effect of cognitive distance on project outcomes is linear, not inverted-U shaped, even when restricting my sample to exploratory projects

Previous research, and specifically Nooteboom and his followers (Nooteboom, 2000; Nooteboom et al., 2007; Nooteboom et al., 2005; Wuyts et al., 2005) detected a quadratic, inverted-U shaped relation between cognitive distance between the technical capabilities of partners and the outcome of their R&D co-operation, specifically when considering explorative projects. They posit that there exist an optimal cognitive distance between partners: "*A trade-off needs to be made between cognitive distance, for the sake of novelty, and cognitive proximity, for the sake of efficient absorption*" (Nooteboom, 2000, p.72).

However, even when restricting my sample to projects considered as of "high" technical risk ($TechRisk \geq 3$), I do not observe any quadratic effect of those variables describing cognitive distance in scientific & technical capabilities (§ 6.8.2.4 and 6.8.2.5). Although this discrepancy may stem from my coarser description of these capabilities, it may also find its origin that my research design is the first that measures directly cognitive distance and co-operative R&D projects outcomes simultaneously, and at project level (i.e. not aggregated at the scale of the whole partnership portfolio of a firm).

8.2.4 Recommendation for practitioners

My recommendations for practitioners would apply both to organisations performing Research & Development, in order to help them selecting their partner, and to public bodies fostering co-operative R&D. The validity of these recommendations is of course restricted by the limitations of my research itself, that are summarised hereafter (§ 8.3).

8.2.4.1 Recommendations for managers planning a co-operative R&D project

Among the main results of **existing** research on co-operative R&D (as summarised above in § 1.3), the following may be relevant for managers considering a co-operative R&D project:

1. co-operation and informal exchange of infomation and services among scientists and engineers are indeed efficient to reach R&D goals more efficiently, and deserve therefore being supported

2. co-operation is more frequent for firms that are large, have a permanent R&D department, belong to sectors with high R&D intensity, and that engage in radical or

uncertain innovation, so that co-operation should be considered with even greater atetntion by organisations bearing these features

3. potential risks of knowledge leakage should be avoided by an appropriate combination of alliance scope and governance structure

4. partners should be selected according to their identity (supplier, customer, competitor or academic institution) and to the nature of the innovation being planned (radical vs. incremental), with the aim of sharing skills rather than costs

5. appropriate balance should be held between *ex ante* planning and operational flexibility, to cope with unavoidable incertainties in the R&D process.

My research brings a contribution to the fourth of these issues, namely to **partner selection**, in the early, planning phase of a co-operative R&D project. This thesis identifies a new set of **criteria** to consider when selecting one's partner, and provides a concrete **methodology** to measure these criteria and to implement this knowledge in practice, as a **decision-helping** tool.

My contribution to the existing literature in Management and Economics on co-operative R&D may be summarised in the Figure 8.2.1 overleaf (which recasts and complements the information contained in Figure 1.3.1).

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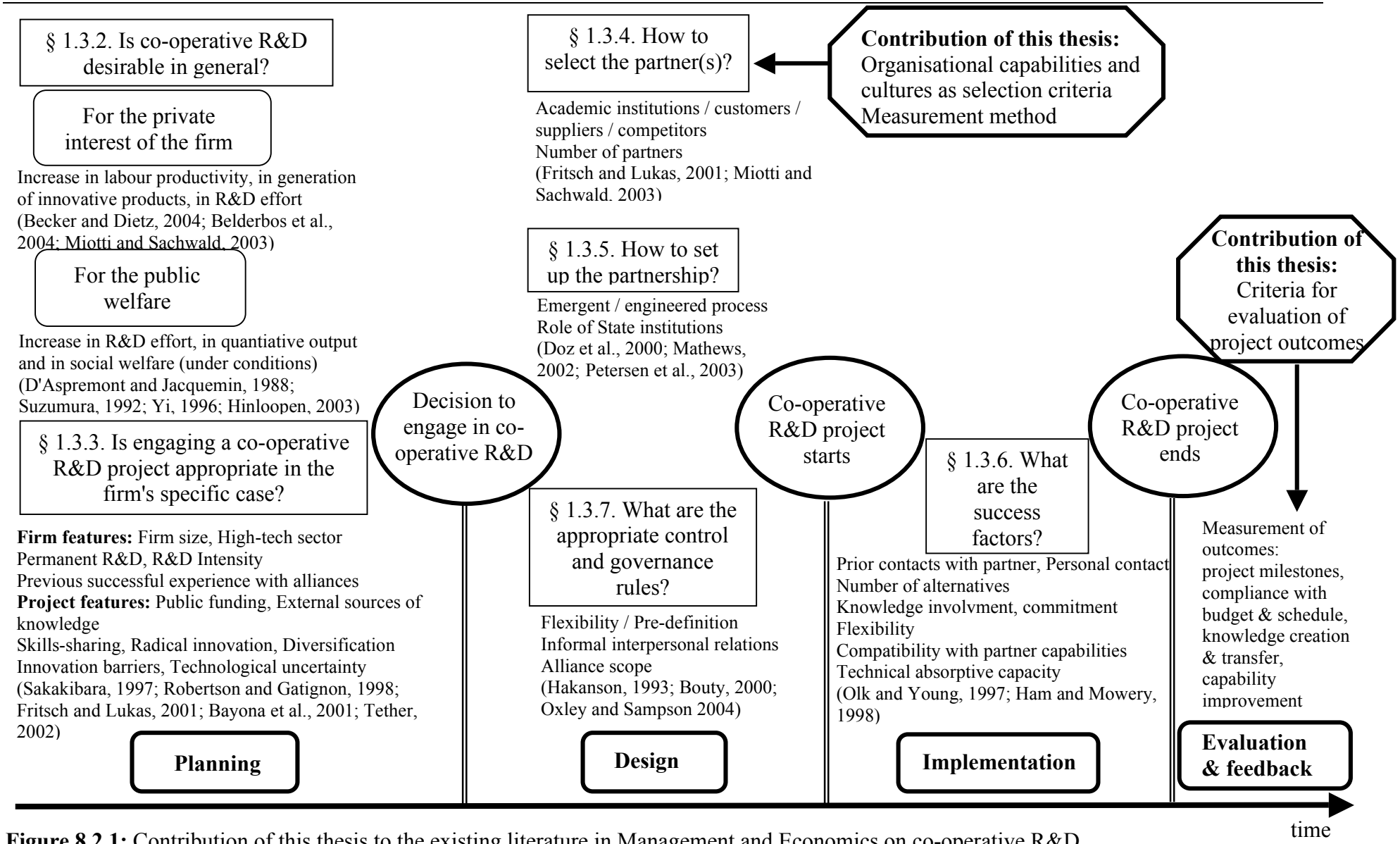

Figure 8.2.1: Contribution of this thesis to the existing literature in Management and Economics on co-operative R&D

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Concretely, my research should be mobilised at the moment when the managers intending to mobilise my research have **short-listed** a small numbers of potentially relevant partner organisations. My results help them to anticipate at that moment the risks and opportunities that each of these short-listed potential partners presents, and to make their choice of a final partner with information that be both better and more relevant.

One important, generic recommendation to organisations in the process of selecting a partner in a co-operative R&D project is to identify, among the project outcomes, those that they consider as having top **priority**. Indeed, according to the nature of the outcome, the variables that have a significant influence vary, as well as the direction of their effect. Since a given combination of predictive variables cannot foster all objectives simultaneously, the managers must first make a choice as to which objective deserves being pursued first, in order to identify the combination of predictive variables (and therefore also the partner among those short-listed) that will selectively promote these priority achievements.

Once the organisation has determined its priorities among the possible outcomes, the **method** to **anticipate** the consequences of selecting one potential partner in the short list to achieve that specific outcome is the following:

1. the organisation should measure the variables relevant for that specific outcome (identified in Tables 6.7.1 to 6.7.4), using the survey provided in Appendix B. If the potential partner is already known, its capabilities should be evaluated using the same survey items. This data should then be processed using the quantification conventions described in § 5.7.1
2. it should in parallel request its potential partner(s) to proceed to the same operations, in a symmetrical way
3. if the potential partner is already known by the organisation, and if a self- and partner-evaluation is available for both organisations' relevant capabilities (following the procedure described above in step 1), the "best available estimate" is computed for both organisations' capabilities, using the mean between the self- and the partner-evaluations, as per § 5.7.3. If only the self-evaluation of capabilities are available, because the potential partner are not yet known to one another, then this self-evaluation is used as the "best available estimate"
4. once the "best available estimates" for both organisations are known, the variables significant for the prediction of the outcome being sought are computed according to the computation methods described in § 5.7.2
5. the organisation may then compare the scores obtained for each significant variable with its mean value in the "descriptive statistics" tables (following the general presentation template of § 6.6.2) of the section relevant to the outcome being considered, in § 6.8 and 6.9
6. the organisation may then anticipate the effects of their and their partner's organisational capabilities and cultures on the specific outcome that they consider as important, according to the Tables 6.7.1 to 6.7.4. If the value obtained by the dyad made by the organisation and its potential partner for a significant variable is above the mean value over the observed sample given in the "descriptive statistics" table, and if the effect of that variable is positive on the outcome considered, then the organisation may expect its outcome to be superior to the mean values in the sample given by the tables describing the outcome variable in the relevant section of § 6.8

and 6.9. The conclusions should be adapted for values under the mean and for negative effects, in a straightforward way.

Once this overall effect of the potential partners' organisational capabilities and 'world views' is computed, the predictive value of the result should not be overstated. Indeed, the prediction made by this research only indicates a **general tendency** observed over **the sample** being investigated, made of the people and organisations that accepted to answer the survey, and on those projects that the respondents chose. Therefore, even if all efforts were made for the sample to be diverse (cf. § 6.1 and 6.2), there is no control over its representativeness. In addition, the variables being considered only explain a **limited** part of the variance in the co-operative R&D outcomes under study.

Said differently, even if a pair of organisations were to follow all recommendations presented here to attain a specific co-operative R&D project outcome, no guarantee is given that this expected outcome will indeed be reached for the following reasons: (1) several other factors, not included in the research presented, may influence the project; (2) the project may differ in some unexpected way, from the ones in the sample being investigated by the research.

8.2.4.2 Recommendations for public bodies supporting co-operative R&D

My recommendation to public bodies fostering co-operative R&D projects relates to (1) the geographic selection of co-operation partners and to (2) the overall amount of public support made available for co-operative Research & Development.

Considering the geographic selection of co-operation partners, the recommendation from the results of this thesis is to strongly reconsider recent policies that promote co-operation at short geographic distance, in 'clusters' (Blanc, 2004; Darmon, 2004; Pezzini, 2003). Indeed, geographic distance plays no role in the outcomes of co-operative R&D projects that I studied, so that any financial support using geographic distance between partners as an allocation criterion would be wasted, or would result in the unjustified rejection of high-value ventures.

My results would actually encourage the opposite, namely the **support** of **R&D cooperation over long geographic distances**, at least within the geographic and cultural area of the European Union. Indeed, the distribution of geographic distances between partners in the projects studied in my thesis, described in Figure 7.1.1, displays a steeply descending curve, with projects at short geographic distance being very widely over-represented in the sample. I would tend to believe, although this would be the purpose of further research, that this distribution is not specific to my sample, and that it is rather general. The result of my thesis that geographic distance plays no role in the outcomes of co-operative R&D projects means that the proportion of projects achieving any outcome is identical, whatever the geographic distance between partners being considered. This means also that a large potential for relevant and potentially successful partners exist at longer geographic distances than those that are currently exploited, and that it would deserve being explored. Since the reason why organisations do not engage in co-operation over longer geographic distances apparently stems from plain economic costs or from historic and moral reasons (as I hypothesised in § 7.1.1, and specifically for SMEs, although this again would deserve more in-depth, qualitative research), it would build the case for the specific financial support for co-operative R&D projects over long geographic distances.

I would also recommend increasing cautiously the rate of public support to co-operative R&D (provided this support remains allowed by World Trade Organisation regulations - which might potentially be achieved provided the R&D project is legally transformed into a public provisioning contract for a prototype or a document). Indeed, the concern with too high a public support of R&D is that it may lead to low-quality projects, wasting precious public budget. The evidence from my research tends to show that the level of public financial support for a co-operative R&D project (*PublicSupport*), seldom has an effect on project outcome, and if is has, the effect is positive (§ 6.9.3.5 and 6.9.3.7). Had we reached saturation of the effect of public support to co-operative R&D, the effects would be negative on some outcomes. As long as these effects remain positive or insignificant, the level of public support may be cautiously increased, until saturation is detected.

A further, longer-term consequence of this thesis for public policy fostering innovation would arise if indeed the 'world views' model that I presented proved to be confirmed by further research, beyond the first empirical indications given here that it does have an impact on concrete phenomena, namely on the co-operation between organisations. As I described in § 4.4.4, each of the four collective 'polities' has its own, specific mode of innovation. If this typology were to be confirmed by further research, it would mean that public policy fostering innovation should be **differentiated** according to each of the four 'collective polities' of my model, in order to support all modes of innovation, without believing that "one size fits all", or that one "best practice" deserves being hegemonic. Promotion of venture capital and of high-growth stock markets would encourage economic actors engaged in the 'polity' of 'Liberty'; promotion of experiential, face-to-face, trans-generational learning, such as apprenticeship, that of concrete experiments, prototyping and field tests would favour those engaged in the 'polity' of 'Tradition'; long-range, large-scale integrated tecnological plans aiming at grand purposes would encourage the actors active in the 'Visionary polity'; while finally an encouragement for friendly spin-offs, such as complements to the initial dotation in machinery, know-how, and operating capital would support the innovation mode prevalent in the 'Communitarian polity'.

8.3 Limitations

Like any research, mine presents limitations, that I will detail hereafter: (1) I only consider one industry, (2) my sample size remains limited, (3) I only consider pairs of partners, and do not consider potentially significant variables such as the size of the consortium and the duration of the project, (4) there is a risk of self-selection bias by respondents and (5) the granularity of my description of scientific & technical organisational capabilities remains coarse.

8.3.1 Single industry

One first obvious limitation is that I restricted myself to the industry of electronics and telecommunications equipment. Although I believe this choice of research scope makes sense (§ 1.6.2.4) and despite its innovativeness and its relevance for overall industrial development, it is not the whole picture of industrial innovation.

8.3.2 European cultural context

Despite its cultural diversity, Europe does not contain the whole wealth of cultural conventions and 'world views'. Therefore, the fact that my research be geographically limited to one continent, and to four countries only within that continent (even if I made the effort to consider regions in which all European 'family models' are present), restricts its generalisability.

8.3.3 Sample size

Another limitation is related to the number of cases being investigated: my initial sample was of 514 projects, out of which 120 accepted to contribute to the research. Although the initial sample contained a significant proportion of the publicly-available population of co-operative R&D projects that have been undertaken in the last years in the four countries under study, the total number of cases being investigated remains limited.

However, the significance level of the statistical effects being evidenced is high, with p-values of the regression coefficients reaching values as low as $7{,}89.10^{-07}$, with a upper limit set at 5 %, so that this limitation, although always relevant (almost by definition) in quantitative studies, does not seem to impair the meaningfulness of my results.

8.3.4 Sample limited to pairs and absence of data on the project size and duration

One important limitation of my research is that I deliberately restricted my sample to projects involving pairs of organisations (§ 1.6.2.5). I asked my respondents, when they were involved in larger consortia, to select among their partners the one with which they had had the closest interaction to answer my survey (§ 5.4). Considering that most contemporary co-operative R&D is structured in large (and sometimes very large) consortia (Saad, 1998), this feature of my research may restrict its validity.

On the other hand, I would question the level of effective co-operation between the members of large R&D consortia. When organisations are very numerous, organising meetings and opportunities of actual collaborative work becomes extremely difficult. Anecdotal feedback obtained during interactions with respondents during my research tended to convince me that members of large consortia tend to work in parallel, and essentially independently from one another, with minimal interface between "work packages". Therefore, I would tend to consider that, in order to study inter-organisational **co-operation**, restricting the study to small groups makes sense.

More generally, Saad (1998) observed that the size of a co-operative R&D project (the number of participating organisations in the consortium) and its duration exert a significant influence on outcomes. Neither of these variables was present in my research.

8.3.5 Possible selection bias of the projects by the respondents

For confidentiality reasons, I had in most cases no information as regards the identity of the partner and of the co-operative project (§ 5.6.3). In addition, I relied exclusively on the goodwill of my respondents, who had no obligation whatsoever to answer my survey. Although my introduction letter specified that I was interested in all sorts of projects, whatever their outcome, I had no means to influence the respondents' selection.

I have therefore no control on the possible selection bias of my respondents in favour of successful projects. I have no means to know if such a bias exists, and if so, what its extent may be. This may be an important limitation of my investigation, due to its very survey-based design.

8.3.6 Coarse granularity in the description of scientific & technical capabilities

The final limitation of my research is that the description I used of scientific & technical fields of capability was rather coarse, both for yield, research schedule and confidentiality reasons (§ 7.1.8). However, this coarseness may have made me miss some interesting

phenomena, such as the inverted-U shaped relation between cognitive distance and innovative effectiveness observed by earlier research (§ 7.1.8) and the complementarity between scientific & technical capabilities (§ 7.1.9).

8.4 Further research

This PhD thesis opens paths for future research on inter-organisational co-operation, and more specifically in R&D, and on organisational capabilities and 'world views', that I will detail hereafter.

One direction of further research would of course be to **overcome the limitations** listed above (§ 8.3): covering more industries, working on a larger sample, in countries and continents others than those I investigated, on co-operation consortia with 3 to up to 7 or more partners, including variables such as consortium size and project duration, having access to a finer description of scientific & technical capabilities (potentially using secondary data), and controlling for the selection bias of respondents (potentially by being supported by an official funding body mandating the selection of a randomly selected project), would broaden the significance of my results.

Another direction of further research would be to provide explanations for the **unexplained phenomena** that appeared in my work, potentially using qualitative methods. Why does the cognitive distance between capabilities play a much smaller role than their combination? What is the origin of the unexplained observations listed in § 7.2.7? What influences the modification of R&D Management capabilities?

Some further **exploitation of existing data** could be performed, such as a detailed investigation of the modification of capabilities in each of the 54 sub-fields, starting with those in R&D Management, for which no satisfactory explanatory model was found at an aggregated scale. The effect of technical risk on the variance of outcomes could also be of interest. In addition, the verbal, qualitative data I gathered on the main learnings from the project and on the main success factors remains fully to be exploited.

Considering the very immature stage of research on the topic, that I pointed at earlier (Zibell, 2007), further refinements and extensions could be brought to the **method** that I introduced in this work for the **operationalisation of organisational capabilities and 'world views'**: (1) the functions investigated could go beyond those necessary for innovation, and include other functions of Table 5.5.1; (2) the methods that I imported from earlier studies, and that were placed in the optional part of my survey (§ 5.6.1), could be validated by a full-scale research; (3) a method to measure the "Equality vs. Inequality" dimension of 'world views' would need to be established and validated.

The further empirical investigation of **'purposive communication networks'** using e-mail and telephone switchboard logs, and of components of organisational **'world views'**, based on evidence such as accounting systems and content analysis of internal documents, would contribute to the validation of my theory on the stability of these features (chap. 2).

The **'world views'** model could be used to investigate **further branches of social sciences**, such as Marketing, Political science, Human Resource Management, Strategic Management and Political Economy (§ 8.1.3).

An empirical validation of the **relations** between the **'world views'** and the regional, industrial or functional **settings** where they are expected to prevail (§ 4.4) would enhance the validity of this theoretical contribution of mine.

A direction of investigation of which I have just started to scratch the surface, and that could be worth pursuing, is the effect of the **geographic environment** on R&D and innovation, attempting to operationsalise with greater accuracy and success than I did (§ 5.5 and 6.1) the interesting but still unspecified concepts of "*creative milieux*" (Törnqvist, 1989) or "*ecumenal relations*" (Berque, 2000).

More generally, this research breaks new ground for the description of the **heterogeneity** of organisations, and of what really and meaningfully distinguishes them from one another. It proves that the tools that I introduced, namely organisational 'world views' and capabilities as I operationalised them are relevant and significant predictors of a phenomenon that had remained yet badly understood, namely the outcomes of co-operative R&D projects. However, I believe that this descriptive framework of organisations may be used much more broadly.

One such case could be the dynamic, evolutionary, agent-based **modelling of R&D networks** and of **industrial supply chains**. Indeed, my research not only evidences the nature of the relevant heterogeneity between the agents, but also the rules of evolution of these features over time, following the establishment of co-operative R&D links. Considering the positive feedback loops that I evidenced (§ 7.2.2), the empirical results of this research could account for the stabilisation of semi-permanent constellations and networks of co-operating organisations (Orsenigo et al., 2001; Cassi, 2006), and for scientific & technical specialisation of organisations, in an ever-increasing heterogeneity between them.

More broadly, this descriptive framework could be used in all studies where organisations, instead of being reduced to a "representative" unit, are considered as diverse and heterogeneous, such as in the studies on the varieties of capitalism, inter-cultural management, organisational behaviour and strategic management.

Ultimately, this work could be considered as a contribution to the more general endeavour of **Economics** based on the **co-operation** and **differentiation** of economic actors, to complement and enrich the currently prevailing paradigm of mimetic competition.

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10 Appendices

Appendix A Systematic Review of the literature on the operationalisation of collective competencies (2007)

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"Measuring collective competencies of organisations

- a systematic review of literature"

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A.Abstract

The present Systematic Review explores the existing academic literature on the instruments to measure collective competences of organisations. The purpose is to identify those that could be further used in a PhD work on the competences of organisations involved in co-operative R&D projects. This area of research is at the intersection of Strategic Management, Human Resources Management, Evolutionary Economics and Business Performance Measurement.

The methodology starts with a set of keyword strings for search in bibliographic databases. The extracted articles were then filtered for relevance and quality according to pre-defined criteria. An expansion of the resulting list was performed using cross-referencing and citation analysis. The final core list contains 33 articles.

Descriptive statistics illustrate an emergent and highly fragmented field: the number of articles in the list rises sharply over the last 25 years, but no agreement is reached on either the nature of the variables to measure nor on the means to do so.

The understandings of the concept of competence either aim at classifying firms (in a minority of articles), or at ranking them. In the latter case, the concept is assimilated to the proximity to best practices, to an efficiency or to an effectiveness in reaching functionally defined goals.

Four families of methods are used in the existing literature to measure collective competences of organisations: questionnaires, exploitation of secondary data, case studies and interviews, in descending order of frequency in the core list.

The selected articles provide a set of relevant concepts, of methods, of constructs, of third-party quantitative metrics and of individual questionnaire items useful for the further research.

A.Table of Contents

A.1 Scoping study - introduction

A.1.1 Justification for the research

Orthodox, neo-classical economics may be characterised by the following assumptions (Nelson and Winter, 1982):

- the economic system is a static equilibrium, based upon an intellectual model of Newtonian physics of perfect absence of friction and reversibility of time
- organisations experience diminishing returns as their size grows
- the behaviour of the firm and of the individual consumer is that of choice optimisation, between a set of options that are "given" at zero cost by the existing state of knowledge and technology.

Under these assumptions, orthodox economics demonstrates that the equilibrium attained possesses some (weak) properties of optimality: Pareto optimality, under which the situation of a given actor may not be changed without deteriorating even more the situation of another actor.

Even without considering the relevance of the optimality criterion of neo-classical economics, numerous critiques, specifically the school of evolutionary economics, have focused on the realism of its assumptions.

Historically, T. Veblen (1998) was the first, in 1898, to criticise the static nature of neo-classical economic theory. He specifically argued against the underlying "hedonistic" anthropology of an isolated and static individual only moved by "given" and immutable desires:

> *"The hedonistic conception of man is that of a lightning calculator of pleasures and pains, who oscillates like a homogenous globule of desire of happiness under the stimuli that shift him about the area, but leave him intact. He has no antecedent nor consequent. He is an isolated, definitive human datum, in stable equilibrium except for the buffets of impinging forces that displace him in one direction or another.[...] When the forces of the impact is spent, he comes to rest, a self-contained globule of desire as before " (p.411)*

On the contrary, according to Veblen, the human being and society as a whole, are embedded in historical development and evolution:

> *"The circumstances of temperament [...] are products of his hereditary traits and his past experience, cumulatively wrought out under a given body of traditions, conventionalities, and material circumstances; and they afford the point of departure for the next step in the process. The economic life history of the individual is a cumulative process of adaptation of means to ends that cumulatively change as the process goes on, both the agent and his environment being at any point the outcome of the past process" (p.411)*

He therefore called for an "evolutionary" economics, defined as a "the theory of a process of cultural growth as determined by economic interest, a theory of cumulative sequence of economic institutions" (p.413).

Following this early path, R. Nelson and S. Winter (1982), in their groundbreaking book, contended that the 3 main assumptions of neo-classical economics described above could be questioned.

The vision of the economic system as being static is in contradiction with the observation of economic change. Technical improvements to manufacturing methods, improving productivity in fabrication of a known and existing product, can be included in neo-classical models as exogenous inputs. However, further dimensions of change, such as the creation of new products and product differentiation, are not taken into account. In addition, changes in the environment are considered by neo-classical economics as mere external 'shocks' causing only temporary and reversible perturbation, after which the economic system is assumed to revert to its pre-existing 'equilibrium' sate. Observation shows that the economic system undergoes irreversible changes, under an historical process, with no return to the status quo ante.

The assumption of diminishing returns is essential for neo-classical economics to ensure the very existence of non-monopolistic equilibria in each market. However, fixed costs industries, typically those with high R&D or manufacturing investments, or network industries display large economies of scale and scope. This phenomenon was empirically identified by A. D. Chandler (1990) in the growth of large American and German concerns. It was conceptualised by W. B. Arthur (1988) as leading to self-reinforcing monopolies, and potentially to lock-in into technically sub-optimal solutions.

Finally, the 'perfect rationality' assumption of zero cost in the collection of information to define the set of solutions among which to choose, and in computing to find out the optimal one was criticised by March et al. (1958). They argued for a process of "bounded rationality", according to which the actors sequentially explore the possible solutions and stop at the first one that satisfies their minimum requirements, in a "satisficing" process.

As an alternative to neo-classical economics, R. Nelson and S. Winter (1982), alongside with G. Dosi et al. (2000) proposed the concept of evolutionary economics. Its main ambition is to account for historical developments and change, in a situation of permanent disequilibrium, thereby contrasting with the static equilibrium paradigm of neo-classical economics.

The evolutionary theory strongly relies upon the existence of stable capabilities of organisation or "routines", that evolve -slowly- over time. These stable, but yet not immobile, capabilities of the organisation are deemed to be the repository of "organisational memory" (Nelson and Winter, 1982, p.99) and the very subject of evolution in the organisation. The behaviours caused by these 'routines' are subsequently selected by an outside "selective pressure" (Cohen et al., 1996, p.683).

In this theory, the 'routines' used by organisations in their daily activities are in no way optimal. They would rather be some temporarily stabilised modes of operation or of solving a technical problem, considered as "satisficing"(March et al., 1958), and kept alive, "often well beyond the circumstances which spurred their introduction" (Cohen et al., 1996, p.660), for cognitive or political reasons., because they embody a "truce" between conflicting interests (Nelson and Winter, 1982).

Standard models of evolutionary dynamics introduce a mono-dimensional variability of firms, along one single dimension, that of productivity in the manufacture of a single, well-defined good (Nelson and Winter, 1982; Winter et al., 2003). However, in order to fully exploit the potential of the underlying cognitive and evolutionary micro-foundations of the theory, a greater level of diversity must be generated. In the same sense, a capacity to learn, and for each organisation to actually evolve in the space defined by its internal features and supporting routines, should be added to the theory. Specifically, complexity theory developed by P. M. Allen in the field of economic systems upon initial ideas of I. Prigogine and I. Stengers (1979) introduced micro-diversity in behaviours and search strategies (Allen, 2000).

In this sense, the theory of economics as an evolutionary complex system, if taken to its logical conclusions, could answer many of the critiques addressed to neo-classical theory.

However, in order for evolutionary economics to gain acceptance, its foundation stone, the existence of the stable, replicable and yet changing routines and capabilities of the organisation, must be empirically supported. Specifically, tools must be found to operationalize the observation and measurement of such collective routines and capabilities. This task is challenging, as recognised by M.Cohen et al. (1996), since the tools being considered by the scholars at that time are either historical, longitudinal investigation of organisations' archives, or ethnographical field studies. Both sets of tools are extremely costly in time and resources. The purpose of the present Systematic Review is to investigate the literature to consider how far existing research has gone in the direction of (potentially lower-cost) operationalisation and measurement instruments.

A.1.2 Discussion - Perspectives, key themes and concepts

The notion of organisations' capabilities or competencies is rather inter-disciplinary, being at the intersection of:

- evolutionary economics, as described above
- Human Resources management
- strategic management.

These disciplines consider the concept from very diverse perspectives: for evolutionary economics, the competencies of organisations are a theoretical foundation stone as seen above; for Human Resources management, they are an extension of the core concept of individual competencies, and this extension may contribute to better justify the existence of the discipline, for if the source of an organisation's performance lie in its competencies, this justifies a greater role for those managing them; for strategic management, it is one hypothesis among others in the quest for sustainable competitive advantage, but the focus clearly is the latter.

On the other hand, the issue of measuring entities at the collective level of an organisation is the very purpose of the Business Performance Measurement discipline. This discipline focuses however on the measurement of 'performance', which is a distinct concept from that of 'competence' that I study.

A.1.2.1 The Strategic Management perspective

In strategic management, the aim of research is to identify the sources of sustainable competitive advantage. Two main approaches have been used in the literature: the consideration of the environment of the firm, and that of its internal status.

The first approach is rooted in the 'Structure-Conduct-Performance' paradigm familiar to Industrial Economics (Porter, 1985). In his book, M. Porter describes the list of features that an industry should have in order for the firm to thrive in it. For the author, the "attractiveness" of an industry is determined by his well-known "5 competitive forces": "the entry of new competitors, the threat of substitutes, the bargaining power of buyers, the bargaining power of suppliers, and the rivalry among the existing competitors" (chap.1) The author claims that a firm may change this competitive landscape by using appropriate strategies among the "three generic strategies for achieving above-average performance in an industry: cost leadership, differentiation, and focus". However, this vision considers that the firm has little limitation on the range of its available choices, and that the firm is able at any time, and at zero cost, to choose the industry it operates in or the 'generic strategy' that it considers as 'optimal' within the chosen industry. This assumption, based upon neo-classical vision of the firm as a free-

floating optimising agent, appears little grounded empirically: firms do remain in a given industry for long periods, and have limited strategic mobility. The additional flaw in this vision is that for a firm to sustain any advantage obtained from the clever usage of Michael Porter's analysis framework, it would need to be able to prevent imitation by competitors, and no phenomenon in this framework prevents this.

In reaction to this belief that the sources of a firm's competitive advantage are external to it, E. T. Penrose (1995) coined the notion that "the firm is more than an administrative unit; it is a collection of productive resources, the disposal of which between different uses and over time is determined by administrative decision" (p.24, emphasis added). These resources can be physical and tangible: "plant, equipment, land and natural resources, raw materials, semi-finished goods, waste products and by-products and even unsold stocks of finished goods" (p.24). They can also be human resources, with different forms of (skilled or unskilled) labour and professions.

More importantly, according to E.T. Penrose "it is never the resources themselves that are the 'inputs' in the production process, but only the services that the resources can render" (p.25, emphasis in original). What she calls "the services yielded by resources" are "a function of the way in which [the resources] are used" (p.25, emphasis added). In other words, the differences in the way a similar set of resources is actually mobilised are rooted in the competences present in the firm, and forms "the uniqueness of each individual firm" (p.25). It is the dense interaction and the co-evolution between highly heterogeneous human and material resources that build together the competitive position of the firm. This competitive position never is generic: it is specific to a given product-markets couple, and is based on a highly evolutionary and history-dependent path.

> *"No firm does produce just anything that happens to be in strong demand at any time in the economy [...] Each firm [...] focuses its attention on particular product-markets selected from the total market. The selection of the relevant product-markets is necessarily determined by the 'inherited' resources of the firm - the productive services it already has" (p.82)*

These early insights by E. T. Penrose were not fully formalised until the early 1990s (Barney, 1991; Prahalad and Hamel, 1990).

The main contribution of J. Barney (1991) is a formalisation of the features that a set of resources need to have in order for the firm to gain a sustained competitive advantage. His reasoning is that, in order for a set of resources to yield sustainable competitive advantage, they should not be mobile between firms, nor easy to acquire on an open market for production factors. Indeed, if the resources were mobile or easily accessible, any firm having initiated a winning strategy using this mobile or easily accessible resource would be imitated by its competitors and lose any advantage it may temporarily have had.

J. Barney posited that in order for resources to yield sustainable competitive advantage, they must simultaneously be "valuable, rare, imperfectly imitable and non-substitutable" (p.100). This list of features has become known under its acronym of VRIN resources. The resource must be developed internally, over time, since (by definition) they are not available in open factors markets.

C.K. Prahalad and G. Hamel (1990), in a more practitioner-oriented article of great influence, expose analogue theses, based on examples more than theoretical considerations. The "core competencies" are the technological and organisational bundles of "diverse production skills and [...] multiple streams of technologies [...]in new and interesting ways" (p.82). They

provide the source of families of innovative and difficult-to-imitate products, following common technological principles declined into products suiting the needs of diverse markets. These product families, bringing high value to numerous customers, can be sold in large quantities at a premium. They should therefore generate high profit margins. In addition, if they are the result of an unique bundle of technologies and manufacturing skills, they should remain unchallenged in the market for long periods of time, and generate these above-average profits sustainably.

The vision of a firm's resources being static, in a sort of immobile repository, was first criticised by D. J. Teece et al. (1997). In their view, the firm is embedded in a highly mobile and changing environment, to which it must adapt to survive and be profitable. They therefore define "dynamic capabilities" as "the firm's ability to integrate, build and reconfigure internal and external competences to address rapidly changing environments" (p.516). The competitive capacity of the firm isn't rooted in its position, as contended previously (Barney, 1991; Prahalad and Hamel, 1990), but in its mobility and internal processes: "Competitive advantage of firms lies with its managerial and organisational processes, shaped by its (specific) asset position, and the paths available to it" (p.518). The key capabilities become that of learning and reconfiguration, essentially by trial and error. This learning is a slow, path-dependent process, because changing many elements of a firm's activity simultaneously would jeopardise it: "Learning is a process of trial, feedback and evaluation. If too many parameters change simultaneously, the ability to conduct [...] experiments [and] to ascertain cause-effect relationships is confounded" (p.523). It is also slow because of the coherent nature of existing productive models and organisations, with organisational processes and incentives reinforcing one another (Boyer and Freyssenet, 2000). As a result, "capabilities cannot be bought, they must be built. This sometimes takes years - possibly decades" (p.528).

Although this inclusion of dynamics in strategic management was welcomed, it was also criticised on 2 grounds. On the first hand, the dynamic capabilities as "internal processes" were felt as vague and difficult to connect to empirical evidence. On the other hand, they were also considered as "second-order" capabilities, as "capabilities to acquire capabilities", in a potentially endlessly recursive fashion.

K. M. Eisenhardt and J. A. Martin (2000) reconsider this concept of 'dynamic capabilities', and contribute an answer to these critiques. For them, 'dynamic capabilities' correspond to specific, identifiable corporate processes, well-described in empirical research. They provide examples for each broad category of 'dynamic capabilities':

- integrating resources: product development, strategic decision making
- reconfiguration of resources: knowledge transfer processes, corporate re-organisation of business units
- gain and release of resources: knowledge creation, alliances & acquisitions, exit from obsolete positions.

Therefore, they conclude that the notion is indeed valid as a descriptive concept. However, they criticise the belief that they may explain competitive advantage. Following the (unsupported) assumption that organisational behaviours necessarily converge towards an industry "best practice", whatever the initial position, a phenomenon that they designate as "equifinality", they posit that the 'dynamic capabilities' are imitable and transposable. Therefore, competitive advantage doesn't lie in the dynamic capabilities themselves, but rather in the instantaneous set of resources existing. This explains why, according to the authors, the validity of the Resource-Based View of the firm is limited to "moderately dynamic" markets. On the other hand, in "high-velocity" markets, the relevance of any resource may be challenged by the evolutions of the market environment.

A very convincing clarification of the relationship between static and dynamic capabilities was given by S. G. Winter (2003), followed by C. E. Helfat et al. (2007). According to S. G. Winter (2003), "ordinary or 'zero-level' capabilities [are] those that permit a firm to 'make a living' in the short term" (p.991). The 'zero-level' capabilities defined here are also called "operational capabilities" by C. E. Helfat et al. (2007), while "a dynamic capability is the capacity of an organisation to purposefully create, extend or modify its resource base" (p.4).

This recent set of definitions also removes a conceptual ambiguity that tended to relate the concepts of 'competence' or 'capability' with superior performance, in the wake of the earlier works (Prahalad and Hamel, 1990). In these more recent definitions, "capacity refers to the ability to perform a task in at least a minimally acceptable manner" (Helfat et al., 2007, p.5). The word 'capacity' only implies adequate performance, sufficient for some effect to be obtained. The qualification of the capacity as being 'mediocre' or 'outstanding', its level of "evolutionary fitness" or "external fit" (p.7) is a different, subsequent problem to be solved, and isn't any more implied in the word 'capacity' alone.

Despite this recent clarification that conceptually disconnects 'capabilities' from 'performance', several studies have attempted to validate this connection empirically. These studies were systematically reviewed by S. L. Newbert (2007). His conclusions are that the level of empirical confirmation of the Resource-Based View of the firm's performance is relatively low, with only 53% of all studies confirming it. However, an even more interesting conclusion for our research is the extreme heterogeneity and apparent lack of consensus on the means to measure and operationalise the 'competencies' or 'capabilities':

> *"It is important to acknowledge the myriad ways in which the various independent [potentially explanatory] variables have been operationalised. Of the 417 (76%) tests in which a specific resource, capability or core competence serves as an independent variable, 26 different resources, 32 different capabilities and 6 different core competencies are studied[...]. However, relatively few resources, capabilities and core competencies have received attention in multiple studies" (p.138)*

To complete the last sentence, of the 26 'resources' listed, only 10 were investigated in 3 articles or more, with the maximum number of articles exploring a given 'resource' being 7; of the 32 'capabilities', only 3 were investigated in 3 articles or more, the maximum number of articles being 4 and of the 6 'core competencies' listed, all were studied in 2 articles or less (Newbert, 2007, Table 4).

A.1.2.2 The Human Resources Management perspective

In Human Resources Management, the concept of individual competence is the cornerstone for recruitment, assessment and promotion. As illustrated for example in a successful practitioner-oriented textbook, at each step, decisions are taken by comparison between what is expected from the individual in terms of these competences and what is actually measured from him/her (Tyson, 2006).

In this environment, individual competencies are measured according to 4 broad, potentially overlapping dimensions: "knowledge, skills, attitudes, personal attributes" (p.129). The process of "job analysis" defines the competences necessary for each position. The methods used for this analysis are direct observation, interviews, diaries and questionnaires of people that are actually engaged in the job being analysed. The general principle is that of functional breakdown, a global task or capacity being decomposed into smaller, hopefully measurable components. For each component of the competence, a scale is defined, with each mark being

associated to a short text defining the achievement level. The global competence requirements of a given position are typically displayed according to a "spider diagram".

Considering the strategic importance of competence, great care is taken to measure it on each individual, be it a recruitment candidate or a member of staff under periodic evaluation, according to reliable and valid instruments (p.163). The methods used are numerous (pp. 165-168), but their very number indicates how difficult the goals of reliability and validity are to reach:

- ability tests of achievement, on the technical aspects of the work that the person has learnt previously
- ability tests of aptitude, to evaluate what the person may develop after training
- personality tests
- group situational tests
- interviews
- "behaviourally anchored rating scales -BARS" (p.200)
- 360° feedback from colleagues, customers, managers and subordinates (p.201).

The evaluation tools for the individual performance and competence of employees are very often proprietary. The first reason is that the very job analysis is specific to each company and to the way it performs its division of labour, and as such may be considered as confidential information. Another is that the function of evaluating people is in itself a (lucrative) business, and the firms operating in this field keep their tools as internal trade secrets or under copyright protection.

Despite its paradigmatic dominance in the field of Human Resource Management, the notion of competence remains elusive in its nature. An interesting effort to conceptualise it was performed by G. Le Boterf (1994).

According to this author, competence is the ability to do something in a situation of action. He uses an analogy with linguistic competence (p.27):

- the ability to speak is the capacity to integrate vocabulary and grammar rules into individual linguistic performances (the sentences)
- the ability to act (in a professional environment), or professional competence, is the capacity to integrate knowledge, cognitive capabilities and skills (p. 25) into individual professional performances (actions and results).

He develops a "systemic model of competence" (pp.44-46, table 8), in which:

- the inputs are the professional situations and tasks
- the functions are:
    1. the cognitive elaboration of an operative representations of the situation
    2. the consideration of self-image - "image de soi" - that determine the extent to which resources will be mobilised, according to whether the task is considered reachable, compatible with one's dignity or within one's area of responsibility
    3. the activation of memorised knowledge and of cognitive skills ("inference operations of induction, deduction, transduction, comparison, operationalisation" - p. 45),
    4. the decision of choosing a given professional action
- the outputs are professional actions
- the feedback learning loops are activated according to the post-hoc results of the decisions taken.

Human Resources Management has thus developed a very large theoretical and practical expertise and toolkit to handle, evaluate, manage, plan, reward individual competences. In

this sense, it mimics the methodological individualism prevalent in economics, and very present in Anglo-Saxon culture. However, organisations do exist as collective bodies, and the literature on strategic management has underscored the importance of collective competences.

Building upon the existing expertise in Human Resources Management in competences in general, some authors have endeavoured to explore the first steps of collective competences, in a bottom-up movement.

The first scale of collective action being considered is that of the team or small group of people. S. Tyson (2006) identifies 2 important tasks in a group: to ensure that the collective task is indeed performed; and to build up cohesiveness by to socio-emotional labour. He also lists 20 components of team competence (p.29), following this broad framework, that were the result of earlier work.

G. Le Boterf (1994) associates team competence with a "common operative image" of the situation and of the problem to be solved, a "common language and code", and a "co-operative ability" (or "savoir coopérer") (p. 129). He lists 3 types of teams (p.135):

- base-ball or cricket teams, in which people "play within a team, but not as a team"
- football, in which "each player occupies a specific position, but co-ordinates its action with the others"
- double tennis, in which each player "permanently adapts himself to the other [player's] action".

Although the reflection of Human Resources Managers on the definition and assessment of individual competence has proven to be very thorough, it seems from these rather recent references that the reflection on collective competences in this field remains in its infancy.

A.1.2.3 The Evolutionary Economics perspective

As described earlier in the introduction, the micro-foundation of evolutionary economics theory is the fact that individual people's behaviours and organisations contain some stable elements subject to the evolutionary processes of random variation, environmental selection and retention (Paulré, 2004; Nelson and Winter, 1982). These stable elements are an individual's "skills" and "routines" at organisational level.

R. R. Nelson and S.G. Winter (1982) define an individual's "skill" as "a capability for a smooth sequence of coordinated behaviour that is ordinarily effective relative to its objectives, given the context in which it normally occurs" (p.73) It may be body movements coordinated with decisions (e.g. driving), or imprinted in mental process (e.g. calculus).

The authors define the "routine" at organisation level. The concept mainly is valid for organisations that provide roughly the same good or service over a given period, with "criteria for doing well or poorly" (p. 96), in the "circular flow" (Schumpeter, 1934) or static situation of absence of change. Routines act as the repository of "organisational memory" (p.99) and of memorising by doing. They are defined by the usual set of actions prescribed for a person's job, by the reactions to orders and other forms of "coordinating messages", so that every person behaves in a way that is expected by the other members of the organisation (should this behaviour be nominal or not). Routines are also the result of an "intraorganisational truce" (p.107) on the rules defining each person's role, on the sharing of workload and benefits, and on the allowances within the unspecified range of accepted action. A strong adherence to routines is often observed in order to prevent the (costly and uncertain) breach of this truce.

Since the routines are the stable elements in the organisation that undergo the evolutionary process, the authors introduced an analogy of "routines as genes" (p.134) that has exercised great influence on later works.

A more comprehensive definition of routines was later given by M.D. Cohen et al. (1996): "A routine is an executable capability for repeated performance in some context that [has] been learned by an organisation in response to selective pressures" (p.683). Routines are based upon deeply memorised individual skills of individuals, are semi-automatic, and rely upon "tacit" knowledge (Polanyi, 1967). The authors claim that their concept of 'routines' is embedded in scientific knowledge on "short-tem memory limits, reasoning powers and differentiated forms of long-term memory and learning". The underlying cognitive theory is the following. People act in an effective way when they are being required to repeat the same behaviour in identical or analogue situations. This set of analogue situation is progressively imprinted "by doing" in the actors' memories. When faced again with it, the actors recognise the common pattern and respond semi-automatically, fast and efficiently to it. M.D. Cohen et al. (1996) thus consider that their theory of routines relies upon a form of "cognitive realism" (p.654).

The semi-automatic behaviour mode of routines was however considered not satisfactory when the issue is to consider actions of greater reflection level and intentionality. G. Dosi et al. (2000) thus introduced the concept of "organisational capabilities". For them:

"To be capable of some thing is to have a generally reliable capacity to bring that thing about as a result of intended action. Capabilities fill the gap between intentions and outcome, [...] in such a way that the outcome bears a definite resemblance to what was intended." (p.2, emphasis in original)

They later gave empirical examples of such 'organisational capabilities': in semiconductor and automotive manufacturing (Appleyard et al., 2000; Flaherty, 2000; Florida and Kenney, 2000), in drug discovery (Henderson and Cockburn, 2000; Pisano, 2000), in bank process replication (Szulanski, 2000), in electronic equipment maintenance (Narduzzo et al., 2000) and even in pizza baking (Argote and Darr, 2000).

This empirical evidence does display the existence of 'organisational capabilities', although the distinction between these and 'routines' (supposedly in the intentionality level) does not appear as being very clear-cut. However, the investigation methods being used to evidence these 'organisational capabilities' generally are ethnographic. They are extremely costly to replicate, unless one may use "an army of ethnographers" (Cohen et al., 1996, p.681). The 'organisational capabilities' evidenced in these studies also are extremely idiosyncratic. They do not appear to relate to a common structure or pattern that would make them re-usable in another context than the one in which they were observed. It thus appears very difficult to use them in a cross-sectional investigation of several firms or organisations.

A.1.2.4 Perspectives on measurement

Business Performance Measurement as a discipline follows suit on the developments of accounting as a tool for managers to have a representation of the current situation of their business. The purpose is for business managers to have the relevant information at the right time, in order to take the right decisions.

Historically, the first methods were to re-use the data produced by the accounting procedures, and to adapt them to operations control and decision-making. From a cost of measurement perspective, it leveraged the mandatory costs incurred for an accurate accounting system and attempted to re-use the data in a broader scope. These first developments, initiated in the

second half of the 19th century by DuPont, resulted in analytical cost accounting, in which costs were attributed to individual products according mainly to the direct labour effort attributable to them (Kaplan, 1984). The main perceived advantage of financial, accounting-based data is the high accuracy, reliability and repeatability of the figures provided.

However, these methods solely based upon financial data have proved to become increasingly limited in their usage and their relevance to business control and action needs. A very popular concept incorporating a much broader view of the information needed to make decisions, called the "balanced scorecard", was developed by R.S. Kaplan and D. P. Norton (1992). This set of measures attempted to group into a single view the elements considered as key for the future success of the firm (p.72):

1. "How do customers view the company? [customer perspective]" generally "time, quality, performance and service, and cost" (p.73)
2. "What must the company excel at? [internal perspective]", for example "cycle time, quality, employee skills, and productivity" (p.75)
3. "Can the company continue to improve and create value? [innovation and learning perspective]", mainly in a continuous improvement framework
4. "How does the company look to shareholders? [financial perspective]", typically "profitability, growth, and shareholder value" (p.77).

These developments have led to the progressive creation of the discipline of Business Performance Measurement; whose work programme was defined by A. Neely et al. (1995). For these authors, "performance measurement" is "the process of quantifying action, where measurement is the process of quantification and action leads to performance" (p.80). The purpose is indeed to design systems that set quantified, objective goals to people or sub-divisions within the organisation, in line with the organisation's overall strategy, and to assess in what extent these goals have been met, in order to trigger either rewards or corrective action. The key evaluation criteria for the appropriateness of a Performance Measurement System is then "how much does [the measurement process itself] cost?" and "what benefit does [it] provide?" (p.81). The individual performance measures typically focus on quality, time, cost and flexibility (Table 2, p.83). The overall vision is that of a form of company-wide cybernetics, with the Performance Measurement system providing the information necessary to close the feedback loop. As described by a 'white paper' of the leading supplier of Business Performance Measurement software, Business Objects, the issue is "to set goals, measure success, and take the action needed to improve performance" (Business Objects, 2007).

The main interest of this perspective is that measurement is at the very centre of the issues being investigated: what metrics should be used, how do they relate to the phenomena of interest, how reliable, accurate and noise-free are they? On the other hand, the difficulties in using this approach in a research on the competencies of organisations seem to be the following:

- first, what is measured is performance levels, and not specifically competence, a difference which will be discussed further in the "Findings" section of his study
- second, apart from the financial reporting that is specified in great detail and mandated with universal applicability within a given jurisdiction by law or by Generally Accepted Accounting Practices, the performance measurement system of a given organisation is highly specific to that firm. Since the objectives being set are deduced from the organisation's strategy, the very entities being measured are a consequence of this strategy. There is little reason why the metrics used should be comparable from one organisation to the next. The transposability of measurements may thus be questioned

- third and finally, the data retrieved from those performance measurement systems is (probably righteously) considered as both strategic and confidential. Access to the data may be highly problematic in a study performed by an external researcher.

A.1.3 Proposal for a Systematic Review question

It may be concluded from the discussion above that each of the 4 approaches considered contributes to the investigation of measuring collective competences and abilities of organisations, but are all incomplete.

The Strategic Management approach, being mainly concerned with firm performance, has, until recently with C.E. Helfat et al. (2007), concentrated its investigation on the relation between collective competences and abilities, on the one hand, and this performance, on the other hand. It has therefore dedicated little energy to the actual measurement of either. This results in poor conceptual stability of the constructs and great heterogeneity in the operationalisation, as evidenced by S.L. Newbert (2007).

The Human Resources Management approach has considerable experience in competence measurement and in high-quality instrument design and validation, with the explicit aims of validity and reliability. However, this approach remains somewhat prisoner of its individualistic paradigm and of its intellectual sourcing in individual psychology. It thus applies these tools mainly to individuals, and experiences difficulties in adapting them to collectives, be they teams, groups and even more so to full organisations.

The Evolutionary Economics approach also starts its bottom-up description and observation with the very low-level micro-foundations of individual, tacit and semi-automatic skills. These elementary tasks have been progressively co-ordinated into larger scale 'routines' of increased degree of consciousness and intention, and of higher dynamic learning capacity. However, the epistemology of direct, ethnographic or archival empirical observation has produced an extremely costly methodology that is difficult to duplicate at large scale.

Finally, the techniques of Performance Measurement are highly relevant to measuring collective phenomena at firm or sub-division level, but they tend to measure performance rather than competence, to be idiosyncratic and highly confidential. They may then be difficult to leverage in a study performed by an external researcher.

The purpose of the present Systematic Review is thus to find what authors may have written on the issue of "the measurement tools and instruments of collective competences and abilities of an organisation": what tools were proposed, what their theoretical background is, what their empirical validation has been. This review will explore the literature at the intersection of these 4 fields of Strategic Management, Human Resources Management, Evolutionary Economics and Business Performance Measurement, in order to draw from the contributions of each, and to overcome the limitations of either approach with the insights drawn from the others.

A.2 Systematic Review Protocol - Methodology

A.2.1 Consultation Group / Panel

The people that were consulted during the Systematic Review were the following.

Person	Title	Organisation
Prof. Cliff Bowman	Professor	Cranfield University, SoM, Strategic management
Dr. Véronique Ambrosini	Senior Lecturer	Cranfield University, SoM, Strategic management
Heather Woodfield	Information Specialist for Social Sciences	Cranfield Library
Dr. David Denyer	Senior Research Fellow	Cranfield University, SoM, Organization Studies

I consulted Cliff Bowman and Véronique Ambrosini at 2 stages of the Systematic Review:

- initially, to identify the works considered as essential / seminal in this field
- after I had set up my core list of papers, to hierarchise their importance and potentially add some more.

I consulted Heather Woodfield to use citation databases to find references that shared commonalities with the articles I already had identified, at the stage when I need to expand the "core list" of articles following the first round of investigation.

I consulted David Denyer on several occasions, initially on the very appropriateness of the research question for a Systematic Review, on the adequacy of my method for selecting, appraising and extracting data, and on the results of the process after the first and second rounds of investigation.

A.2.2 Personal statement

A.2.2.1 Intentions in making the Systematic Review

One of my ambitions in the full PhD work is to contribute to the evolutionary economics theory. This theory strongly relies on the existence of stable capabilities of organisations or 'routines'. However, these capabilities prove difficult to observe or to operationalise, which reduces the apparent empirical validity of this theory.

One of my intended contribution in the PhD is to empirically validate the usage of some tools and instruments to measure and assess the competencies of organisations. This empirical validation should be in the field of innovative R&D projects in high-tech clusters.

Prior to this work, I need to know precisely what the existing state of the art is of such tools aiming at measuring the competencies of organisations: what tools were proposed, what their theoretical background is, what their empirical validation has been.

I therefore ambition to obtain from this Systematic Review a list of tools that I will be able to use in my later PhD work to measure the competencies of the organisations I plan to survey in European high-tech clusters.

A.2.2.2 Personal and intellectual biases

My personal background is that of natural sciences, and specifically physics. I thus have a epistemological point of view that may be related to 'positivism', although with some significant reservations that are too long to expose in this format, and were the purpose of an external assignment on "Research Strategy".

For the sake of this Systematic Review, I understand a 'tool' or an 'instrument' as having the (typically 'positivist' and quantitative) properties of appropriateness or consistency (it actually measures what it intends to), of fidelity, repeatability or reliability (2 successive measures of the same phenomenon should lead to the same measurement result), universality / transposability (it may be used in a broad range of contexts), monotony (an increase in the entity being measured leads to a consistent increase of the measurement result) and clarity (the signal to noise ratio is high). In order to be able to actually use these tools and instruments in the concrete environment of a PhD, and considering that I intend to apply them to a significant number of organisations (several tens of organisations over the duration of my PhD), I will pay attention to the cost in terms of time and of other resources necessary to implement these tools and instruments.

I have no sponsor influencing my work, or other sources of financial conflict of interest.

I may however be biased by the fact that I already have identified a set of tools and instruments that I believe at this stage are of potential usage for my future research, and this may be a form of vested (intellectual) interest.

A.2.2.3 Key learning outcomes and limitations

The main learning I have received from this Systematic Review is the usefulness of writing the methodology Protocol beforehand. The permanent availability of is document has proved to be invaluable during the period of assessment of the retrieved articles on relevance and quality, as it allowed me to have the assessment criteria physically and mentally present upon the reading of each article. It thus assured the consistency of the evaluation, and contributed to its efficiency.

I will definitely import the results of this Systematic Review into my PhD. They may be facially considered as disappointing, in the sense that the literature on the subject is both fragmented and with little coherence. However, knowing this outcome, and being able to support it with rigour will help justify further methodological choices during the PhD proper.

The main limitations of this Systematic Review may reside in the following:

- I performed 2 iterations of search and selection, expanding from a first core set of articles using citation database search and cross-referencing. This operation yielded diminishing returns, and I stopped there. Although I argue that I have reached a point of saturation, it would have been possible to pursue the iterations one step further
- considering the emergent character of the subject, a further source of information could reside in unpublished works, such as conference papers or internal working papers by the authors identified in the core list. However, both time constraints and quality concerns from the published, and therefore peer-reviewed and filtered material made me consider that the potential from this source probably would not be worth the fraction of remaining time necessary to treat it
- finally, the Systematic Review methodology, being mainly based upon the material reachable through journal databases, did not give me access to books. Although the emergent character of the field may mean that little has yet been summarised into reference books, this latter form of publication often contains interesting and forward-looking ideas and theories that deserve attention.

If I had had the opportunity to re-do this Systematic Review, I probably would have liked to consider methods to investigate books in greater detail.

A.2.3 Map of the investigation field

(Not reproduced)

A.2.4 Aim of the review

The aim of the Systematic Review is to obtain a list of validated tools and instruments used to measure and assess the collective competencies / (cap)abilities of an high-tech organisation. The focus is on 'high-tech' organisations, i.e. organisations involved in industries with a high intensity in R&D and innovation.

A.2.5 Search Strategy

The search strategy that I have adopted is summarised by the Figure 2.1 below.

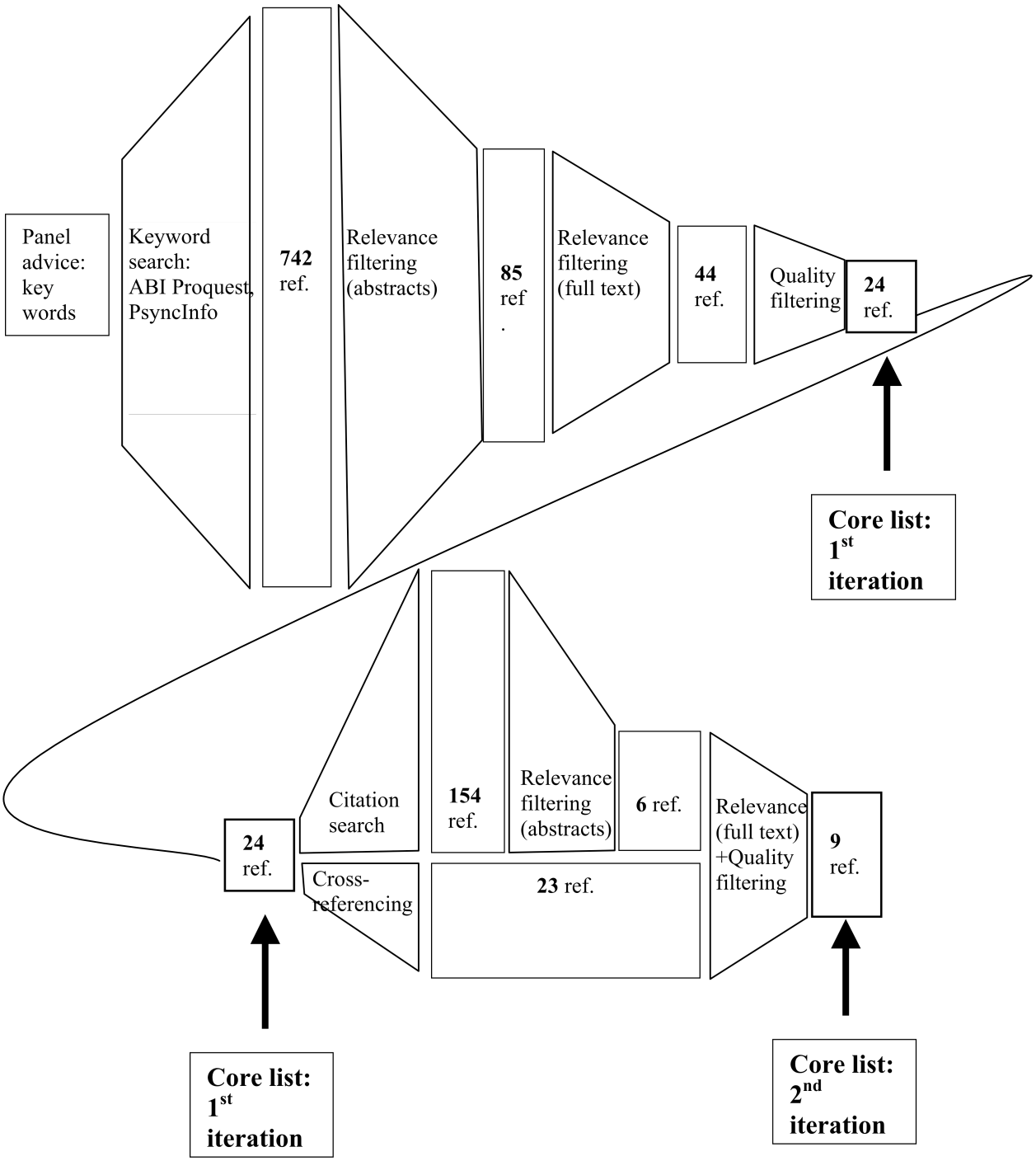

Figure 2.1: Search & selection methodology: Overview

I have first interrogated the members of my advisory panel to access the initial, seminal articles and review books that theoretically give definitions of collective, organisation-level 'competencies', '(cap)abilities' etc, beyond those that I already knew. These initial references led to additional words to be used in the search strings: this proved to be specifically relevant

in an evolving, unstabilised field such as that of collective competencies, in which there is disagreement among scholars on the very words, definitions and concepts.

A.2.5.1 Search strings that were used in the review.

Concept	Keywords	Rationale
Capabilities	(competenc* OR capacit* OR capabilit* OR skill? OR abilit*)	These are the very object I am investigating, my "main concepts'.
Collective / organisation level	(organi?ation* OR collective OR corporat* OR business* OR firm* OR compan*)	
Measurement	(measure* OR evaluat* OR estimat* OR quantif* OR operationaliz* OR tool* OR instrument*)	
Focus on innovation and R&D	(innovati* OR R&D OR research OR "New Product Development" OR NPD OR "New Business Development" OR NBD)	This is the context in which I will apply the measurement instruments.
Focus on business environment	medic* OR therap* OR health* OR government* OR educat*	Papers involving these concepts should be excluded

Table 2.1: Search strings used in the Systematic Review

A.2.5.2 Search strategies on keywords

The first 2 or 3 keyword strings were searched as being "NEAR" one another (to be more accurate, "within 3 words" of one another), when this search feature is being proposed, which is the case of ABI Inform (Proquest) and of PsycInfo.

I will use the measurement tools in an innovation and R&D context for the later PhD. Therefore, I preferentially investigated those tools and instruments that have been developed or validated in this field. It will improve the validity of re-using them, because the context of their development will be maintained.

I therefore used 2 search strategies, that I will describe hereafter using the "Concept" heading referring to each search set of keywords strings of Table 2.1 above:

- Search strategy A: Capabilities NEAR Collective / organisation level AND Measurement AND Focus on innovation and R&D. In this strategy, the constraint on having the 3 main concepts NEAR one another is relaxed, in order to account for the context.
- Search strategy B: Capabilities NEAR Collective / organisation level NEAR Measurement. In this strategy, the 3 main concepts are investigated NEAR one another, but with no restriction on the context.

Since PsycInfo also handles publications in the medical, educational and government fields that I am not interested in, I used the last string connected with the "NOT" operator, in order to exclude the results in these fields.

The pilot searches performed with the target databases gave the following results.

Database	**Existence of search feature of 2 strings being "NEAR" one another**	**Search strategy A Number of results** (peer-reviewed journal articles only)	**Search strategy B Number of results** (peer-reviewed journal articles only)
ABI – Proquest	YES	508	165
Business Source Premier – Ebsco	*no*	*1 921*	*6 732*
PsycInfo (with focus on business environment)	YES	60	9

Table 2.2: Results of the pilot searches

Considering these pilot searches, I did not use Business Source Premier (Ebsco), and restricted myself to the following journal databases:

- ABI Inform (Proquest) for strategic management and economics journals
- PsyncInfo for Human Resources management journals.

A.2.5.3 Potential sources of information under the categories provided

The categories of information sources were investigated along the guidelines described in the Table 2.3 below.

Journals not cited in the databases	Were not investigated, because the management and psychology databases provide the information required
Conference papers Working papers or unpublished papers Documents on the internet	Were not be investigated, for most of the quality work is published in journals
Books	Were tentatively investigated, using reference databases and cross-referencing, but with limited results
Personal requests to knowledgeable researchers and/or practitioners	I consulted the Cranfield faculty in the fields of Strategic Management (from my panel) and Human Resources Management
Reports from relevant institutions: companies, public bodies etc	Not relevant for my research

Table 2.3: Guidelines for the sources of information

A.2.5.4 Relevance selection criteria:

The articles retrieved from the databases using the keyword strings described above in §2.5.2 were selected for relevance, along a 2-steps procedure:
1. by reading the titles and abstracts
2. by reading the full text, with selection criteria varying according to whether the article is empirical, methodological or theoretical.

The titles and abstracts of the articles must contain reference to:

- Collective capabilities, capabilities of organisations / firms
- Concern with measurement / operationalisation / empirical validation or observation.

The full text of the articles must contain the information described in the Table 2.4 below.

Nature of the article	**Information required in the full text for the article to be selected for relevance**
Conceptual / theoretical	• Concern with measurement / operationalisation / empirical validation or observation • Examples of potential metrics
Methodological	• Precise mode of data collection, (e.g. exact questions used in surveys) • Discussion of appropriateness of metrics (do they measure what they intend to?) • Discussion of one at least among the following issues: repeatability / reliability, transposability, noise
Empirical	• Details of metrics used • Discussion or measure of coherence and consistency of metrics used • Assessment of validity of the metrics used • Report of measurement results

Table 2.4: Relevance criteria for full text articles

Of the 114 articles retained as potentially relevant after reading of their title and abstract (over the 2 iterations of the full procedure), 56 were discarded following the further reading of their full text. The relevance selection criteria that were not met by these articles, and thus justified their rejection from further consideration in the Systematic Review, are fully detailed in Appendix 1.

A.2.5.5 Quality Appraisal

I used the quality appraisal method described hereafter, inspired by a framework by J. Marcos (2000), to further select the articles retained as relevant. This Quality Appraisal method has been widely used in earlier Systematic Reviews. I selected it for its simplicity. Considering the large number of articles to evaluate in a short time frame, I believe that a simple tool is better suited than complete evaluation frameworks (Critical Appraisal Skills Programme (CASP), 2002). These complete tools are intended to be used for the evaluation of articles for inclusion in a journal or for the post-hoc evaluation of a full research programme. The time budget for the evaluation of a single paper is of several days, much larger than in the case of a Systematic Review, when I need to assess several tens of articles in about one week.

Criteria	0 - Absence	1 - Medium	2 - High
Contribution to knowledge in the field of measuring collective competences	This article does not provide enough information to assess this criterion / This criterion is absent from the article	Contribution to knowledge exists but is limited in importance and/or significance	Significant addition to current knowledge.
Discussion of the underlying theory		There is a connection between the paper's theoretical basis and extant theoretical knowledge in the field; Empirical / methodological papers built on existing theory	Excellent discussion of the adequacy of measurement tool to existing theory; Good review of prior literature
Discussion of Methodology		The connection between theoretical constructs and empirical proxies exists but is not fully developed	Excellent discussion of operationalisation of constructs and of the validity and appropriateness of proxies
Learning from Data Analysis		Appropriate sample, results are a relevant (but not sufficient) contribution for assessing the validity of measurement tool	Well-designed data sample; results are sufficient alone to draw final conclusions on the validity of measurement tool
Limitation of the Study		Paper mentions its limitations but does not explain their relevance to understand the results	Paper states clearly its limitations; implications are acknowledged

For each criterion, a "Not applicable" rating is available.

Source: adapted from (Marcos, 2000)

Table 2.5: Quality Appraisal method

Articles were further included in the Systematic Review if:
1. they do not score two 0s in the five categories under evaluation;
AND
2. they score 2 at least once in any of the first four categories under evaluation.

This evaluation gives a premium to articles that have at least one feature of great interest, even if they display weaknesses in other areas.

The results of the Quality Assessment for both iterations of the search (see below §2.5.7) are given in the Appendix 4. They result in a list of 33 relevant and high-quality articles.

A.2.5.6 Data Extraction

All articles being retained as relevant for the Systematic Review (following the procedure described in §2.5.4) were stored in the RefWorks database for further citation. The import procedure into this database automatically stores all relevant bibliographical data, such as author, publication, date, journal name, etc...

In addition to this I created a spreadsheet-based database containing additional data on these articles retained as relevant. This database was used for the sake of statistical exploitation and of Quality Assessment filtering. It contains:

- a shorthand identification string of the author name, e.g. Prahalad

- the journal name
- the publication date
- whether the article is theoretical, methodological or empirical
- the mark given on each of the 5 Quality Assessment criteria described above
- the inclusion decision
- the industry involved
- the geographical setting
- the sample size (if relevant)
- the type of method proposed for measurement of collective competencies; e.g. questionnaire, external database analysis, ethnographic study
- the nature of the competence or ability being measured
- the underlying theory or main concepts being investigated; e.g. core competencies, routines, dynamic capabilities

The articles being selected after the Quality Appraisal procedure (described in §2.5.5), the "core list", were then re-read thoroughly in order to add the following fields to the database for each of them:

- physical location of the paper (local storage, Cranfield library, British Library on loan, etc...), for later retrieval
- my comments and critique on the article
- my summary of the article
- anticipated further usage of the article in the Systematic Review or the full PhD.

A.2.5.7 Expansion of the initial "core list" using cross-referencing and citation analysis

The "core list" resulting from this first keyword search and selection amounted to a "core list" of 24 articles. This "core list" was deemed to be too restricted by my panel members and methodology advisor. I consulted my information specialist, and she advised me to expand this "core list" through the following methods:

- cross-referencing: for each article of the "core list", I have extracted the cited articles relevant to my study, i.e. those that describe measurement methods for collective competencies. This relevance was made apparent from the circumstances in which the article was cited in the article of the "core list"
- citation analysis: for each article of the "core list", I have used the Social Sciences Citation database in order to find the "related articles". I have operationalised this concept of "related articles" as those articles that share more than N/4 citations or more with the article of the "core list", N being the number of articles being cited by the article of the "core list". I found these related articles by using the "related records" function available from the Social Sciences Citation database

The results of the expansion using the cross-referencing method are described in Appendix 2: for each article of the initial "core list", the table provides the number of articles appearing as relevant references. This relevance was assessed according to both the article title and the way it was referenced in the article of the initial "core list".

The results of the expansion using the citation analysis method are described in Appendix 3: for each article of the initial "core list", the table provides the number N of article being cited, the number of articles that share at least N/4 references in common with this focal article, and the number of articles appearing both as relevant references and absent from the initial "core list".

These articles were then filtered according to the same relevance and quality criteria as above, and yielded 9 additional articles. The articles of the resulting "2nd order core list" were then again summarised and commented. Considering the time constraints of the study and the diminishing returns of the process, I have considered that I had approached by then a form of saturation point and did not reiterate the process further.

A.2.5.8 Synthesis

I have organised my synthesis along the types of methods used to measure collective competencies, ranked in the order of cost (in time and other resources) to use them operationally.

My conclusion consists of a set of measurement tools that appear as fulfilling as much as possible of the validity programme described initially:

- appropriateness / consistency
- fidelity / repeatability
- universality / transposability
- monotony
- clarity
- cost in time and other resources to use operationally.

I will thus be able to select those tools that could be used further in my PhD work, keeping in mind the focus on technology-intensive industries.

A.3 Findings

A.3.1 Final core list

The final "core list" of relevant and high-quality articles, following the 2 iterations described in the §2.5 above, contains 33 articles. They are briefly summarised below in chronological order and in Appendix 5, in which the following fields are added:

- Search iteration number
- Publication date
- Type of article (Theoretical/ Methodological/ Empirical)
- Method of measurement being used
- Competence being measured.

N°	Reference	Journal name
1	(Lenz, 1980)	Academy of Management Review
2	(Hitt and Ireland, 1985)	Strategic Management Journal
3	(Durand, 1988)	R&D Management
4	(Cohen and Levinthal, 1990)	Administrative Science Quarterly
5	(Conant et al., 1990)	Strategic Management Journal
6	(Leonard-Barton, 1992)	Strategic Management Journal
7	(Deshpande et al., 1993)	Journal Marketing
8	(Henderson and Cockburn, 1994)	Strategic Management Journal
9	(McGrath et al., 1995)	Strategic Management Journal
10	(Murthi et al., 1996)	Journal Marketing Research
11	(Lane and Lubatkin, 1998)	Strategic Management Journal
12	(Dutta et al., 1999)	Marketing Science
13	(Makadok and Walker, 2000)	Strategic Management Journal
14	(Ritter et al., 2002)	Journal of Business & Industrial Marketing
15	(Schoenecker and Swanson, 2002)	IEEE Transactions Engineering Management
16	(Stratman and Roth, 2002)	Decision Sciences
17	(De Carolis, 2003)	Journal of Management
18	(Camison, 2004)	Management Research
19	(Denrell et al., 2004)	Management Science
20	(Moehrle and Lessing, 2004)	Creativity & Innovation Management
21	(Wang and Ahmed, 2004)	European Journal of Innovation Management
22	(Dutta et al., 2005)	Strategic Management Journal
23	(Escrig-Tena and Bou-Llusar, 2005)	Decision Sciences
24	(Ethiraj et al., 2005)	Strategic Management Journal
25	(Jantunen, 2005)	European Journal of Innovation Management
26	(Jerez-Gomez et al., 2005)	Journal of Business Research
27	(Narasimhan et al., 2006)	Marketing Science
28	(Prieto and Revilla, 2006)	The learning organisation
29	(Tu et al., 2006)	Journal of Operations Management.
30	(Vinding, 2006)	Economics of Innovation & New Technology

31	(Garcia-Muiña and Navas-Lopez, 2007)	Technovation
32	(Grimes et al., 2007)	Journal of Small Business & Enterprise development
33	(Wang and Ahmed, 2007)	International Journal of Management Reviews

Table 3.1: Core list of relevant and high-quality articles

A.3.2 Descriptive statistics of the 58 relevant articles

The following section provides information on the 58 relevant articles, broken down between the 33 articles that were "included" in the Systematic Review following the Quality Assessment (and therefore part of the "core list" described above in §3.1) and the 25 articles that were "excluded" for quality reasons.

As may be evidenced from these descriptive statistics below, the measurement of collective competencies of organisations appears as both an emergent and highly fragmented field.

A.3.2.1 Publication dates

The statistics on the publication dates display the characteristics of an emergent subject. The number of relevant and high-quality articles remains low, but grows significantly over each of the 5-years periods being considered, with a very significant proportion of articles having been published in the 5 years to date of the present Systematic Review.

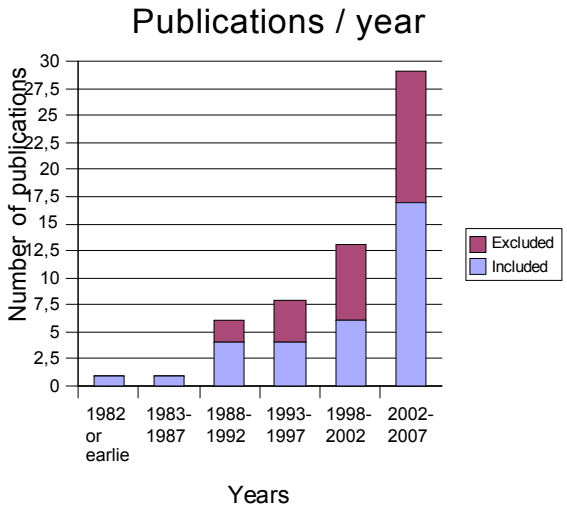

Figure 3.1: Relevant articles / year

Quantitatively, the number of articles being published in each 5-years period is the following.

Period	Included articles	Excluded articles	Total
1982 or earlier	1	0	1
1983-1987	1	0	1
1988-1992	4	2	6
1993-1997	4	4	8
1998-2002	6	7	13
2002-2007	17	12	29
Total	**33**	**25**	**58**

Table 3.2: Number of relevant articles / year

A.3.2.2 Journals

The journals in which the relevant articles were published are very numerous, most journals only publishing one article on out topic of interest: measuring collective competencies of organisations. This characterises a highly fragmented area of literature.

However, some journals have published 2 articles, and the Strategic Management Journal, as an exception, published 11 relevant articles.

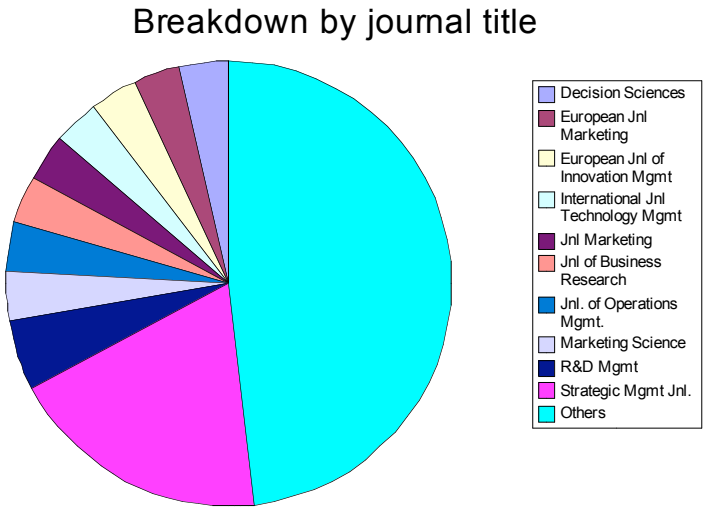

Figure 3.2: Breakdown of relevant articles by journal title

Journal name	**Number of relevant articles published**
Decision Sciences	2
European Journal Marketing	2
European Journal of Innovation Management	2
International Journal Technology Management	2
Journal Marketing	2
Journal of Business Research	2
Journal of Operations Management.	2
Marketing Science	2
R&D Management	3
Strategic Management Journal	11
Others (1 article each)	28

Table 3.3: Number of relevant articles published per journal title

A.3.2.3 Type of article (Theoretical, Methodological, Empirical)

The articles belong to 3 broad types: Theoretical, Methodological and Empirical. The highly predominant type of articles is that of empirical studies (58.6% of total), with reflection on measurement methodology and even more so on theory remaining a minority concern. This may be considered as surprising, since our investigation focus clearly has been on methodological issues.

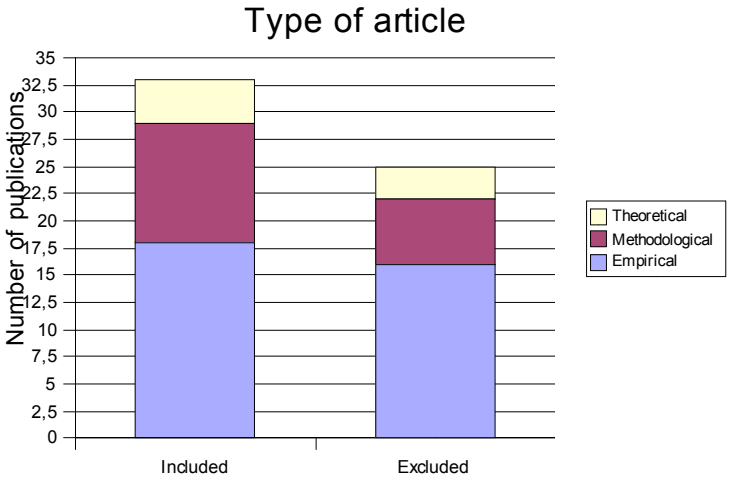

Figure 3.3: Breakdown of articles by type (Theoretical, Methodological, Empirical)

Quantitatively, the numbers are given in Table 3.4 below.

Type of article	Included articles	Excluded articles	Total	Proportions
Empirical	18	16	34	58,6%
Methodological	11	6	17	29,3%
Theoretical	4	3	7	12,1%
			58	100,0%

Table 3.4: Number of articles by type (Theoretical, Methodological, Empirical)

A.3.2.4 Competence being measured

The fragmentation of my investigation field is most strikingly evidenced by that of the actual competencies being measured in the relevant articles. As may be seen in Table A5.1 of Appendix 5 for the 33 high-quality, "included", articles, and from the consideration of the additional 25 "excluded" articles, the description of the competence being measured varies almost with every single relevant article. The only concept being measured in more than one article is that of 'absorptive capacity', that is considered in 4 articles only. All 54 other articles each study a different competence or a different set of competencies.

A.3.2.5 Measurement methods

My investigation focuses on methods to measure collective competencies. The Systematic Review yielded a breakdown of articles along investigation methods that are well-known in social sciences. The highly predominant methods are questionnaires (55.2% of relevant articles) and the usage of secondary data. (25.9% of relevant articles). However, interviews and detailed case studies also are present, albeit in smaller numbers.

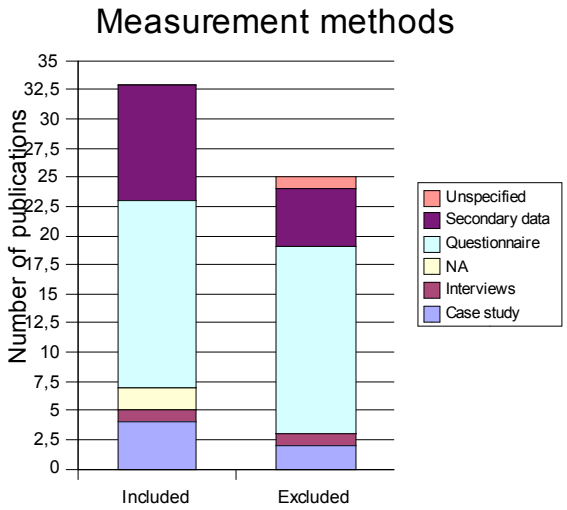

Figure 3.4: Breakdown of articles by measurement method

Method type	**Included articles**	**Excluded articles**	**Total**	**Proportions**
Questionnaire	16	16	32	55,2%
Secondary data	10	5	15	25,9%
Case study	4	2	6	10,3%
Interviews	1	1	2	3,4%
NA	2	0	2	3,4%
Unspecified	0	1	1	1,7%
		Total	58	100,0%

Table 3.5: Number of relevant articles per measurement method

The most obvious reason for the predominance of questionnaires and secondary data analysis appears to be their lower cost and their ability to handle larger number of cases. The order ranking of cost efficiency among the measurement methods may indirectly be evidenced by the Table 3.6 below of descriptive statistics on the size of the samples being treated by the relevant articles. The ability to handle large number of cases is privileged in an intellectual environment where quantitative validation is the norm, as can be expected for people considering measurement from a strictly positivistic point of view.

Method type	Sample size				
	Minimum	Maximum	Median	Mean	Std deviation
Case study	1	138	3,0	33,0	59,2
Interviews	18	50	-	34,0	-
Questionnaire	1	9648	172,5	639,3	1 799,9
Secondary data	64	7240	615,0	1 534,1	2 079,7

Table 3.6: Descriptive statistics on the size of the samples being treated by the relevant articles

As may be deduced from Table 3.6, interviews and case studies approximately have the same low cost efficiency, while questionnaires are significantly more efficient, and the analysis of secondary data has the highest level.

A.3.3 Definitions of competences and (cap)abilities

A repeated statement among the articles that were selected for this Systematic Review is that of a lack of agreement among scholars on the very definition of collective competences, abilities or capabilities. This lack of agreement obviously adversely impacts the chances of an efficient and agreed-upon operationalisation and measurement.

The definitions and implicit understanding of the concept of collective competencies, abilities or capabilities partially depend upon the very purpose of the measurement being performed.

The evaluation of a firm's competencies may be used to evaluate it along a single dimension, with the ambition to predict the firm's overall economic or financial 'performance'. The intention is that of ranking the firm, either against its own set objectives, or against its nearest competitors. The general framework is that of competition among essentially identical

organisations. This position is the very dominant view among the articles selected for this Systematic Review.

However, a minority understanding of the purpose of evaluating collective competencies also exists. For these authors, the purpose is that of classifying firms among a set of equivalent categories. The issue is to know what category the firm belongs to, what is the nature of the competence or ability the firm masters, what it is able to do or achieve. The purpose is not to know how it behaves within its category compared to the other firms of the same category, or how well it masters its competence. In this framework, the firms are considered as essentially heterogeneous in the nature of their abilities, more than in their level of competence. They are therefore susceptible to co-operate. This understanding is very important in the perspective of my future PhD on the co-operation of heterogeneous firms around R&D projects.

A.3.3.1 The understanding of a collective competence as the belonging to a class

This minority understanding of collective competence as the belonging to a type within a set of categories is illustrated by an article that considers means to classify firms along the 4 archetypal strategic types of the strategic typology proposed by R.E. Miles et al. (1978): 'prospectors', 'analysts', 'defenders' and 'reactors' (Conant et al., 1990).

This classification along somewhat equivalent types is also present in a work by R. Deshpande et al. (1993) that classifies 'organisational culture' by following R. E. Quinn and J. Rohrbaugh (1983), that define a "competing values" model of "organisational effectiveness". R. Deshpande et al. consider that organisational cultures are a blend of 4 types, that are related to the Jungian model of personality. These types are a combination of polarities along 2 axes:

- "*one axis describes the continuum from organic to mechanistic processes, that is, whether the organisational emphasis is more on flexibility, spontaneity and individuality, or on control, stability and order" (p.26)*
- *"the other axis describes the relative organisational emphasis on internal maintenance (i.e. smoothing activities, integration) or on external positioning (i.e. competition, environmental differentiation)" (p.26).*

"The four resulting types are labelled clan [internal maintenance - organic processes], hierarchy [internal maintenance - mechanistic processes], adhocracy [external positioning - organic processes] and market [external positioning - mechanistic processes]" (p.26).

The purpose of identifying the nature of the collective competence in a given R&D organisation (i.e. what are the scientific and technical competences present), and only secondarily of measuring them, also appears in one article (Durand, 1988). It may also be identified in a work that identifies the nature of the 'inventive processes' (as defined the TRIZ model) being mastered by third-party organisations, in order to select potential co-operation partners that would be complementary of the focal firm being studied (Moehrle and Lessing, 2004).

A.3.3.2 The 3 understandings of competence as a performance level

The mainstream understanding of a competence as a performance level often stems from the general ambition of the discipline of Strategic Management (described in §1.2.1 above) to identify the sources (or even the single source) of sustainable competitive advantage. When researchers investigate in the direction of immaterial sources of competitive advantage, to which 'competencies' (or 'abilities', 'capabilities', 'capacities') belong, they tend to consider that any such immaterial source or predictor of further performance may be indifferently labelled as a 'competence' (or an 'ability', 'capability' or 'capacity'). This leads to a significant

amount of intellectual confusion (Grimes et al., 2007; Hitt and Ireland, 1985; Stratman and Roth, 2002).

As an example, the tool developed by A. Grimes (2007) to assess "the capabilities of SMEs to compete internationally", containing 18 'components' illustrates this mixture of heterogeneous concepts of competence:

- 2 'components' relate to overall firm achievements in the chosen area (export marketing)
- 4 'components' refer to intermediate-scale achievements
- 3 'components' refer to intentions and strategy
- 2 'components' relate to culture
- 7 'components' refer to practices (Appendix 2, p.79).

In order to introduce some clarity, I have further subdivided this understanding of 'competence' into 3 schools of thought. A collective competence may be understood either as (1) the proximity to a pre-defined set of 'best practices' or routines or (2) as the economic efficiency with which a goal is achieved, with the implicit understanding that the goal is in essence achievable by all, the only difference among organisations being the cost at which it is reached or finally (3) as the degree to which a collective goal is achieved.

The understanding of collective 'competence' as the proximity to a single set of practices deemed to be 'best' is illustrated by several articles (Grimes et al., 2007; Ritter et al., 2002; Stratman and Roth, 2002; Tu et al., 2006). This approach appears to me as essentially flawed by the assumption that there be a single, eternal 'best' practice, and by a confusion between the end and the means to reach this end. The very history of management practices and management science shows that an evolution takes place, with no reason to stop at any point of time. Therefore, assuming that 'competence' in a field is measured by the distance to what is, temporarily and provisionally, considered as the 'best' practice cannot be correct. In addition, considering that there only is one valid operational mode negates the very possibility of innovation and improvement of the practice, and negates the fact that several paths may exist to reach the same end.

However, more subtle and interesting means to take into account contemporary 'best practices' may be found. In one article, the level of Human Resources Management skills is measured by the number of practices being implemented in the firm, from a list of 7 that were considered as 'advanced' in 1997 when the empirical investigation for the article was performed (Vinding, 2006). This measurement of the Human Resources Management skills may be criticised as above. However, and although such an interpretation is not suggested by the author, this raw number of contingent practices being implemented may be considered as a stable, organisation-wide feature of attempting to provide the employees with the "best available" environment to work in, and therefore as an authentic 'collective competence'.

The understanding of competence as an efficiency to reach one's goals at a low expenditure in resources is found in a string of related articles by a stable group of researchers: (Dutta et al., 1999; Dutta et al., 2005; Murthi et al., 1996; Narasimhan et al., 2006). These articles define competencies in their fields of interest - marketing, R&D, operations, 'absorptive capacity' (Cohen and Levinthal, 1990) - as the ratio of attained goals to the expenditures needed to reach these goals.

More specifically:

> *"capabilities as the efficiency with which a firm uses the inputs available to it (i.e., its resources, such as R&D expenditures) and converts them into whatever*

> *output(s) it desires (i.e., its objectives, such as developing innovative technologies)" ((Dutta et al., 2005, p.278).*

In this understanding of competence as an efficiency, the focus is on how well the organisation mobilises its resources towards its objective, how effective it is in doing so. This efficiency probably gives an indirect indication on how clever and how cohesive the people are in the organisation. However, it makes the key assumption that all firms are able to reach any technical objective, the only difference being the cost at which they reach it. In this world, the only differentiator in the market is the mere cost, which is typical of commodities markets.

This understanding of capabilities as efficiency contrasts with one of capability as an effectiveness. In the latter, the issue is to know what target the organisation can reach or aim at, or how far it goes in the way to that objective. In this vision, the assumption is that not all organisations are able to reach any target: some can achieve technical feats that others simply can't - and this is not an issue of pouring more money into it. In order to achieve the same performance, specific knowledge and competence needs to be developed, and this takes time and expertise - more than bare financial resources. In this world view, the differentiators between firms on the market lie in the non-cost dimensions of product performance and functionalities, which is more relevant for innovative, high-technology markets.

For my further PhD research in the field of innovation economics in high-tech clusters, although the indirect methods being used for these efficiency measurements may be attractive, and albeit the notion of efficiency in R&D may be of interest as an indirect measure of coherence, of intellectual creativity and of problem-solving capacity, I believe that it relates to an industrial setting that is significantly distinct from the one I intend to investigate.

Ultimately, a collective competence may be understood as the degree by which an organisation is able to achieve certain goals, these goals being expressed in functional terms. The stress is not placed on the tools and practices used to achieve the specified goals, nor on the cost incurred to reach them, but on how far the organisation is able to go along this path. This definition is rather well expressed by A. B. Escrig-Tena (2005), for whom a competence

> *"will appear in the performance of certain activities and the achievement of certain results. Skills and knowledge cannot be observed [directly]: the only observable factors are the efficiency and effectiveness manifested in the activities carried out by a company and the consequences derived from this. [...] Competencies can be operationalised by identifying and evaluating the activities and the results arising from them" (pp.230-231).*

A linguistic analogy may be the wording of the Common European Framework for Languages developed by the Council of Europe (2001) to assess the competence level of individuals in a foreign language, for whom "Competences are the sum of knowledge, skills and characteristics that allow a person to perform actions" (p.9).

This understanding of a collective competence as the ability to achieve a goal described in functional terms is rarely explicitly present in the articles selected for the Systematic Review. In several of the questionnaires being used, items relevant to such a concept do appear, although they are intertwined with other items that relate more to the other understandings of 'collective competence' as a performance described above. Such implicit definitions of competence as an ability to achieve functional goals may be found in an article where, among the 55 items describing the firm's potential "distinctive competence activities", 16 describe

practices, and 39 describe the capability to achieve goals expressed in functional terms (Hitt and Ireland, 1985, Appendix, pp.289-291).

This functional expression of competences may also appear in the definition of specific abstract and high-level competencies like:

- the "absorptive capacity" defined as "the ability to exploit external knowledge", and "to recognise the value of new information, assimilate it and apply it to commercial ends" (Cohen and Levinthal, 1990, p.128));
- "comprehension" (McGrath et al., 1995, p.254) defined as "what do we know and how well do we know it?" (p.267) and "deftness" as "how well group processes are operating" (p.267)
- the "strategic capability" defined as "the capability of an enterprise to successfully undertake action that is intended to affect its long-term growth and development" (Lenz, 1980, p.226)
- "knowledge processing" defined as the firm's "ability to recognise emerging trends and identify latent market needs [...] in sensing weak signals and seizing opportunities" (Jantunen, 2005, p.337)
- "organisational learning" defined as "the capability of an organisation to process knowledge - in other words, to create, acquire, transfer and integrate knowledge, and to modify its behaviour to reflect the new cognitive situation, with a view to improving its performance" (Jerez-Gomez et al., 2005, p.716).

This functional concept of competence may also be very clear and apparent in the case of smaller-scale collective professional competences, when the competence being investigated is the forecasting ability in the context of short-term money market portfolio management (Makadok and Walker, 2000), or when forecasting ability is applied to the "effort" needed and the "schedule" of a software development (Ethiraj et al., 2005).

A.3.4 Measurement methods

As was described above in §3.2.7, the methods used in the articles selected for this Systematic Review belong to a set of well-known categories, ranked hereafter in descending order of frequency:

- Questionnaires
- Exploitation of secondary data
- Case studies
- Interviews.

I will therefore present them according to this classification, entering into greater detail in the classification for the most numerous category, that of questionnaires.

Three theoretical articles (Cohen and Levinthal, 1990; Lenz, 1980; Wang and Ahmed, 2007) do not belong to this classification, since they are not specific enough on the operationalisation modes being supported, and will not be further described.

A.3.4.1 Questionnaires

Questionnaires are the most widely-used category of tools to measure collective competences in the literature selected for this Systematic Review. The reasons for this popularity may be that they allow for large numbers of cases to be treated at low cost, permit quantitative validation using standard statistical tools, and yet provide flexibility to generate the exact data needed for the study.

A first observation, drawn from the selected literature, on using questionnaires to assess collective competences of organisations is that they should be used with care, due to the associated inaccuracy of the results, as evidenced by J. Denrell et al. (2004).

Keeping in mind this general remark, the main findings of this section are that the quality of the questionnaires in this Systematic Review is highly heterogeneous. Beyond a satisfying formal validation using statistical tools, the semantic validity and the relevance to the concept being measured in the questionnaires appear to be often questionable (§3.4.1.2). However, a significant number of articles display a range of interesting items and concepts that may be useful in further research (§3.4.1.3).

A.3.4.1.1 General considerations on the inter-rater reliability of questionnaires

J. Denrell et al. (2004) study the reliability of the measurement of collective capabilities within multinational firms. They consider the subsidiaries of these large multinational corporations, and compares the assessments of the capabilities made by the subsidiary itself and by the central headquarters of the firm. The capabilities chosen for the investigation were marketing capabilities, in order to be sufficiently generic across industries, and in order for the evaluation not to rely on well-known and widely used objective metrics (as is the case in manufacturing). The study was performed with 6 Swedish-based multinational firms. For each multinational firm, a set of 3 to 6 marketing capabilities was identified as being of strategic importance to the firm, and as being the focus of existing evaluation and attention. In total, 29 capabilities were evaluated. The empirical setting was thus designed be optimal for a high inter-rater reliability.

Overall, responses were obtained for "689 pairwise evaluations" (p.1498). Agreement between both raters was obtained in 28% of the cases only, with a systematic bias towards better ratings from the subsidiary, the difference being of 0.4 points (in a 7-points Likert scale), "which is significantly different from zero (p-value<0.001)" (p.1498). The difference between raters displays a bell-shaped curve (Figure 1, p.1498), that displays a standard deviation of 1.62 on the same 7-points Likert scale, in addition to the systematic bias described above. These figures, obtained in a favourable environment, place boundaries on the reliability of the measure to be expected from a questionnaire: self-evaluation will probably be biased towards a more positive assessment than external opinion, and a significant level of noise must be expected. The fact that the curve displays a bell shape indicates that the measure, although it is corrupted by noise and a systematic bias, still is meaningful, in the sense that the measured value, corrected from its bias, is a good estimator of the 'true' value.

A.3.4.1.2 The low semantic quality of several questionnaires

A significant number of articles selected for this Systematic Review, although they facially display a high level of professionalism, and mobilise a fair number of quantitative statistical tools to assess the validity of the construct (such as Cronbach's alpha, Confirmatory Factor Analysis, Goodness of Fit,...) , apparently fail to take a critical view of their final result. As a consequence, many of the questionnaires, when considered in the detail of the items, display considerable weaknesses in terms of semantic coherence and relevance (Camison, 2004; Escrig-Tena and Bou-Llusar, 2005; Jantunen, 2005; Jerez-Gomez et al., 2005; Prieto and Revilla, 2006; Ritter et al., 2002; Stratman and Roth, 2002; Tu et al., 2006; Wang and Ahmed, 2004).

One very frequent critique that may be addressed to these articles is that the items describe a set of socially desirable behaviours, a sort of 'wish list', that are therefore highly susceptible to cause very positive self-assessments, particularly in the absence of any external control check.

This source of bias can sometimes almost be related to a form of naïveté, (Jerez-Gomez et al., 2005, Appendix A, p.724; Prieto and Revilla, 2006, Table 2, p.174).

Another frequent critique is the lack of semantic relation between the items of the questionnaire and the concept they claim to operationalise. This is to be found for example in an article that attempts to design and test a measurement tool for the competencies associated with Quality Management (Escrig-Tena and Bou-Llusar, 2005).

Although the article seems to rest on a clear vision of the components of the Quality Management processes - broken down into "customer orientation, continuous improvement, focus on people, global vision of the organisation" (p.226) -, it adopts a classification of competences that appears as highly inadequate (although it was drawn from previous literature), breaking them down in the categories of "managerial, input-based, transformation-based, and output-based" (p.225). Trying to force the concepts of Quality Management into this inadequate framework leads to a structure of 9 sub-competencies (Figure 3, p.227) that are difficult to understand in themselves, difficult to relate to the categories each sub-competence is supposedly related to and difficult to relate to the individual items of the questionnaire. The ensuing statistical validation may attempt to validate the resulting instrument, but the overall impression remains little convincing.

Another source of inconsistency resides in the confusion on the very definition of competence, as described in §3.3.2 above (Grimes et al., 2007; Stratman and Roth, 2002).

Despite these weaknesses, some individual items of the questionnaires described here deserve being remembered for further potential use, specifically some items from the rather ambitious work by C. Camison (2004), that builds a complete instrument to measure the "interfunctional or coordination competences" (p.29) of an organisation:

- 2 items in the "Managerial experience" factor
- the "Managerial leadership" and "Incentive for change & innovation" factors
- 3 items in the "Commitment culture" factor
- 5 items in the "Stakeholder cooperation & satisfaction" factor.

A.3.4.1.3 The relevance of well-designed questionnaires

When questionnaires keep a close attention to the semantic meaning of their items, and to their connection to the underlying constructs, while keeping the same rigour as above in their quantitative validation, they result in interesting suggestions for further work (Conant et al., 1990; Garcia-Muiña and Navas-Lopez, 2007; Grimes et al., 2007; Hitt and Ireland, 1985; Lane and Lubatkin, 1998; McGrath et al., 1995).

M. A. Hitt and R. D. Ireland (1985) provide an interesting break-down of the global corporate activity into 55 functional units (related to the primary corporate functions such as Marketing, Manufacturing, Finance, etc.), each of which may be assessed as a capability. The notion of 'capability' is conceptually confused with that of practices, as in many other studies (see §3.3.2 above). In addition, the questionnaire is frequently (but not systematically) worded in terms of "improvement" needed. This does not allow to know what level of capability currently is achieved by the firm. Considering that a function requires 'improvement' may mean anything between an absolute lack of competence (and the recognition that this gap this must be fixed) to a great level of expertise (when people know what they ignore, and see the scope and nature of the improvement to be brought in).

Quantitatively, the 55 items describe the firm's "distinctive competence activities" (Appendix, pp.289-291). Among these, 29 items describe the 'competence' as an "improvement", and 26 items simply as the statement of the current situation. Provided the wording is readapted

towards statements of the current situation, most of the 39 items describing goals in functional terms could be considered for further research.

J. Conant et al. (1990) operationalise the "strategic typology" proposed by R. E. Miles et al.(1978), and of its consequences on marketing competencies and overall economic performance.

The 'strategic typology' (Miles et al., 1978) presents 4 archetypal strategic types: 'prospectors', 'analysts', 'defenders' and 'reactors'. Each type is defined by a set of characteristics along 11 dimensions that define the coherent answers and solutions given to entrepreneurial, engineering and administrative problems (Conant et al., 1990, Table 1, p.367). The typology is inhomogeneous: the innovative and exploratory "prospector" and the conservative and exploiting "defender" types are considered as "pure", while the "analyst" is an hybrid between the 2 'pure' types, and the "reactor" is considered as a residual type, structurally performing worse than the other three.

The research tests a tool classifying organisations in either of the 4 types using: a self-evaluation using one-paragraph description of each type (that include only 2 or 3 of the 11 dimensions of the strategic typology), and a set of 11 questions, each related to a dimension of the typology and proposing a set of 4 possible answers, each connected to a strategic type.

The understanding that the 'reactor' type is inferior may cause a bias in the wording of the questionnaire, despite the claim made to the respondents that all 4 options are equivalent. The consideration of the 'analyst' type of being 'hybrid' also is a sign of an unfinished theoretical construction.

Despite these theoretical weaknesses, the tool could be adapted, specifically after I relate these strategic types to psychological functions of the MBTI model of organisational 'characters' (Bridges, 2000), along the following lines:

- prospector - Extravert Intuition
- analyst - Introvert Intuition
- defender - Introvert Sensation
- reactor - Extravert Sensation.

R. G. McGrath et al. (1995) develop a model of a firm's persistent performance based upon its competence to renew its product repertoire through 'new initiatives', and upon 2 precursors of competence, called 'comprehension' and 'deftness':

- "comprehension" is "the process by which those pursuing an initiative come to understand precisely what combination of resources will allow it to achieve objectives" (p.254) or "what do we know and how well do we know it?" (p.267);
- "deftness" is "how well group processes are operating" (p.267), or "a quality in a group which permits [mutually] heedful interactions to be conducted at minimal cost" (p.256).

'Comprehension' is necessary for the success of a 'new initiative' because at the outset of it, neither the exact goals are defined with accuracy, nor are the environmental conditions very clear, nor are effective tools and methods ready and validated. The group must thus operate in a given level of uncertainty, that should diminish over time, as the project evolves.

'Deftness' contributes to the attainment of a group's goals by reducing "opportunity, transaction and agency costs" (p.256).

This model was investigated, "the level of analysis [being] the project level" (p.258). "The data for the study were collected from 160 projects underway in 40 different firms in 16 different countries" (p.260).

In the conclusions, "Deftness [...] appears to be a fundamental construct for the study of emerging competence" (p.262). Study of the "genesis of deftness" (p.265) should be fruitful for the studies of "strategic alliances, joint ventures, mergers and acquisitions [...] networks" (p.265).

In my opinion, this article sheds very interesting light on the process of effective collective work. The concept of 'deftness' appears to describe with both accuracy and parsimony a collective body working efficiently and effectively, with efficient transmission of information and the shared feeling that people all contribute to the common effort. The description does not fall into the naïveté of believing that efficient collective work implies harmony or absence of conflict. The questionnaire provided in the appendix (pp.270-275) gives a highly relevant tool to measure the degree by which a group works efficiently and smoothly: this competence definitely is collective, it resides in no specific individual, and to me is a determinant of the efficiency in any collective work. The emergence and development of this 'deftness' in a group probably should be understandable and related to the history of the group, the characteristics of the task, the performance assessment system and the personalities of the members. The work programme of finding the sources and origin of this 'deftness' however apparently hasn't been undertaken, as may be inferred from the titles of the 66 papers citing this one in the Social Science Citation database: this highly specific word of 'deftness' appears in no title, and obviously would if an article had undertaken this task.

On the other hand, the concept of 'comprehension', does not appear to be as fruitful. Its origins are difficult to trace, and the complexity of the concept means that it not simply a 'given' of the group.

I would therefore consider including a measure of the 'deftness', at the level of each co-operative R&D programme, in my further research.

F. E. Garcia-Muiña and J. E. Navas-Lopez (2007) explore the effect of technological capabilities on firm results, and take an innovative approach to measuring both.

The authors focus their investigation on 3 broad types of technological capabilities: exploitation capability, itself subdivided into exclusive and non-exclusive exploitation, and exploration capability. These capabilities are related to a model of innovation made of punctuated equilibria, in which successive "dominant designs" (p.32) structure the market. During the life span of a 'dominant design', the firm that initiated it enjoys temporary monopoly rents, of 'exclusive exploitation', as long as its innovation is neither imitated nor substituted. Once imitation or substitution has taken place, a period of incremental, non-exclusive innovation and exploitation takes place. If however the life span of dominant designs reduces significantly, to an extent that exploitation periods effectively vanish, innovation enters in a regime of permanent upheaval and renewal, where the driving firms are those that permanently explore new grounds.

Exclusive exploitation capability refers to the capacity that a firm has to establish its product as a first-mover innovation, and to protect it from imitation and substitution. Non-exclusive exploitation capability refers to the capacity that a firm has to "rapid[ly] and efficient[ly] incorporate [...] incremental innovations, which is only valuable over short periods of time" (p.32). Exploration capabilities are "the permanent development and incorporation of new knowledge with a short life-cycle and a constant re-defining of current technological paths" (p.33).

These technological capabilities are operationalised using simple metrics drawn from the answers to a questionnaire (Fig. 4, p.37):

- exclusive exploitation capability is measured as "the average time that innovators consider it takes to imitate [or to] substitute [the innovation, relative to] the average time in which the innovation was valuable to the industry" (p.36)
- non-exclusive exploitation capability is measured as "the average time over which incremental innovations were developed" (p.36)
- exploration capability is measured as "the number of high-potential products under development (in relation to firm size)" (Fig.4, p.37).

For me, this article provides an interesting perspective on technological capabilities, with simple yet effective and innovative measurement techniques, that I may want to re-use or adapt.

A.3.4.2 Exploitation of secondary data

Secondary data from existing databases bears the advantage of being already present, at large scale. When the information available fits the needs of the researcher, which is a condition not easily met, it provides the means to reach large numbers of cases at relatively low cost, and therefore to quantitatively validate results. The data sources used by the articles being investigated in this Systematic Review were provided by the following organisations: United States of America Patent Office, Moody's, the Center for Research Planning, Lexis-Nexis, Dialog, the Danish government, Compustat, the Strategic Planning Institute.

The articles selected for this Systematic Review either exploit directly the data, without much elaboration (§3.4.2.1), or mobilise more sophisticated econometric techniques to extract information such as an organisation's efficiency (§3.4.2.2).

A.3.4.2.1 Direct exploitation of databases

One empirical study aims at interpreting the sources of the persistent differences existing between the R&D efficiency of pharmaceutical firms, after having accounted for differences in scale and scope of the firms (Henderson and Cockburn, 1994). The authors distinguish between "component competence" on specific scientific and technical areas and "architectural competence" on the ability to assemble these elements into coherent systems and to include new ones (p.65).

Component competence is the reunion of disciplinary expertise in a field of science and of competence in a disease area. The discounted stock of patents is used as a proxy of component competence in a given disease area. No proxy is given for the component competence in a scientific disciplinary field. The operationalisation of 'component' competence using patent data is rather straightforward, and is often used in the literature on innovation, but it is often criticised as being simplistic.

Architectural competence is operationalised through interview data, that will further be described in §3.4.4 below.

P. J. Lane and M. Lubatkin (1998) conceptualise and empirically test the notion of "relative absorptive capacity": a "student" firm will learn more from a "teacher" firm in a knowledge transfer alliance if the dyadic relation between both firms meets certain conditions for the efficient transfer of knowledge. This concept builds upon and enriches the earlier "absolute" absorptive capacity developed by W. M. Cohen and D. A. Levinthal (1989; 1990), that stated that a firm's capacity to learn is intrinsic and only dependent on the firm's R&D spending level (relative to its sales).

The article specifically measures the capacity the 'student' firm has to understand new knowledge from the 'teacher' firm, through a complex calculation. First, the "participation

rate" of a firm to a given scientific discipline is computed as the ratio of the number of 'research communities' - as defined by the Center for Research Planning database - the firm is involved in to the number of 'research communities' dependent on that scientific discipline. In order not to give too big a weight to scientific disciplines that generate a small number of 'research communities', the 'participation rate' is "weighted" by multiplying it by the square root of the number of 'research communities' that the scientific discipline leads. This results in a "weighted participation rate" of each firm in the scientific disciplines present. The 'weighted participation rate' of the teacher (the biotechnology firm) is normalised to a common mean and standard deviation value, and the 'weighted participation rate' of the student (the pharmaceutical firm) in the same scientific discipline is multiplied by this normalised value, resulting in a "knowledge relevance score" (p.469) that translates the relative importance of each scientific discipline to both the teacher and the student.

The 'knowledge relevance score' is applied to biochemistry, which is considered as the common 'basic' set of knowledge, and to all the other scientific disciplines, that are considered as the 'specialised' knowledge fields in which the knowledge transfer is supposed to take place. The capacity to understand new knowledge is then a function of the common 'knowledge score' in biochemistry and of its difference in the other disciplines.

This article provides a very innovative insight into the dyadic nature of the competencies involved in interorganisational relations. The fact that an organisation's competences should also be considered in the light of the partner organisation(s) is very welcome. Although I may not re-use the full complexity of the quantitative tool provided, I will probably keep in mind its concepts for the analysis and understanding of co-operative R&D projects in my PhD work.

T. Schoenecker and L. Swanson (2002) investigate the global Firm Technological Competence, measured both by the means available (the input) and by the achieved goals (the output), and both in terms of scale and quality.

The measures of the scale of Firm Technological Competence are (table 1, p.37): the total amount spent on R&D per year, the total number of patents the firm was granted and the number of new product introductions.

The measures of the quality of Firm Technological Competence are (table 1, p.37): R&D intensity, i.e. the amounts spent on R&D divided by sales, the impact of the firm's patents (as the ratio comparing the frequency in which the firms' patents are cited to the average frequency), the science linkage (measured by the number of scientific articles cited in the firm's patents), the technology cycle time (measured by the median age of the patents cited by the firm's own patents).

Although simple, these metrics are classics in the field of innovation economics.

D. M. De Carolis (2003) investigates the relation between a firm's performance, its competence and the imitability of its knowledge.

'Technological competence' of the firm is measured as follows: "Company A has issued N patents during a given year. Within 2 years of their issue date, M patents had cited these N patents. Of these M citations, X citations belonged to company A - self-citing. The ratio X/N is the measure used for technological competence" (p.39). 'Imitability' of the firm's knowledge is measured symmetrically. "Of these M citations, Y patents were by other companies. The ratio Y/N is the measure used for imitability" (p.39).

This article is an interesting attempt to capture 2 major concepts of the core competency theory: internal build-up of competence and imitability. However, some important conceptual limitations appear in the operationalisation of the latter concept.

'Imitability of the firm's knowledge' is operationalised using citations from other firms than the one having issued the patent. The argument goes that if company B cites a patent from company A in its patent, it is imitating and appropriating knowledge from company A. This vision is highly debatable. From a legal point of view, citing an earlier patent is exactly the opposite of appropriating the content of that patent: it is the acknowledgement of the existence of this prior Intellectual Property Right, and marks the boundary between the existing state of the art (where no property may be claimed), and the innovation contained in the current patent (where property is indeed claimed).

This objection notwithstanding, the idea of using self-cites of patents to track the build-up of internal competence, as a trace left of past R&D activity, is most interesting, and deserves being kept for further study.

A. L. Vinding (2006) studies the relationships between innovativeness of a firm and the components of its 'absorptive capacity' (Cohen and Levinthal, 1990), i.e. of the firm's capacity to "assimilate and utilise external knowledge" (p.509).

The variables representative of the firm's 'absorptive capacity' are:

- the share of employees that have an academic degree
- the average work experience of the employees
- the level of Human Resources Management, being measured by the number of practices being implemented in the firm, from a list of 7 that were considered as advanced in 1997
- the level of connection to the outside world, measured on a 3-levels scale: the firms that have developed no closer relationships to external actors during the reference period 1993-1995, those that have developed them with "either customers / suppliers [...] or with knowledge institutions" (pp.509-510) and those "that have developed closer relationships with both types of actors" (p.510).

Despite the observations made in §3.3.2 on the reference to 'best practices' to assess competence, this article uses simple but rather straightforward tools to assess the components of 'absorptive capacity'.

A.3.4.2.2 Mobilisation of econometric techniques

A stable team of researchers, S. Dutta, O. Narasimhan and S. Rajiv (1999; 2005; 2006), has consistently used Stochastic Frontier Estimation to measure collective competence as an efficiency of either the whole firm (its 'absorptive capacity') or of specific functions within the firm (R&D, marketing, operations).

The efficiency of the R&D, marketing or operations function may be measured by modelling a representative output as a function of a set of potentially contributing inputs (Dutta et al., 1999). The relative (in)efficiency of a given firm A is the difference between the efficiency reached by the firms at the frontier of efficiency and the one reached by firm A. The relationship between output and input takes the shape of a Cobb-Douglas production function, with the error term containing both a purely random, zero-mean, error, and a inefficiency term that only takes positive values (a truncated normal distribution function).

Each capability is measured by the efficiency a specific input-output relation:

- marketing efficiency is measured by the relation of sales to "technological base, advertising stock, stock of marketing expenditures, investment in customer relationship and installed base" (eq.2, p.552)
- R&D efficiency is measured by the relation of "quality-adjusted [by innovativeness or width] technological output" to "technological base, cumulative R&D expenditures and marketing capability" (eq.3, p.553) and to the product of market capacity and technological base (eq.6, p.558)
- operations efficiency is measured by the relation of "cost of production" to "output, cost of capital, labour cost, technological base and marketing capability" (eq.4, p.554).

Stocks are cumulated with a "Koych lag function, with earlier years [...] receiving a lower weight than later years" (p.555).

In a much simpler article, the authors only measure the efficiency of the R&D function of firms, by modelling an output, the "firm's production of innovative technologies", as a function of an input, "R&D expenditures", and of "environmental conditions" (Dutta et al., 2005, equation 1, p.279).

Another article is more ambitious, and explores the origins of 'absorptive capacity'(Cohen and Levinthal, 1990), as a combination of R&D, marketing and operations capabilities (Narasimhan et al., 2006). 'Absorptive Capacity' is defined as the "ability to acquire and utilise external know-how" (p.511), and conceptualised as the "efficiency with which a firm absorbs, relative to what it could have absorbed given the resources it has deployed" (p.512).

In addition to measures of functional efficiencies analogous to those described above, the absorbed knowledge by a firm is operationalised using patents and patents citations (p.518). Each year, the firm's "Domain of Expertise" is defined as the set of patent classes (as defined by the US Patent Office taxonomy) the patents of the firm belong to. The "Know-How Drawn On" by the firm is the set of patent classes that patents cited by the firm's patents belong to. The number of patent classes that are cited by patents of the firm without belonging to the firm's 'Domain of Expertise', "normalised with the number of [patent] classes that are backward cited" (p.518) represents the amount of knowledge that has been drawn by the firm from 'outside', and therefore the knowledge 'absorbed'.

Beyond the general issue of considering competencies as an efficiency rather than an effectiveness, and that I have treated elsewhere (§3.3.2), these articles raise a host of technical questions, mainly on the relevance of the variables used as inputs and outputs to the Stochastic Frontier Estimation models. These issues may be illustrated by the fact that the authors incorporate macroeconomic market conditions into the model as 8 field-specific dummy variables (Narasimhan et al., 2006, p.518) within the "semiconductors and computers" (p.517) industry. This implies that economic conditions differ more between sub-fields of this industry than from one year to the next. However, this industry is highly cyclical: accounting for variability of macroeconomic conditions probably would have better been done using dummy variables for each year of the sample.

Despite these reservations, it may be that more appropriate specifications of Stochastic Frontier Estimation models could be useful to measure functional or global efficiency of a firm, using secondary data, if this measure of efficiency proved to be relevant to my further work.

B.P.S. Murthi et al. (1996) assess the complex notion of "managerial skills" in the discussion of 'first-mover advantage'. To that end, they use as a proxy the measure of the firm's efficiency in 2 areas: marketing and manufacturing, using a different econometric method, Data Envelopment Analysis. The purpose of this method is to "maximise the ratio of the

weighted outputs to the weighted inputs of a firm, subject to the condition that all such ratios are less than or equal to one" (p.331).

The authors use data from the PIMS database, that contains more than 500 data per firm per year (described in appendix A, p.335). "Marketing efficiency" as understood by the authors, "describes the relation between 2 outputs, namely ROI and market share, and 5 managerial inputs, namely, product quality, price, marketing expenditures, image and direct costs" (p.331). "Production efficiency" is computed using "ROI as the output, and purchases and manufacturing expenses as inputs" (p.331).

Provided access to this very rich database is possible, provided the database contains data relevant to R&D, and provided data is available for European firms, this method could prove to be an interesting alternative to Stochastic Frontier Estimation for the measurement of competence as an efficiency.

R. Makadok and G. Walker (2000) investigate forecasting ability, in the context of short-term money market portfolio management. The object whose evolution is to be forecast is extremely simple and one-dimensional: the short-term interest rates of US Treasury bonds. Forecasting ability has a much more general applicability in management situations, in "any [...] decision requiring an irreversible investment" (p.854).

Forecasting ability is measured using the coefficients of a regression model (Hatanaka, 1974) explaining the interest rates of a period t with those of the preceding period (t-1) and the average maturity of the considered fund in period (t-1), using the concept of Granger causation (Granger, 1969): "X is said to Granger-cause Y if Y can be forecast better using past Y and past X rather than just past Y" (Makadok and Walker, 2000, p.859). Forecasting activity of the fund manager is evidenced by the fact that the maturity of his/her portfolio appears to 'Granger-cause' interest rates. Since a good forecaster would shorten this maturity in case of interest rates rises, the measure of "forecasting ability" is the opposite of the regression factor. The data for interest rates and average maturity of funds were collected using archival data of professional journals of the industry, thus avoiding survivor-selection effects and self-censorship.

This operationalisation using archival data both meets excellent validity and avoids the risks of survivor selection and filtering memories. In addition, forecasting capability is a essential competence of an innovative firm, and it would make sense to include a measure of it in a further research on innovation. Unfortunately, the tool being presented here is highly specific to the industry being investigated - money market management - , and its generalisability is very poor. It will therefore require significant adaptation to be re-used in a different context.

A.3.4.3 Case studies

In case studies, the authors dedicate more time to each of the organisations under investigation, in order to obtain deeper and better controlled information.

T. Durand (1988) presents a method in 3 steps to quantify the technical and scientific competencies of an R&D laboratory, with a target size of between 10 and 200 people. The method is well-suited for R&D laboratories that apply their knowledge to engineering and industrial problems, and therefore mobilise multidisciplinary skills.

The first step is to investigate the history of past R&D programmes. R&D programmes are "the parts of [a laboratory's] activity that are organised to respond to certain well-defined objectives: developing a prototype, modifying a process, solving a technical problem" (p.172). The objective of the programme often is defined in terms of functional and technical specifications to reach, and is associated with both a funding and a deadline in time, which

relates it to industrial settings. The method is to interrogate either written archives or older members of staff to obtain first the chronological list of programmes and then the budget and workforce allocations of each programme over the years.

The second step is to establish a "Programme-competencies" matrix. To do so, a list of competencies relevant to the lab must first be established, by in-depth interviews of members of the staff. Once the list of relevant competencies is complete and stable, the matrix is constructed: each row is associated to a competence, and each column to a programme.

The third and final step is to establish the competence profile of the R&D lab, by adding up the person-years related to each competence in the 'Programme-competencies' matrix, in each row. Thus, the cumulated person-years experience of the R&D lab on each competence may be quantitatively evaluated.

This in-depth study requires about one week of audit work to complete in a medium-sized R&D laboratory of 50 people.

The limitations of this simple approach are (1) the depreciation of competence over time and (2) the usage of a common, coarse unit of "person-years", whatever the individual competence of the person is. In addition, it requires a good access to the firm and to its confidential information, which may be problematic.

Despite these limitations, this method appears as sound and interesting to quantitatively investigate the competencies of an R&D organisation. It is well-suited for industrial and engineering environments, and clearly takes into account the cumulative, historical process of competence-building. If the time budget allows, some key organisations in my PhD work may be investigated using methods inspired by this one.

One theoretical article evidences and coins the phenomenon of "core rigidities" (Leonard-Barton, 1992). When the coherent set of knowledge described as 'core capacity' becomes inadequate to some new challenges, they become 'core rigidities' (p.118).

"Values, skills, managerial systems, and technical systems that served the company well in the past and may still be appropriate for some projects or parts of projects, are experienced by others as core rigidities - inappropriate sets of knowledge. Core rigidities are the flip side of core capabilities" (p.118).

Misalignment between a project and the firm's 'core capacities', i.e. when these become 'core rigidities', is illustrated in the 4 dimensions of "(1) employee knowledge and skills [...], (2) technical systems [...], (3) managerial systems [...] (4) values and norms" (p.113). "Less strength in non-dominant disciplines" (p.118) ends up with some technical problems being not being solved, or in inadequate decisions taken. Incompatible technical systems between the requirements of the new product and the legacy may lead to delivery delays. The managerial reward system may prove to be a dis-incitation to engage in non-core capacity projects: "highly-skilled people are understandibly reluctant to apply their abilities to project tasks that are undervalued, lest that negative assessment of the importance of the task contaminate perceptions of their personal abilities" (p.119). Giving responsibilities to people in projects non-aligned with 'core capacities' is considered as very risky, with their "corporate identification badges" (p.120) at stake.

These phenomena were evidenced in an empirical study based upon a set of 20 case studies of new product and process development in 5 technology-intensive firms (4 cases/firm). Qualitative interviews, each lasting from 1 to 3 hours, were performed with the people who had been involved in the selected R&D projects, design, manufacturing and marketing. Interview notes and analyses were submitted to the firms, so that they could validate how

generalisable the findings were of the other projects within the firm. Reciprocally, the academics provided information about the generalisability across firms.

Considering the very real difficulties experienced by firms when venturing outside of their 'core competencies', the cost, delays and risk of failure attached to such projects, the article suggests to me an indirect mode of identifying competences (although this reflection is absent from the article proper). It is when organisations attempt to diversify, when they venture outside of their field of competence, that the nature of this competence is best evidenced - by default, and as in a form of negative image. The diversification attempts that are easy and successful belong to the organisation's competence, while those more difficult, that fail or that require external help or even incorporation of external knowledge, evidence the frontier of the organisation's capabilities.

M. G. Moehrle and H. Lessing (2004) expose a method to investigate the nature of the inventive capacity of a firm, by considering the 'inventive principles' that are mobilised in the firm's published inventions. The 'inventive principles' relate to the "Theory of Inventive Problem Solving" (or TRIZ according to its Russian acronym) that had been developed by the Russian researcher Altshuller (1984, 1996). The list of 40 'inventive principles' was determined empirically following the analysis of ca. 40,000 patents between 1946 and 1970: the main intuition being that all inventions mobilise a limited set of inventive principles. The list, being empirical, does not display any structure, nor is it based upon any theory of invention, creativity or cognition.

The assumptions of the research are:

"(1) each inventive principle represents a large group of inventions based on the same major idea. Therefore, the application of such a principle by a company shows a specific technical competence (2) the set of principles used by a company gives a profile of its technical problem-solving competencies" (p.233)

Thus, determining the inventive principles mobilised by a firm's inventions should give an insight into a hidden dimension of that firm's innovative competence.

These assumptions were tested in a case study with a major German firm manufacturing chemical products and cleaning aids. The technical field chosen was that of "floor-cleaning aids (mops)" (p.234). Using patent database search, 300 patents were produced. Expert analysis was used to select the 65 patents describing major inventions.

Each of the 65 patents was associated with the one or several 'inventive principles' that it mobilises, ending with a list of 104 occasions to mobilise an 'inventive principle'. This stage was the most time-consuming, requiring 2 hours of expert work per patent. These were then associated with their (individual or collective) inventor, to create a profile. The focal firm for which the study was performed and its 2 major competitors were analysed and given a verbal profile, according to the 'inventive principles' each firm mobilises most (Figure 3, p. 237).

If the 'inventive principles' were indeed stable within a person or an organisation and difficult to transfer from one person or organisation to the next, then the proposed method would have some descriptive power of the nature (and not only of the intensity) of the inventive capability of the person or organisation. If evidence existed of the validity of such assumptions, using this method in the further PhD could provide very original information on a rarely considered aspect of an organisation's competence.

S. K. Ethiraj et al. (2005) operationalise and measure the influence of 2 key capabilities - 'firm-specific' capabilities and 'project management' capabilities - on the profitability of software-services projects, in a large Indian software firm:

- "*Client-specific capabilities are a function of repeated interaction with a given client across multiple projects over time. They largely reflect tacit knowledge of the client's business domain and operating routines*" (p.26).
- "*software development and project management capability*" that encompass (p.33) .
    1. "*software design and building capabilities [...] the capability to understand the requirements of the client and design an appropriate system or architecture to address them [...] to efficiently build the code in conformance to the design and co-ordinate the entire code development process that is usually distributed [...]"*
    2. *"effort estimation and management capabilities"*
    3. *"schedule estimation and management capabilities".*

The study was performed in one of the 25 largest Indian software services firms, over 138 projects that were executed between 1996 and 2001 for 57 different clients.

The variable operationalising 'client specific capabilities' is a binary variable, "coded 0 if the [focal] firm has executed projects for the client in the past and coded 1 if it is the first project executed for the client" (p.36).

'Project management capabilities' are operationalised with "3 metric variables" (p.36):

- "the number of in-process defects identified during the project execution phase" (p.36) normalised by a metric of project size
- "effort overruns, i.e. difference between actual [number of] person-months required to complete the project and [the number of] person-months that were initially estimated" (p.36)
- "the extent of schedule slippage, i.e. delay in project completion date" (p.37).

The variable used to operationalise the variable of 'client-specific' capability is a coarse, binary variable, and this negatively impacts its empirical significance. The mean value of this variable is 0.15 (Table 1, p.39), which means that only 15% of the sample population is made of projects with new customers. The accumulation of experience that is expressed by the concept of 'client-specific' capability most probably develops over time and over several projects. This implies that the difference in 'client-specific' capabilities between 2 firms being both 'existing' customers may be greater than the difference between one of them and a 'new' customer. Therefore, a more reliable operationalisation of this concept would have been the total number of projects executed for a given customer.

Providing access is to the data is available, the metrics used by this article (with the minor modification stated) for these 2 competences may prove to be highly relevant for my further study of co-operative R&D projects, that share many common features with software development projects.

A.3.4.4 Interviews

R. Henderson and I. Cockburn (1994) in their study of biopharmaceutical firms, evidence 'architectural' competencies in addition to the 'component' competences described above (§3.4.2.1). These 'architectural' competence variables are measured by exploitation of more than 110 qualitative interviews with chief scientists, R&D directors and field chemists, each interview being 1 to 3 hours long, and referring to the actual history of the R&D programme. Four organisational (or "architectural") variables are constructed from the interviews, and placed on a 5-points Likert scale (p.72):

- "PROPUB: Publication plays a key role in promotion". This variable is strongly correlated to the fact that the R&D lab is geographically close to a major university

and to the fact that the firm is involved in co-operative research projects with universities
- "CROSS: Firm sustains a rich flow of information across [internal] boundaries"
- "DICTATOR: a single individual makes key resource decisions"
- "GLOBAL: Worldwide research is managed as an integrated whole"

The advantage of using qualitative data to inform the variables is that it avoids respondent bias to a direct question implying socially valued behaviours (e.g. "do you work in teams ?"). If the researcher is in the role of simply receiving the descriptive narrative, it gives a better chance to understand into the actual history, what actually happened, independently from any moral or social judgement. On the other hand, the effort to measure these 4 variables is considerable, so the issue of yield of such an effort may be raised. This is specifically true when considering that in the further empirical work by the authors, 2 of these 4 'architectural' variables prove not to have any significant effect on the phenomenon under study.

R. Deshpande et al. (1993) explore the relations between market orientation, innovativeness, business culture, on the one hand and performance on the other hand, in the Japanese context.

The definition of 'business culture' described above (§3.3.1) and inspired by earlier works (Quinn and Rohrbaugh, 1983), although it claims to be related to Jungian categories, grossly misinterprets it, and displays a striking ignorance of Jungian theory. The 4 'culture types' being displayed (p.26) appear along 2 existing dimensions of the MBTI model ('focus of energy' and 'attitude in the outer world'). However, the 'types' appearing at the crossover of the poles of these 2 dimensions are related to some of the 8 'psychological functions' of the Jungian model, but with no consistency whatsoever in their relation to their position along the 2 dimensions described.

The interesting feature of this article is that it leads its investigation by interrogating "matched sets of buyer-seller pairs [... or] matched dyads" (p.28). They designate their sampling unit as a "quadrad, that is, the combination of 2 buyer-seller dyads" (p.28, stress added). In each of the 50 Japanese firms under study, 2 "marketing executives" (p.28) were submitted a questionnaire on their culture, market orientation, innovativeness and performance. They were then asked to name a specific customer, to which the same set of questions on the seller's customer orientation were asked.

The fact of having pairs of respondents in each firm moderates the single-informant bias. In addition, interviewing the counterpart in the other (buyer) firm provides a more 'objective' view on the claimed qualities of the selling firm, which partially address the respondent bias issue described above (§3.4.1.1) and raised in another work (Denrell et al., 2004). These features of the interview configuration make it very interesting for my further research, specifically when investigating co-operative R&D relationships between organisations.

A.4 Conclusions. Instruments for further study

Following this Systematic Review of literature, I will consider using the following elements of method and of instruments in my further study on the collective competences of organisations engaged in co-operative R&D projects.

Measurement method	**Element to be further considered**	**Reference in the 'core list' of the Systematic Review**
Questionnaire	Questionnaire items on "Managerial experience", "Managerial leadership", "Incentive for change & innovation", "Commitment culture", "Stakeholder cooperation & satisfaction".	(Camison, 2004)
Questionnaire	Questionnaire items describing the ability to achieve goals in functional terms, re-worded towards describing the current situation	(Hitt and Ireland, 1985)
Questionnaire	Description of 'strategic types' following a description closer to the MBTI model of organisational 'characters'	(Conant et al., 1990)
Questionnaire	Questionnaire measuring 'deftness'	(McGrath et al., 1995)
Questionnaire	Metrics for 'exploitation' and 'exploration' capacity	(Garcia-Muiña and Navas-Lopez, 2007)
Exploitation of secondary data	Method to measure the capacity to understand new knowledge from the partner firm	(Lane and Lubatkin, 1998)
Exploitation of secondary data	Metric of patents self-cites to track the build-up of internal competence	(De Carolis, 2003)
Exploitation of secondary data	Idea that forecasting ability may be an interesting collective competence to measure in an innovative environment	(Makadok and Walker, 2000)

Table 4.1 (first part): Measurement instruments to be considered in further study

Measurement method	**Element to be further considered**	**Reference in the 'core list' of the Systematic Review**
Case study	Programme-competencies matrix method	(Durand, 1988)
Case study	Idea that the collective competencies of an organisation are well evidenced during diversification attempts	(Leonard-Barton, 1992)
Case study	External inventory of the 'inventive principles' of a firm along the TRIZ framework	(Moehrle and Lessing, 2004)
Case study	Metrics for 'project management' and 'client-specific' capabilities	(Ethiraj et al., 2005)
Interview	Procedure of cross-checking information through matched pairs of respondents in partner organisations	(Deshpande et al., 1993)
Interview	Procedure of interrogating 2 people in the same organisation to limit single-respondent bias	(Deshpande et al., 1993)

Table 4.1 (last part): Measurement instruments to be considered in further study

In addition, if the understanding of competence as an efficiency proved to be relevant, I would consider the econometric methods of Stochastic Frontier Estimation (Dutta et al., 1999; Dutta et al., 2005; Narasimhan et al., 2006) or of Data Envelopment Analysis (Murthi et al., 1996), in order to assess R&D efficiency.

A.Appendix 1: Irrelevant documents

(not reproduced)

A.Appendix 2: Cross-referencing results

(not reproduced)

A.Appendix 3: Citations analysis results

(not reproduced)

A.Appendix 4: Quality Assessment

(not reproduced)

A.Appendix 5: Details of the final "core list"

(not reproduced)

A.Appendix 6: Bibliography of the Systematic Review

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Appendix B Complete text of the main part of the on-line survey (English version)

The text below presents the survey with the code for the questions and for the answers. This code gives an indication on the entity being measured, and specifically on the dimension of the 'world view'. This knowledge could have biased the answers. This is why the code was not displayed to the respondents during the survey, and why it is shown here to make the survey easier to understand.

For each question, the code is provided in **broad** characters, the possible answers are listed, and the help message is given in *italics*. The asterisk * before a code denotes a question to which the answer is mandatory. This happens only in cases when the information is necessary for further logical branching. Explanations for the better understanding of the survey are provided in *(italics and in brackets)*.

Introduction page

Cranfield - Université Paris 1

Research on Competencies and Co-operation Success factors of co-operative R&D projects in Europe - organisational capabilities and cultures

The purpose of this survey is to identify the relations between:

- the capabilities and cultural conventions present in each of the partnering organisations and
- the outcomes of a co-operative R&D project engaged by these organisations.

We want to investigate the success factors of co-operative R&D projects, beyond the catch-all phrases of "complementary capabilities" and "compatible cultures". What do these phrases mean precisely? How can an organisation anticipate whether it has (or not) "complementary abilities" and a "compatible culture" with its intended partner? What would be the empirical foundations of a "cooperation-based" economics?

These are the questions we address, in an Europe-wide study.

Welcome!

to the web-based part of our research on "Success factors of co-operative R&D projects in Europe", a Doctoral Research project jointly supervised by Université Paris 1 - Centre d'Économie de la Sorbonne (France) and Cranfield University - School of Management (United Kingdom) .

We are very grateful that you take some time to participate in our research, and look forward to sharing its results with you.

Your participation in the study will involve answering questions about the capabilities and culture of your organisation, on your perception of the capabilities of your partner in a specific co-operative R&D project, and on the outcome of this project. Completion will take approximately 20 minutes, and may be interrupted and resumed at any time. All questions are designed so that you can answer "from the top of your head", without needing to look into written sources of data. Providing the order of magnitude of the answer is enough. Should you need any assistance to answer this questionnaire, you may call Laurent Zibell at […] during office hours.

We remind you that your participation is entirely voluntary and that you can withdraw from the study at any time and for any reason without penalty or loss of privilege.

The information provided by you will be held totally confidentially. It will be communicated to no one, either in your organisation, nor in your partner organisation in this co-operative R&D project, nor elsewhere. Neither you nor your organisation will be identified in any presentation or publication of this research. It will be impossible to trace your data back to you or your organisation individually.

You should note that this experiment is not being run from a "secure" https-server of the kind typically used to handle credit card transactions. This means that there is a small possibility that responses could be viewed by unauthorized third parties.

We hope that you will find this research enjoyable and interesting.

Have a good journey with us!

Confidentiality notice: Following the Freedom of Information Act (2000) of the United Kingdom and the law "Informatique et Libertés" (1978) of France, you may request access, correction or deletion to nominative data by simply e-mailing to the survey administrator, Laurent ZIBELL, MSc laurent.zibell@malix.univ-paris1.fr

All data for this survey is safely stored in Sophia Antipolis, France, by our hosting provider PhpNux (http://www.phpnux.com/mentions.php), following the European Union Data Protection directive 95/46/EC.

Initial questions

*** Init1:** What is the legal nature of your organisation?

- Non-profit R&D organisation
- Firm

Init2: What is the total number of employees in your organisation?

- 1-10 employees
- 11-49 employees
- 50-249 employees
- 250-2000 employees
- > 2 000 employees

Init3: In what region is your organisation located?

(Text answer)

The location is that of the establishment where you work (that may be different from the corporate headquarters of your organisation). The "region" is the county in the United Kingdom, the province in Belgium, the Netherlands or Sweden,etc..

Innovation-related competencies of your Research department / your Business Unit

In these questions, you will be asked to rate the competence level of your Research department / your Business Unitas compared to the organisations that address the same scientific subjects / to your competitors. The competencies being addressed are those specific to the innovation process.

These questions refer to your Business Unit (if your organisation is a firm), or to your Research Department (if your organisation is a public research organisation), that is, to the

fraction of your overall organisation that is concerned with the same type of product-market couples (for a firm) or of scientific issues (for an R&D organisation). E.g: if your firm was General Electric, the questions would refer to the aero-engines Business Unit if you belonged to it, but not to the medical instruments Business Unit, nor to the whole company.

If however your organisation is very homogeneous (either because it is small, or because it is fully engaged in a single type of business or scientific activity), then these questions refer to your whole organisation.

***InvGen:** Among the following, what do you believe are the management areas of competence that are present in your Research Department / your Business Unit?

- Strategic marketing
- Management of Research & Development operations
- Legal and Intellectual Property

For each, the question is whether the competence is:

- Absent
- Present, but not part of "core" competence
- "Core competence"

Present, but not part of the essential ("core") competence = the tasks are performed at standard professional level, but no more. The "core" competencies are those considered by the Research Department / the Business Unit as essential for its success, and that make a difference with other comparable organisations.

***InvTech:** What do you believe are the technical & scientific areas of competence that are present in your Research Department / your Business Unit?

- Fundamental and Applied Physics
- Hardware design technologies
- Software design technologies and Computer Science
- System design competencies
- Manufacturing technologies

(Same question and help as in InvGen)

StratMkt: *(Only if Strategic Marketing was selected as a 'core competence' in InvGen)* How would you rate the level of competence of your Research Department / your Business Unit in each of these functions of Strategic Marketing?

- Anticipate evolutions of market, competition and strategic environment
- Define product roadmap, hierarchize and schedule research / development work
- Define functional specification of future products, translate market needs into terms that may be exploited by R & D
- Identify the new usage modes of existing products and their new requirements from customer feedback

For each, the question is whether the sub-field of competence is:

- Absent
- Present, but not "core"
- Weak "Core competence
- "Standard "Core competence
- "Strong "Core competence
- "World-leading "Core competence"

Present, but not part of the essential ("core") competence = the tasks are performed at standard professional level, but no more. The "core" competencies are those considered by your Research Department / your Business Unit as essential for its success, and that make a difference with other comparable organisations.

In these "core" competence areas:

- *"weak" = your Research Department / your Business Unit considers itself under the level of its competitors, and that it needs improvement*
- *"standard" = at the same level as the competitors of your Research Department / your Business Unit*
- *"strong" = distinctively above the European competitors of your Research Department / your Business Unit*
- *"world-leading" = your Research Department / your Business Unit is among the top 5 organisations world-wide in this field*

RDMgmt: *(Only if R&D Management was selected as a 'core competence' in InvGen)* How would you rate the level of competence of your Research Department / your Business Unit in each of these functions of R&D Management?

- Anticipate technical and scientific evolutions
- Identify, locate, and qualify relevant external sources of technical and scientific competencies
- Specify and control exploratory research
- Influence decisions in international co-operative technical standardisation work
- Define technical specification of the final product from the functional specifications provided by Marketing
- Design the technical solution meeting specified requirements
- Incorporate user feedback on product failures
- Anticipate research project / technical development budget (manpower and material resources) and schedule
- Manage the specific human requirements of R&D scientists, engineers and technicians
- Share and allocate tasks, set goals among members of the research / development team
- Meet the research / development duration schedule
- Meet the research / development costs budget
- Meet the technical requirements of the product / of the research outcome = compliance with functional specification
- Meet the cost objectives of the product = successful "design to cost"

(Same question and help as in StratMkt)

LegalIP: *(Only if Legal &IP Management was selected as a 'core competence' in InvGen)* How would you rate the level of competence of your Research Department / your Business Unit in each of these functions of Legal and Intellectual Property (IP) management?

- Design and word a technical or scientific co-operation contract
- Design and word a patent
- Patent strategy: define the patents deserving being filed, extended internationally, maintained or abandoned
- Design and word a licensing contract

(Same question and help as in StratMkt)

Phys: *(Only if Physics was selected as a 'core competence' in InvTech)* How would you rate the level of competence of your Research Department / your Business Unit in each of these areas of Fundamental or Applied Physics?

- Quantum and statistical physics
- Laser physics
- Solid-state physics and materials science
- Thin-film and surface physics

(Same question and help as in StratMkt)

Hard: *(Only if Hardware design was selected as a 'core competence' in InvTech)* How would you rate the level of competence of your Research Department / your Business Unit in each of these areas of Hardware design technologies?

- Placement and routing of microcircuits
- Radio frequencies, electromagnetic compatibility
- Lasers and diodes
- Magnetism, electricity, electrostatics, fluidics
- Mechanical, optical and thermal design
- Chemical and biological design

(Same question and help as in StratMkt)

Soft: *(Only if Software design was selected as a 'core competence' in InvTech)* How would you rate the level of competence of your Research Department / your Business Unit in each of these areas of Software design technologies and Computer Science?

- Hardware description language programming (VHDL, Verilog)
- Digital Signal Processing (audio, video, radio, xDSL, error detection & correction)
- Cryptography
- Compiling, synthesising
- Real-time programming and scheduling, time-aware parallel programming
- Sequential and object-oriented language programming (C, Java, C++…)
- Communication protocols, telecommunications and networks
- Built-In electrical and functional tests

(Same question and help as in StratMkt)

Syst: *(Only if Systems design was selected as a 'core competence' in InvTech)* How would you rate the level of competence of your Research Department / your Business Unit in each of these areas of System design competencies?

- Architecture: functional definition of modules & sub-systems
- Specification of interfaces
- Allocation of technical budget (mass, time, power consumption, error, jitter, mechanical or electrical tolerances…) between modules & sub-systems

(Same question and help as in StratMkt)

Manuf: *(Only if Manufacturing technologies was selected as a 'core competence' in InvTech)* How would you rate the level of competence of your Research Department / your Business Unit in each of these areas of Manufacturing technologies?

- Vacuum and ultra-vacuum

- Precision optics and mechanics (machining, polishing)
- Matter deposition technology (CVD, MOCVD, MBE…), including thin films
- Matter removal technology (wet etching, dry etching, plasma…)
- Implantation and ion beams
- Heat treatments
- Polymers and solvents
- Clean rooms, filters, fluids
- Industrial automation
- Metrology and control
- External test benches

(Same question and help as in StratMkt)

InnovCompSizeTeam: What is the typical size of the technical team in charge of a Research project / of a New Product Development in your Research department / your Business Unit?

- < 5 people
- 5 - 10 people
- 11 - 50 people
- 51 - 200 people
- 200 people

When your Research department engages in a new project / when your Business Unit designs a new product / service, what is the number of technical employees (scientists, engineers, technicians) working in parallel on the same project?

InnovCompDurProj: What is the duration of a typical Research / New Product Development project in your Research department / your Business Unit?

- < 3 months
- 3 - 6 months
- 7 - 12 months
- 1 - 3 years
- > 3 years

What is the typical duration between the kick-off meeting of a Research / a New Product Development project and the final event of the project, such as delivery of final report, acceptance test, etc..., in your Research department / your Business Unit?

InnovCompQualAssur: In the unhappy case when the product that your Business Unit designs happened to encounter a failure, what would be the foreseeable consequences?

- No human damage, material damage <100 €
- No human damage, material damage 100 - 10 000€
- Wounded people, material damage 10 - 1 000 k€
- 1 - 100 dead people, material damage 1 - 100 M€
- >100 dead people, material damage > 100 M€

The possible consequences of a failure generally condition the safety and Quality Assurance rules that must be taken into account in the design process. Generally, the greater the consequences, the more stringent the safety and Quality Assurance rules in the design.

Culture & values of your unit

In this section, you will be asked about what is generally believed in your unit, what is considered as important and of high value.

Your "unit" generally is your Business Unit (in a firm) or your Research Department (in a non-profit R&D organisation). However, in cases such as recent re-organisations or mergers, this group of people may be rather heterogeneous in its opinions and beliefs. We will then designate as "your unit" in the following questions a smaller, more homogeneous group: the group of people, still rather large, that includes the whole project team and that have worked together long enough to have developed a common culture.

There is no "right" or "wrong" answer here. The main point is that you report what you believe is the opinion most widely shared in your unit. Please be careful not to express your personal opinion or preference. Only report in a matter-of-fact fashion the dominant opinion in your unit (even if you personally don't agree with it).

(In each of these questions on 'world views', the first answer provided stands for the first polarity along the dimension being investigated, i.e. the 'Sensing' polarity for a CultSN question, the 'J' polarity for CultJP, the "Egalitarian" polarity for CultEq and the 'Liberal' polarity for CultLib. Reminder: neither the code nor the meaning of the answers are displayed to the respondents in the survey. In addition, the order in which the answers are proposed is random. This is made in order to reduce the probability that the respondent identifies the underlying logic and then rationalises his/her answers according to the image s/he would like to project).

CultSN1: Is your unit better at
- producing and delivering established products / services
- planning and creating new products / services

CultJP1: Does your unit
- spell out the details of its policies
- let people work in their own best style

CultEq1: In your unit, large differences in pay are generally considered as
- a source of envy and discord
- a factor of motivation

CultLib1: In your unit, a good leader is a person that
- listens to the opinion of others, including his / her subordinates
- has things done his / her way

CultSN2: Does the leadership base its decisions on
- detailed information about situations
- on general trends and a big picture or concept of what is going on

CultJP2: Would you say that your unit emphasises
- reaching decisions quickly
- considering things from every angle, even if it takes a little while

CultEq2: In your unit, when a person receives a good promotion, s/he more often
- tends to not to boast about it, in order not to upset his/her colleagues
- is happy and proud to discuss it with his/her colleagues

CultLib2: In your unit, is it generally expected that
- each person may express his/her own views and ideas

- everybody is in line with the corporate policy

CultSN3: Does your unit more often steer its course by
- the actualities of the present situation
- the possibilities it perceives in the future

CultJP3: If your unit has a fault, is it that
- it locks into decisions too quickly
- it keeps too many options open for too long

CultEq3: In your unit, are people mainly considered as being
- equal
- different

CultLib3: In decision-making, which consideration ultimately prevails
- the agreement of the people involved
- the authority of the person in charge

CultSN4: When changes are being discussed, which gets more attention
- the step-by-step plan for getting to the destination
- the vision of where things are going

CultJP4: Does your unit more often act
- on the basis of set priorities
- because of opportunities it discovers as the situation evolves

CultEq4: In personnel management, does your unit apply in priority the principles of
- "equal pay for equal work"
- "to each according to his/her talents"

CultLib4: In its strive for performance, does your unit rather support
- every person's autonomy
- group cohesiveness

CultSN5: Is your unit better at
- producing reliable products and information
- coming up with innovative ideas or designs

CultJP5: Does your unit rely on
- carefully established procedures
- "playing it as it lays"

CultEq5: Does your unit consider as more fair to ensure
- comparable pay for people of equivalent qualification & seniority
- equal opportunities for all

CultLib5: In your unit, the fact of expressing disagreement with the instructions of one's manager is considered as
- an opportunity to enrich reflection
- a loss of time

CultSN6: Is your unit's leadership better described as
- solid and down to earth
- intuitive and visionary

CultJP6: Does your unit more often choose to
- reach a decision
- look for more options

CultEq6: In your unit, is it more customary to
- hide one's salary from colleagues
- openly discuss salaries among colleagues

CultLib6: When it comes to justifying a decision, do the managers in your unit rather
- demonstrate their expertise and articulated knowledge of the field
- invoke their experience and hierarchical position

CultSN7: Do your unit's values emphasise acting
- practically and reliably
- ingeniously and inventively

CultJP7: Which describes better your unit's style
- stick to solid ground
- ride the river of change

CultEq7: According to your unit's way of doing things, people should ideally be promoted according to
- objective metrics of merit
- a combination of their energy, capacity to seize opportunities and luck

CultLib7: In your unit, the information flow tends to be more
- from the bottom up
- top-down

CultSN8: When changes need to be made, does your unit prefer to deal with them
- broken down into little steps
- as one integrated transformational leap

CultJP8: When projects are being planned, are they usually
- tightly scheduled on a firm timetable
- flexibly scheduled on an itinerary that can change with circumstances

CultEq8: In your unit, bonuses are mostly distributed
- according to well-defined and publicised rules
- at the discretion of the managers

CultLib8: If you were to use a metaphor to describe your unit, which one would be best suited
- a commando
- a Roman legion

CultSN9: Which better describes your unit
- sticking to the tried and true
- undertaking bold new ventures

CultJP9: Is your unit more likely to
- plan ahead
- make it up as it goes along

CultEq9: In your unit, it is considered that becoming a top-level leader
- may be learnt in appropriate continuous learning programmes
- is a natural gift that must be detected early on and nurtured in dedicated "high-speed career tracks" for high-potential managers

CultLib9: In your unit, it is generally considered that personal initiative and creativity should be

- nurtured and given room for expression
- canalised to fit with the unit's objectives and strategy

(In the following five questions, the answers are associated respectively with the following 'collective polities', in that order: Visionary - § 4.4.4.3, Tradition - § 4.4.4.1, Liberty - § 4.4.4.2, Communitarian - § 4.4.4.4. Again, during survey administration, the four possible answers were randomly presented to the respondents, in order to avoid rationalisation)

CultFam1: In your unit, in order to be well considered and promoted, a person should rather
- have excellent intellectual skills, be at ease with concepts and strategic vision
- have excellent credentials, be very reliable and trustworthy
- have an excellent sense of economic opportunities, be a "money-maker"
- have excellent human and relational skills, be supported by his/her superiors, peers and subordinates

CultFam2: Your unit mainly prides itself upon
- the excellent technical performance of its products / services
- its long tradition of excellence and the deep skill of its technical & scientific personnel
- its remarkably high growth and profitability
- its excellent reputation among all stakeholders

CultFam3: *(Restricted to private firms)* It is often said that the primary aim of a firm is to generate profit and value for its shareholders. What would be the secondary goal that your unit would pursue?
- Contribute to universal welfare by providing well-designed and efficient products / services
- Maintain and develop its competence base
- There is no other goal
- Have a strong team-spirit inspired by its leaders, be a cohesive unit

CultFam4: The main danger your unit should protect itself against would be
- inefficiency, confusion and arbitrary
- a loss or dissolution of its core competencies
- legal (or other) constraints that would restrict its ability to pursue new business opportunities
- internal discord and dissension

CultFam5: When provisioning high-quality external products / services, and in order to select its supplier, your unit mainly considers
- their compliance of the proposed product / service with technical specification
- the experience and competence of the supplier
- the value for money
- the reputation of the supplier and the popularity of the product / service on the market

Co-operative R&D PROJECT: Initial conditions

In this section and later, we will focus on one co-operative R&D project, that we will call the PROJECT. Your partner in the PROJECT will be called PARTNER.

The PROJECT must be completed, for you to know what the outcomes were. The PARTNER must be the same than the one that answers the survey symmetrically to you.

SetUpTechRisk: What was the level of technical risk that you anticipated for the PROJECT before it was launched?

- Low-risk project, straightforward development from existing knowledge
- Medium-risk project, minor uncertainties that only challenge development cost or duration
- High-risk project, major uncertainties that challenge its very feasibility
- Highly exploratory research, with very limited visibility on potential outcomes

SetUpLeader: What organisation do you believe was the leader in the set-up of the PROJECT?

- Your organisation
- Your PARTNER

The leading organisation generally is the one that sets the objective, that gathers the team and that organises the general progress of the work.

SetUpMotivSelect: What were the main motivations of your organisation for selecting your PARTNER for the PROJECT, or for accepting to work with it?

- Availability with your PARTNER of specific innovation-related management competencies
- Availability with your PARTNER of specific technical / scientific competencies
- Strategic compatibility: compatible goals, absence of competition with the partner, identical set of friends and foes in the industry
- Geographic proximity
- Cultural compatibility
- Previous successful co-operation experience

For each, the question is whether the potential source of motivation for selecting the partner is:

- Not relevant for selection / acceptance
- Minor motivation for selection / acceptance
- Major motivation for selection / acceptance

SetUpPubSupp: What proportion of the PROJECT budget was paid for by public bodies?

- < 10%
- 10 -25%
- 25 - 75%
- 75%

Whatever the source of funding: local, regional, national, European...

Innovation-related competencies of your PARTNER

In these questions, you will be asked to evaluate the competence level of your PARTNER, following your observations, in fields related to the innovation process. We are conscious that this is a subjective evaluation. We remind you that your evaluation will remain strictly confidential: no-one, and specifically not your PARTNER, will know your evaluation.

(In this section, the list of capabilities is the same as in the section on "Innovation-related competencies of your Research department / your Business Unit")

*** PartInvGen:** What do you believe are the general management areas of competence that are present with your PARTNER?

Present, but not part of the essential ("core") competence = the tasks are performed at standard professional level, but no more. The "core" competencies are those considered by your PARTNER as essential for its success, and that make a difference with other comparable organisations.

*** PartInvTech:** What do you believe are the technical & scientific areas of competence that are present with your PARTNER?

PartStratMkt: *(Only if Strategic Marketing was selected as a 'core competence' in PartInvGen)* Following your experience of interacting with it, how would you rate the level of competence of your PARTNER in each of these functions of Strategic Marketing?

(Same list of competence sub-fields as in the section on "Innovation-related competencies of your Research department / your Business Unit")

Present in the organisation, but not part of the essential ("core") competence = the tasks are performed at standard professional level, but no more. The "core" competencies are those that your PARTNER considers as essential for its success, and that make a difference with other comparable organisations.

In these "core" competence areas:

- *"weak" = your PARTNER is under the level of its competitors / of comparable organisations, and would need improvement*
- *"standard" = your PARTNER is at the same level as it"s competitors / as comparable organisations*
- *"strong" = your PARTNER is distinctively above it"s European competitors / European comparable organisations*
- *"world-leading" = your PARTNER is among the 5 top organisations world-wide in this field*

(Same question, applied to the other capabilities, and with the same list of sub-fields as in the section on "Innovation-related competencies of your Research department / your Business Unit")

Co-operative R&D PROJECT: learning outcomes

In these questions, we will ask you about the learning outcomes of the PROJECT.

OutKnowCreat: What type of knowledge was created during the PROJECT, that you believe your Research Department / your Business Unit has assimilated?

- Scientific knowledge – "know why" phenomena appear
- Technical / engineering knowledge – "know how" to achieve some target functional or performance specification
- Marketing knowledge – receptivity of pilot customers, willingness to pay, maturity of the need…
- Clearly identified dead end - this project taught you that this path should not be pursued, and why
- Identification of new, unforeseen opportunities - this project led you to new and more ambitious ventures

Tick all that apply.

What is being referred to here is knowledge that your Research Department / your Business Unit did not have before the PROJECT, and that it is now able to use operationally and with no external help.

OutKnowTransf: What type of knowledge was transferred from your PARTNER to your Research Department / your Business Unit during the PROJECT, that you believe you have assimilated?

- Scientific knowledge – "know why" phenomena appear
- Technical / engineering knowledge – "know how" to achieve some target functional or performance specification
- Marketing knowledge – receptivity of pilot customers, willingness to pay, maturity of the need…

(Same recommendations as above)

ModifStratMkt: *(Only if Strategic Marketing was selected as a 'core competence' in InvGen)* How did the PROJECT modify the competencies of your own organisation in each of these functions of Strategic Marketing?

(Same list of sub-fields as in the section on "Innovation-related competencies of your Research department / your Business Unit")

For each, the question is whether the sub-field of competence:

- had No effect on competence
- Maintained existing competence
- Improved existing competence
- Created new competence

(Same question, applied to the other capabilities, and with the same list of sub-fields as in the section on "Innovation-related competencies of your Research department / your Business Unit")

OutQualLearn: Following your experience, what did your organisation learn in the PROJECT that is the most valuable or important?

(Open question)

Co-operative R&D PROJECT: concrete outcomes

In this section, we will ask you about the concrete outcomes of the PROJECT.

Outputs: What were the concrete outputs of the PROJECT?

- Scientific publications
- Patents
- Technical proof of concept (lab demo)
- Functional prototype (meets functional specifications)
- Industrial prototype (meets environment, production & cost requirements)
- Pilot production
- Commercial launch & full-scale production
- Commercial success

- Spin-out creation

Tick all that apply

OutCostBudget: In the PROJECT, how well did the effective operation respect your initial budget for financial and manpower resources?

- Effective operation under initial budget
- Effective operation on initial budget (±10%)
- Effective operation slightly above initial budget (10-30%)
- Effective operation significantly above initial budget (30-100%)
- Effective operation well over initial budget (>100%)

Financial resources are the expenses for material, consumables, etc... on the project. Manpower resources are the number of man-hours (or man-months) that were used for the project.

OutSchedBudget: In the PROJECT, how well did the effective operation respect your initial schedule?

(Same list of alternatives as above)

The schedule includes specifically the overall time allocated to the PROJECT, from the kick-off meeting to the delivery of results.

OutQualOpinion: From you experience in the PROJECT, what were the main factors that contributed, positively or negatively, to its outcome?

(Open question)

End of main survey

CONGRATULATIONS! You have just completed the main part of the survey.

If you like the spirit of this survey, and if you wish, you may complete additional sections (in English) that you will be able to select in the present section.

ChoiceOptionalSect: What would be the additional, optional sections in which you would like to answer some questions?

- Demographic features of your Research Department / your Business Unit
- Internal competencies of your Research Department / your Business Unit (Human Resources, General Management)
- Structural, very stable features of your Business Unit (*)
- Set-up of the PROJECT
- PROJECT operations
- You and your region

Tick all that apply. You may select any number of sections, including zero. In this case, you will directly be led to the end of the survey.

(*) This optional section is mainly meant for private firms.

Appendix C Optional part of the on-line survey: justification and text

Justification of items

Demographic features of the Research Department / the Business Unit:

- Age, tenure length and education level of personnel that, following Sveiby (1997), I believe may have an influence both on the performance of R&D activity, and on the receptiveness to innovation
- Proportion of women, of people of foreign nationality or born abroad, and of people born and educated in a different region among managers, engineers and scientists, that may be a proxy for the receptiveness to innovation and to the unexpected, in engineering environments that are very male-dominated, and in European societies that may be considered as closed to foreign influence

Internal capabilities of the Research Department / the Business Unit that are difficult to observe from the outside, even from the partner in the co-operative project. These capabilities relate to General Management (Corporate mission, Corporate external behaviour, Anticipation, External and Internal relations) and to Human Resources Management (Role of managers, HRM practices, International experience, Access to information, Corporate atmosphere). The items are re-used from Camison (2004).

Structural features of the Business Unit, such as the concentration of customers and suppliers in the market, its overall economic size and geographic scope, barriers to entry, the age and rate of renewal of the technology. These items, because they structure the way things are being done in the organisation, have a strong influence on diversification, and can become 'core rigidities' (Leonard-Barton, 1992). The items are inspired by the 'Industrial Morphology' tool developed by Teissier du Cros (1976) for the investigation of diversification strategies.

Set-up of the project, because of the influence that this phase may have on the overall project success (Saad, 1998):

- outcomes of a previous project performed with the same partner, and features of this existing co-operative relationship (if any)
- selection process of the partner (duration, number of candidates)

Project operations:

- language being used, that may have an influence on the mutual understanding between the project teams, on a very basic linguistic level
- fraction of their working time dedicated to the project by its leader and by the members of the team, because this level of dedication may have an influence on project success as a control variable, independently from any issue related to the heart of my research on organisational capabilities and cultures
- time necessary to travel from the site of one partner to that of the other, frequency of meetings, that are a more precise description of the effects of geographical distance, that is considered in the literature as having an effect on co-operation (§ 1.4.3)
- dependency upon the partner, expressed as the duration necessary to switch partners

- working atmosphere, re-using the concept of 'deftness' proposed by McGrath et al. (1995) and their survey items, and therefore a construct very close to that of 'co-operative competency' proposed by Sivadas and Dwyer (2000)

Relationship of the respondent to the **region** and to his/her geographic environment, in order to start describing with greater repeatability the rich concepts of "*place*" developed by Tuan (1977), of "*creative milieu*" by Törnqvist (1989) and mainly of "*ecumenal relation*" by Berque (2000):

- definition of the regional 'world view', each of the possible answers being connected to one of the four 'collective' polities defined above (§ 4.4.4)
- feelings and levels of personal energy (dullness, depression; boredom; calm, quiet; speed, vivacity; excitation; tension) being felt in key locations (in the office building; in the area around the office building; in the historic city centre of the region; in the area around home; at home)
- the locations, among the five listed above, in which the respondent feels most productive for the four psychic activities relevant for the innovation process (inspiration and creativity - or Extravert Intuition; giving structure and coherence to new ideas - or Introvert Intuition; solving concrete problems and finding ways to bypass obstacles - Extravert Sensing; thoroughly completing a task, until its ultimate details - or Introvert Sensing).

When Likert scales are used, I choose to use four-level scales, in order to force the respondents to a choice, and to avoid the neutral, information-poor middle ground.

Text of the optional part of the survey

Demographics of your Business Unit / your Research Department

(Only if 'Demographic features of your Research Department / your Business Unit ' was selected in question ChoiceOptionalSect)

These questions refer to your Business Unit (if your organisation is a firm), or to your Research Department (if your organisation is a public research organisation), that is, to the fraction of your overall organisation that is concerned with the same type of product-market couples (for a firm) or of scientific issues (for an R&D organisation). E.g: if your firm was General Electric, the questions would refer to the aero-engines Business Unit if you belonged to it, but not to the medical instruments Business Unit, nor to the whole company.

If however your organisation is very homogeneous (either because it is small, or because it is fully engaged in a single type of business or scientific activity), then these questions refer to your whole organisation.

StructDem1: What is the most represented age category among the people working in your Business Unit / your department?

- <28 years old
- 28-35 years old
- 36-42 years old
- 43-49 years old
- 50-56 years old
- >57 years old

Please select the age category that contains the greatest number of people in your Business Unit / your department = the age category that has the relative majority

StructDem2: What is the most represented tenure length among the people working in your Business Unit / your department?

- <2 years tenure
- 2 - 5 years tenure
- 6 - 15 years tenure
- >15 years tenure

The tenure length is the time that a given employee has spent in your organisation. Do not count the time spent with previous employers, but count only the time spent in your organisation. Please select the tenure length category that contains the greatest number of people in your Business Unit / your department = the tenure category that has the relative majority.

StructDem3: What is the most represented education level among the people working in your Business Unit / your department?

- < Secondary school final examination
- Secondary school final examination
- Bachelor degree
- Master degree
- Doctorate / PhD

Please select the education level that contains the greatest number of people in your Business Unit / your department = the education level that has the relative majority

StructDem4: What is the proportion of women among the managers, scientists and engineers of your Business Unit / your department?

- <5%
- 5 - 15%
- 15 - 35%
- >35%

StructDem5: What is the proportion of people of foreign nationality or born abroad among the managers, scientists and engineers of your Business Unit / your department?

- <5%
- 5 - 15%
- 15 - 35%
- >35%

StructDem6: What is the proportion of people born and educated in a different region or country among the managers, scientists and engineers of your Business Unit / your department?

- <10%
- 10-25%
- 25-50%
- 50-80%
- >80%

Internal competencies of your Research department / your Business Unit

(Only if 'Internal competencies of your Research Department / your Business Unit (Human Resources, General Management)' was selected in question ChoiceOptionalSect)

In this section, you will be asked your level of agreement or disagreement on statements relating to the usual operations of your Research department / your Business Unit.

GenMgmt1: Corporate mission

- The top management team effectively defines and communicates a strategic vision
- Many members of the Research department / the Business Unit relate negatively to the corporate mission statement
- Employees and managers generally feel a sense of common purpose in the Research department / the Business Unit

Please choose the appropriate response for each item *(in the following four-level Likert scale)*:

- Fully agree
- Agree
- Disagree
- Fully disagree

Please state your level of agreement or disagreement with these statements referring to your Research department / your Business Unit. Please beware that some statements are deliberately written in a negative sense.

GenMgmt2: Corporate external behaviour

- The Research department / the Business Unit has a record of honesty in its relations with all its stakeholders
- In some circumstances of high strategic importance, the Research department / the Business Unit knows when not to stick to its commitments
- The Research department / the Business Unit does not feel as strongly committed to its small suppliers as to its large customers

(Same Likert scale and same advice as in GenMgmt1)

GenMgmt3: Anticipation

- The Research department / the Business Unit has a good track record in anticipating new scientific / business development opportunities
- The Research department / the Business Unit has sometimes been surprised and taken off balance by unexpected events
- The top management has generally been clever at preventing or circumventing external threats
- The Business Unit"s investments in new businesses and ventures have proven to be very judicious
- The Business Unit has had the opportunity to regret some divestments

(Same Likert scale and same advice as in GenMgmt1)

GenMgmt4: External relations

- Our managers and directors have, and use, an excellent professional network
- We are generally able to identify relevant external partners
- It has sometimes been difficult for us to check the trustworthiness of external partners

(Same Likert scale and same advice as in GenMgmt1)

GenMgmt5: Internal relations

- Conflicts between departments are frequent
- When it comes to arbitrating internal conflicts, the top management"s decisions are well accepted
- Key executives and department heads have a sense of the common good and heed the interests of the organisation as a whole

(Same Likert scale and same advice as in GenMgmt1)

HRM1: Role of managers

- The members of our Research Department / our Business Unit do not regard the managers as role models whose behaviour they should follow
- Our managers are skilled in taking and legitimising decisions
- Managers in the Research Department / the Business Unit are generally considered as well adapted to their position and to the scope and nature of their responsibilities
- In our Research Department / our Business Unit, clearly identified behaviour models exist to be adopted by employees
- It happens that the implementation of management decisions is slow, or even stalls before full completion

(Same Likert scale and same advice as in GenMgmt1)

HRM2: Human Resources Management practices

- Our employees accept the remuneration and incentives policy of the Research Department / the Business Unit
- Our employees are aware of and accept the Research Department / the Business Unit"s criteria for evaluation, promotion and reward
- Our career planning and continuous education systems are considered as unfair and inefficient

(Same Likert scale and same advice as in GenMgmt1)

HRM3: International experience

- Our managers possess the capacity to manage with a global outlook stemming from their understanding and experience of multicultural phenomena
- Our managers have acquired a significant part of their experience in multinational organisations or in international management tasks

(Same Likert scale and same advice as in GenMgmt1)

HRM4: Access to information

- It is easy for an employee to find who is in charge of what in the Research Department / the Business Unit
- Sometimes, finding the relevant source of competence in the Research Department / the Business Unit is difficult
- In our Research Department / our Business Unit, finding the relevant data is easy and fast.

(Same Likert scale and same advice as in GenMgmt1)

HRM5: Corporate atmosphere

- The turnover of our employees and managers is too high
- We attract and retain well-trained and competent employees and managers
- Our employees do not feel a sense of personal commitment to quality

- Our personnel are aware of the history and importance of the Research department / the Business Unit"s achievements
- Absenteeism among our employees and managers is low
- The Research department / the Business Unit"s members don't respect its traditions
- The Research department / the Business Unit has no record of loyalty in its relations with its employees
- Our employees and managers are loyal to the Research department / the Business Unit and to their own commitments

(Same Likert scale and same advice as in GenMgmt1)

Structural features of your Business Unit

(Only if 'Structural, very stable features of your Business Unit' was selected in question ChoiceOptionalSect and if the organisation is a private firm)

These questions refer to very stable features of your Business Unit, that appear so "natural" or as being so much "the way things are done" that they are almost invisible. However, they do shape the behaviour of your organisation"s members, and also what the organisation as a whole is able to do. Generally, changing these stable features can only be done very slowly, very few at a time.

These questions refer to your Business Unit, that is, to the fraction of your overall organisation that is concerned with the same type of product-market couples. E.g: if your firm was General Electric, the questions would refer to the aero-engines Business Unit if you belonged to it, but not to the medical instruments Business Unit, nor to the whole company.

If however your organisation is very homogeneous (either because it is small, or because it is fully engaged in a single type of business or scientific activity), then these questions refer to your whole organisation.

StructEco1: What would be the "entry ticket" for a new firm to enter the market of your Business Unit?

- < 2M€
- 2 - 10M€
- 10 - 50M€
- 50 - 1 000M€
- >1 000M€

If a firm completely new to the market of your Business Unit wanted to enter it, what is the overall investment that it would need to do so? (Acquisition of equipment, salary of employees during training and during the time necessary to gain the first customers...)

StructEco2: What is the typical amount of a single invoice in your Business Unit?

- < 100€
- 0.1 - 10k€
- 10 - 50k€
- 50 - 1 000k€
- >1 000k€

When your Business Unit sends an invoice to one of its direct customers, what is the typical amount of this invoice?

StructMarkt1: What is the geographic scope of the market of your Business Unit?

- Region
- Nation
- Europe
- Industrial and emergent countries
- World (all countries, including poor developing countries)

What is the geographic area in which your Business Unit considers that it should sell its products/services (even if this proves difficult)? What is the geographic area in which your Business Unit considers that it is a part to the competitive game being played?

StructMarkt2: What is the total turnover on the market of your Business Unit = its "size"?

- <1M€
- 1-10M€
- 10-100M€
- 100-1 000M€
- >1 000M€

What is the sum of the turnovers of your Business Unit and your competitors on the geographic market that you consider to be competing in (regional / national / European... etc, as specified previously)?

StructMarkt3: What is the total number of potential customers on the market of your Business Unit = the concentration of demand?

- Highly dispersed demand. >100 000 potential customers
- Dispersed demand. 1 000 - 100 000 potential customers
- Medium dispersed demand. 10 - 1 000 potential customers
- Concentrated demand. 2 - 10 potential customers
- Monopsony. Only 1 potential customer

What is the total number of individuals / of organisations that could purchase the products of your Business Unit (or that of your competitors) on the geographic market that you consider to be competing in (regional / national / European... etc. as specified previously)?

StructMarkt4: What is the total number of competitors on the market of your Business Unit = the concentration of supply?

- Highly dispersed supply. >100 competitors
- Dispersed supply. 21 - 100 competitors
- Medium dispersed supply. 6 - 20 competitors
- Concentrated supply. 2 - 5 competitors
- Monopoly. Only 1 supplier (your firm)

What is the total number of firms active on the geographic market (regional / national / European... etc. as specified previously) that your Business Unit considers to be competing in?

StructMarkt5: What is the duration of your sales cycle?

- < 1 month
- 1 - 3 months
- 3 - 12 months
- 12 - 36 months (i.e. 1 - 3 years)
- 3 years

What is the duration between the first commercial contact with a potential customer of your Business Unit and the moment when the customer actually orders?

StructMarkt6: What is the revenue model of your Business Unit?

- Fixed price per hour worked, with real expenses paid
- Fixed price per unit produced
- Fixed price for the delivery of a complete operational system
- Fixed subscription fee per time unit (e.g. per year) for an unlimited usage
- Success fees

(the revenue models are ranked in ascending order of risk) What are the events that trigger the payment by the customer of your Business Unit?

StructTech1: How long does a product / service usually remain unchanged in the catalogue of your Business Unit?

- >15 years
- 5 - 15 years
- 2 - 5 years
- 6 months - 2 years
- < 6 months

When a product is created, it generally remains some time in the product catalogue, before it is either replaced, significantly improved or simply suppressed. The question refers to the usual time during which a product remains in the catalogue of your Business Unit with no signficant changes.

StructTech2: How long ago did the technologies, that your Research Department / your Business Unit currently uses, start to be available?

- >100 years ago
- 30 - 100 years ago
- 6 - 30 years ago
- 2 - 5 years ago
- < 2 years ago

The technology that your Research Department / your Business Unit uses (machines, instruments, software) has started being available at a given date for broad dissemination. Since then, it may have experienced minor changes, but has essentially remained the same. The question refers to the date when the technology started to be available to users such as your Research Department / your Business Unit.

StructTech3: What is the proportion of your Business Unit's turnover that is dedicated to Research & (New Product) Development?

- < 1%
- 1 - 5%
- 5 - 15%
- 15 - 40%
- >40%

Research and New Product Development are all the scientific, technical and engineering activities that relate to the design of new products and new production processes, from the very fundamental scientific principles to concrete applicative studies.

StructTech4: What is the duration of your production cycle?

- < 1 month
- 1 - 3 months
- 3 - 12 months
- 12 - 36 months (i.e. 1 - 3 years)

- >3 years

What is the duration between the order by your customer and the moment when your Business Unit actually delivers the order?

Co-operative R&D PROJECT: set-up

(Only if 'Set-up of the PROJECT' was selected in question ChoiceOptionalSect)

In this section, we will focus on the PROJECT. We will ask you questions about the way the PROJECT was set up and organised, and about the qualification and selection process of your PARTNER.

*** PrevPartner:** Had your organisation in the past already already performed a previous co-operative R&D project with your PARTNER, before the PROJECT we are discussing today?

- Yes
- No

PrevOutputs: *(Only if 'Yes' was answered to question 'PrevPartner')* What were the concrete outputs of the last previous co-operative R&D project that you had performed with your PARTNER?

(Same list as in question 'Outputs' of the main survey)

PrevCostBudget: *(Only if 'Yes' was answered to question 'PrevPartner')* In this last previous co-operative R&D project with your PARTNER, how well did the effective operation respect your initial budget for financial and manpower resources?

(Same list and advice as in question 'CostBudget' of the main survey)

PrevSchedBudget: *(Only if 'Yes' was answered to question 'PrevPartner')* In the last previous co-operative R&D project with your PARTNER, how well did the effective operation respect your initial schedule?

(Same list and advice as in question 'SchedBudget' of the main survey)

Date1Contr: *(Only if 'Yes' was answered to question 'PrevPartner')* In what year did your organisation sign its first co-operative R&D contract with your PARTNER?

(Numeric answer)

PrevContrDur: *(Only if 'Yes' was answered to question 'PrevPartner')* Since your organisation first signed a co-operative R&D contract with your PARTNER, for what proportion of the time did it have one or several active co-operative R&D contract(s) with them?

- 100% - You were continuously in contractual relationship with your PARTNER
- 85 - 99% - You were almost continuously in contractual relationship with your PARTNER
- 50 - 85% - You were most of the time in contractual relationship with your PARTNER
- <50% - You were occasionally in contractual relationship with your PARTNER

e.g. If your organisation signed a first contract with your PARTNER 10 years ago, and had an active contract with them during a total of 4 years, then the proportion is 40%.

SetUpDurQualif: How much time did your organisation need to identify and qualify suitable potential partners for the PROJECT?

- 1 month or less
- 2 to 3 months
- 4 to 6 months
- 7 to 12 months
- more than one year

This is the time between the moment when the decision was taken to engage in the PROJECT and the moment when the final list of qualified organisations was established, among which a selection process was to take place.

SetUpQualifMode: How were the suitable potential partners identified and qualified for the PROJECT?

- We did not have the initiative. We were directly contacted by the potential partner
- The potential partners were already known to our organisation through previous experience
- We issued a Call for Tender / a Request for Proposals
- We identified potential partners through personal contacts & network
- We performed a pro-active systematic exploration (Internet, telephone calls...)

SetUpNbCompet: *(Only if 'Your organisation' was selected in question 'SetUpLeader' of the main survey)* How many organisations in total do you consider as potentially qualified to engage in an equivalent co-operation for the PROJECT, (price, expertise, quality, schedule), including the partner that you ultimately chose (your PARTNER)?

(Numeric answer)

You finally chose to co-operate with one external partner organisation, your PARTNER. However, there were potentially several others that could have performed an equivalent work. How many qualified organisations did you consider in total?
e.g. if you consider that your PARTNER is the only one qualified, you should answer "1".

SetUpDurSelect: *(Only if 'Your organisation' was selected in question 'SetUpLeader' of the main survey)* How much time did your organisation need to select your PARTNER for the PROJECT, among the organisations it considered as qualified?

(Same list of options as in question ' SetUpDurQualif')

This is the time between the moment when the final list of qualified organisations was established and the moment when your organisation took the final decision to co-operate with your PARTNER .

SetUpDealMak: How long has the legal & technical deal-making process been for the PROJECT?

(Same list of options as in question ' SetUpDurQualif')

Duration between selection of partner and signature of co-operation contract: technical content, specification of tasks and milestones, sharing of IP rights and of expenses (financial & manpower)

SetUpInternSupp: Internal support for the project *(Agreement expressed on a four-level Likert scale)*

- The amount of financial resources each partner was expected to contribute in the PROJECT effort was clearly laid out
- The amount of manpower each partner was expected to contribute in the PROJECT effort was not clearly laid out

Financial resources are the expenses for material, consumables, etc... on the project.

Manpower resources are the number of man-hours (or man-months) that were used for the project.

Co-operative R&D PROJECT: operations

(Only if 'PROJECT operations' was selected in question ChoiceOptionalSect)

In this section, we will ask you questions about the concrete working conditions and on the everyday operations of the PROJECT. [Only answer this question if you answered 'PROJECT operations' to question 'ChoiceOptionalSect '

OperLangUsed: What language was used for the communication between teams in the PROJECT?

- the mother tongue of the project team members of your organisation
- the official working language of your organisation
- the official working language of your PARTNER
- the mother tongue of the project team members of your PARTNER
- a language that is neither the mother tongue nor the working language of either teams or organisations

Tick all that apply
Example1: Your are an Italian organisation, your PARTNER is a Dutch organisation. In both organisations, people speak their mother tongue as the official working language. The communication language of the PROJECT was English. You should tick "a language that is neither the mother tongue nor the working language of either teams or organisations"
Example2: You are a Polish organisation, and the members of the project team are native Polish speakers, English is the official working language of the organisation. Your PARTNER is British and its official working language was English. The communication language of the PROJECT is English. You should tick: "the official working language of your organisation", "the official working language of your PARTNER" and "the mother tongue of the project team members of your PARTNER"

OperFracTimeLeader: What fraction of his/her time did the technical project leader in your organisation dedicate to the PROJECT?

- 100% of his/her time - S/he was totally dedicated to the PROJECT
- 51-99% of his/her time - S/he was mainly dedicated to the PROJECT
- 20-50% of his/her time - The PROJECT was an important, but secondary, task for him/her
- <20% of his/her time - The PROJECT was a minor task for him/her

OperFracTimeMember: What fraction of his/her time did the typical team member in your organisation dedicate to the PROJECT?

(Same list of options as in question OperFracTimeLeader)

OperDurContr: What is the duration of the formal co-operation contract underpinning the PROJECT?

- 6 months or less
- 7 to 18 months
- 19 to 36 months
- 3 years or more

OperDurTrans: What was the transport duration between the site where the project team of your organisation worked and the site where the project team of your PARTNER worked?

- 15 minutes or less
- 15 to 60 minutes
- 1 to 3 hours
- 3 to 6 hours
- more than 6 hours

OperInterPhyMeet: How often on average did physical meetings take place, that gathered participants from the different partner organisations to the PROJECT?

- Once per week
- Once per fortnight
- Once per month
- Once per quarter
- Once per semester
- Once per year or less often

These physical meetings may have been for whatever reason.

OperTelMeet: How often on average did teleconference meetings take place, that gathered participants from the different partner organisations to the PROJECT?

(Same list of options as in question 'OperInterPhyMeet')

These teleconference meetings may have been for whatever reason.

OperControl: How often did meetings take place, that were dedicated to the control of the PROJECT?

(Same list of options as in question 'OperInterPhyMeet')

Control involves reporting, progress meetings, inspection, intermediate and final acceptance tests, etc..

OperReAdjust: How often did meetings take place, that were dedicated to re-adjustment of the PROJECT?

(Same list of options as in question 'OperInterPhyMeet')

Re-ajustment is the process of re-defining objectives and tasks according to new information obtained during the course of the PROJECT.

OperDurSwitch: How long do you believe would have been necessary for you to switch partners in the PROJECT?

- 3 months or less
- 4 to 12 months
- 1 to 3 years
- more than 3 years

In the unhappy case when you would have been dissatisfied with your PARTNER, how long do you believe it would have taken for you to change your partner and arrive at the same level of co-operation efficiency? (= time to identify the replacement partner, to conclude contract, to upgrade the partner to the current level of knowledge...)

OperDeft: Everyday work atmosphere during the PROJECT. *(Agreement expressed on a four-level Likert scale)*

- Few of the others on the PROJECT team knew what to do
- All the others in the PROJECT team were competent to do what was needed

- Few people on the PROJECT team could depend on one another to do what was needed
- Few people on the PROJECT team knew what information was important to the others
- On the PROJECT, there were very few hidden agendas
- Important information often got held up
- Information was always accurate
- New people joining the PROJECT were very easily assimilated
- All people in the team understood one another, we all 'spoke the same language'
- Few people on the PROJECT team could depend on one another to implement decisions
- Information needed to move the PROJECT forward was simply not available
- The PROJECT was very short of key skills
- There was general agreement that correct decisions were being made

Please select the appreciation that best describes what usually happened during the PROJECT. In these statements, the "PROJECT team" refers to the whole group made of the members of your organisation and of your PARTNER that were dedicated to the PROJECT.

You and your region

(Only if 'You and your region' was selected in question ChoiceOptionalSect)

In this more exploratory section, we will ask you questions about the region where you work and live *(Reminder of answer to question 'Init3' of the main part of the survey)*, and on the way you relate to it. Indeed, we believe that a region, in its cultural and geographic dimensions, can have an influence on the innovation process that we study.

(In the following four questions, the answers are associated respectively with the following 'collective polities', in that order: Visionary - § 4.4.4.3, Tradition - § 4.4.4.1, Liberty - § 4.4.4.2, Communitarian - § 4.4.4.4. Again, during survey administration, the four possible answers were randomly presented to the respondents, in order to avoid rationalisation)

RegFam1: In your region, it is generally considered that the main role of public authorities in economic issues is:

- to organise and plan strategic projects e.g. in science, industry, infrastructure
- to contribute to the region's economic prosperity
- to leave private economic actors freedom to act to their best interest
- to contribute to social cohesion

RegFam2: In your region, people would mainly pride upon

- its contribution to humankind's culture and achievements
- its traditions and heritage
- its high level of civil rights and individual liberties
- the cohesiveness of its social fabric and the warmth of its community

RegFam3: In your region, people would mostly relate to the following phrase

- "Society will be organised for the progress of science and industry, with the aim at the improvement of the moral, intellectual and physical situation of the most numerous and poorest class" (de Saint-Simon, 1841)
- "Between each individual and entire humanity, stands the nation / the region, with its peculiar origin and history, with its special manners and customs, with their claims for existence and continuance for the future" (List, 1856)

- "The only part of the conduct of anyone, for which he is amenable to society, is that which concerns others. In the part which merely concerns himself, his independence is, of right, absolute. Over himself the individual is sovereign." (Mill, 1871)
- "Union and peace are the goals, because where the union is, strength necessarily stands" (Savonarole, 1993)

RegFam4: If your region had a weakness, it would rather be
- the difficulty for local players to agree on common projects
- a form of self-centred provincialism / parochialism
- the lack of infrastructure and public services
- the difficulty to accept dissenting voices

RegEnergy: What would best describe what you generally feel in each location?
- In your office building
- In the area around your office building
- In the historic city centre of the region
- In the area around your home
- In your home

One answer to be chosen in the following list:
- dullness, depression
- boredom
- calm, quiet
- speed, vivacity
- excitation
- tension

RegJoy: What would best describe what you generally feel in each location?

(Same list of places as in question RegEnergy)

One answer to be chosen in the following list:
- joy, cheerfulness
- sadness, melancholy

RegLoneliness: What would best describe what you generally feel in each location?

(Same list of places as in question RegEnergy)

One answer to be chosen in the following list:
- loneliness, isolation
- feeling well surrounded, in a warm atmosphere

RegSafety: What would best describe what you generally feel in each location?

(Same list of places as in question RegEnergy)

One answer to be chosen in the following list:
- safety, security
- insecurity, fear

RegHardness: What would best describe what you generally feel in each location?

(Same list of places as in question RegEnergy)

One answer to be chosen in the following list:
- hardness, dryness
- softness, mellowness

RegClarity: What would best describe what you generally feel in each location?

(Same list of places as in question RegEnergy)

One answer to be chosen in the following list:
- clarity of mind
- confusion

RegNe: What is your preferred and most productive place for inspiration and creativity?

(Same list of places as in question RegEnergy)

RegNi: What is your preferred and most productive place for giving structure and coherence to new ideas?

(Same list of places as in question RegEnergy)

RegSe: What is your preferred and most productive place for solving concrete problems and finding ways to bypass obstacles?

(Same list of places as in question RegEnergy)

RegSi: What is your preferred and most productive place for thoroughly completing a task, until its ultimate details?

(Same list of places as in question RegEnergy)

RegFutWork: Where would you wish to live and work in 5 years from now?
- in the same region as today
- in a different region of the same country
- in a different country

Appendix D Milestones in the data collection procedure

During the pilot phase, I attempted to obtain the details of project managers from the Director of R&D in a firm (or from the Director of a research laboratory). The procedure for this stage is defined by the following milestones:

- **0-Nil**: no action has yet been undertaken
- **01- Director R&D Located**: the contact details of the Director of R&D have been confirmed by a telephone call
- **02-Initial Letter Director R&D sent**: The initial letter is sent by post. The purpose of using the postal service is that the letter then remains physically on the desk of the recipient, which entices to some form of response, while people discard or forget their (very numerous and weightless) e-mails much more easily in the depths of their electronic inbox. Two weeks after the initial letter was sent to the Director of R&D, I called his/her assistant to enquire on whether the letter has indeed reached him/her, and if further information is needed
- **03-Reminder Director R&D sent**: the reminder is a second postal letter, sent one week after the reminder call
- **04b-Details Project Manager received**: this stage is reached when I have received the name and contact details of one or several project managers from the Director of R&D

Once I have received the details of a project manager, either directly through a database of co-operative projects or through the answers of a Director of R&D, the procedure to obtain responses from the project managers is defined by the following milestones:

- **04a-Details Project Manager received**: If the contact details of the project manager were obtained through a database of co-operative projects, this milestone is reached after their validation by telephone
- **05-Initial Letter Project Manager sent**: The first letter to the project manager is again by post, for the same reasons as for the initial letter to the Director of R&D. The text of the letter differs slightly according to the source of the contact details. If they were obtained by the Director of R&D, then I mention this fact in this first letter. If they were obtained in a database, I specify the source, so that the person knows where I obtained the information from.
- **06-Project Manager Called Emailed**: I call the project manager by telephone ten days after having sent the initial letter, in order to check his/her willingness to participate in the research, and, if so, to provide him/her with the information s/he may need, and also for him/her to choose the most appropriate project. This also creates a human relationship to the respondent, that contributes to him/her feeling emotionally responsible for giving an answer. I follow the phone call with an e-mail containing the direct links to the on-line surveys (for the respondent him/herself and for his/her partner)
- **07-Reminder Project Manager Partner sent**: The reminder is a second postal letter, sent two weeks after the telephone call. It asks for both the project manager and his/her partner to answer the survey. This paper reminder is followed by one e-mail reminder, one telephone call and one last e-mail reminder, at one week interval. The e-mail reminders are sent using functions embedded in the LimeSurvey software.

- **08-Questionnaire Done Project Manager**: This milestone is reached when the project manager has completed his/her survey. I receive an automated e-mail warning from the LimeSurvey software when this has taken place. The software simultaneously sends a personalised thank you e-mail to the project manager.
- **09-Reminder Partner sent**: This postal reminder is sent ten days after the completion of the survey by the project manager, in the case when the partner has not provided an answer yet. It is followed by the same e-mail and telephone reminders as in Step 07.
- **10-Questionnaire done partner**: Same conditions as those for the completion of the survey by the project manager, in the rare case when the partner has answered before the project manager. The thank you e-mail is sent to the project manager, for him/her to forward it to his/her partner.
- **11-Reminder Project Manager sent**: This stage follows stage 10, when the partner has answered before the project manager. The reminder letter is adapted to this situation.
- **12-Details Partner received**: This stage is reached when the Project Manager accepts to divulge the name and details of the partner, for me to contact him/her directly.
- **13-Initial Letter Partner sent**: Same as Stage 05, interacting this time directly with the Partner.
- **14-Partner Called Emailed**: Same as Stage 06, interacting directly with the partner.
- **15-Direct Reminder Partner sent**: Same as Stage 07, interacting directly with the partner.
- **16-OK**: This milestone is reached when both the project manager and his/her partner have provided an answer to the survey.

In addition, two stages are defined to qualify the premature end of the procedure:

- **88-Dead after 1 answer**
- **99-Dead**

These milestones are reached when no further contact is desirable, either because I received a negative answer, or because I have received none after having spent the resources I believe are appropriate, and I consider that any further insistence would be a waste of time and energy. The distinction between these categories is related to the fact that, although a response from a single organisation is insufficient for me to draw full conclusions, it does provide some information that may prove to be useful, and thus deserves being counted separately from outright failures.

Appendix E Résumé substantiel en Français.

E.1 Introduction générale

L'Économie comme discipline académique commence, avec Smith (1776), par placer la concurrence entre acteurs économiques au centre de sa réflexion. Ces acteurs économiques sont considérés comme isolés les uns des autres, sans relation autre que celle médiatisée par le "commissaire priseur" walrasien (1874). Cependant, dès List (1856), la vision selon laquelle la coopération entre agents économiques peut être à l'origine de l'efficacité des systèmes économiques nationaux se fait jour.

Il faut cependant attendre la fin du vingtième siècle pour que la coopération explicite entre firmes fasse à nouveau l'objet d'un intérêt de la part des chercheurs (Perroux, 1955; Aoki, 1988; Hamel et al., 1989), avec la notion d'alliance stratégique. Cet intérêt est partiellement causé par la forte augmentation du nombre de ces alliances, observée empiriquement à la même époque, et qui se confirme depuis (Hagedoorn, 2002; Paulré et al., 2003; Kremp and Mairesse, 2002; Corbel, 2005). Les motivations mises en avant pour la coopération inter-firmes sont la réduction des couts et des risques de développement, les économique d'échelle et d'envergure (Dodgson, 1993; Belderbos et al., 2004), ou encore les trois "logiques de cration de valeur" que sont la "co-option", la "co-spécialisation" et l'apprentissage (Doz and Hamel, 1998). Cependant, ces coopérations ont des taux d'échec élevés (Das and Teng, 2000b; Brouthers et al., 1995; Sivadas and Dwyer, 2000).

Face à ces taux d'échec, la question des prédicteurs du succès de la coopération inter-firme se pose. Quatre courants d'interprétation se dégagent. Dans une perspective de gouvernance et de coûts de transactions, le facteur-clef est la prévention des comportements opportunistes (Hamel et al., 1989; Dussauge et al., 2000; Das and Teng, 2000a). Pour Doz et Hamel (1998), l'accent porte sur la compatibilité stratégique. L'économie géographique, et en particulier celle née de l'observation des pôles de concentration de la R&D (ou "*clusters*") , met en avant l'importance de la proximité géographique entre acteurs pour favoriser la transmission locale de connaissances et la confiance mutuelle (Hotz-Hart, 2000; Feldman, 2000). Enfin, un courant de recherche développe la notion de "*distance cognitive*" (Nooteboom, 2000) ou réciproquement de "*proximité organisée*" (Torre and Rallet, 2005). L'idée générale est que des organismes sont d'autant plus susceptibles de coopérer qu'ils partagent des cadres interprétatifs communs. La mesure de cette 'distance cognitive' est très hétérogène (Knoben and Oerlemans, 2006). Dans les études quantitatives, les méthodes de mesure utilisées sont :

(1) une variable de nationalité pour décrire la dimension culturelle (Coenen et al., 2004; Gertler, 1995; Schamp et al., 2004); et (2) un indice de spécialisation technologique obetnu à partir de données de brevets (Branstetter and Sakakibara, 2002; Colombo, 2003; Greunz, 2003; Nooteboom et al., 2005; Wuyts et al., 2005; Cantner and Meder, 2007). La notion de 'proximité organisée' regroupe une "*logique d'appartenance*" à un même ensemble institutionnel et une "*logique de similitude*" entre représentations mentales.

Il m'apparait nécessaire de prendre en compte d'autres phénomènes pour tenter de prédire le résultat de la coopération inter-firmes. En effet, une motivation fréquemment mise en avant pour la coopération inter-firme est la **complémentarité des compétences** (Doz and Hamel, 1998; Richardson, 1972), alors qu'une difficulté fréquemment évoquée est la **compatibilité culturelle** (Mason, 1993; Bailey et al., 1998), sans pour autant que ces notions soient définies avec précision. Je prends l'hypothèse que ces compétences et cultures sont **collectives**, et qu'elles sont **incorporées** dans les organisations (Penrose, 1995; Barney, 1991; Prahalad and Hamel, 1990; Teece et al., 1997; Eisenhardt and Martin, 2000; Winter, 2003; Helfat et al., 2007).Je me propose dans cette thèse d'explorer les liens entre complémentarité des compétences, compatibilité culturelle et R&D coopérative.

J'ai procédé à une revue de littérature sur la question, qui convergé vers 22 références pertinentes. Dans une première approche, les chercheurs se contentent de reprendre à leur compte les notions utilisées par les praticiens, sans les expliciter plus avant. Ainsi, des notions d'"*alchimie*" ou de "*mariage*" entre partenaires (Mason, 1993), de "*confiance*" (Koza and Lewin, 1998), de complémentarité des compétences ou de "*culture partagée*" (Taylor, 2005) sont utilisées sans être définies. Une hypothèse âprement discutée est celle de l'existence et de la pertinence d'une compétence liée à la gestion des alliances elles-mêmes. Pour certains (Kale et al., 2002; Lambe et al., 2002; Sampson, 2005; Zajac, 1998; Hoang and Rothaermel, 2005), cette compétence est générique et exerce une influence positive sur la réussite des projets coopératifs de R&D. Pour d'autres au contraire (Zollo et al., 2002), la compétence est spécifique à la dyade considérée, et ne peut être transposée à d'autres. J'ai enfin considéré quelques études qui traitent plus spécifiquement des compétences comme prédicteurs des résultats de R&D coopérative. Sivadas et Dwyer (2000) construisent et mesurent un concept de "*compétence coopérative*" qui se matérialise par la communication et la coordination explicite entre équipes. Arya et Lin (2007) étudient des dyades d'associations de lutte contre le Sida, et considèrent leur recouvrement d'activités et de sources de financement. Bizan (2003) étudie le partage des tâches entre partenaires dans des projets de R&D israélo-

étatsuniens. Branstetter et Sakihabara (2002) comparent les profils technologiques des partenaires, obtenus à partir de données de brevets. Enfin, Saad (1998) considère des variables de confiance, de solidarité, de compétence globale et de complémentarité du consortium de R&D, de clarté ou de conflit des objectifs, mais sans comparer les réponses isssues de plusieurs organisations membres du meme consortium.

Mes questions de recherche dans cette thèse sont les suivantes :

(1) quelles combinaisons, à l'échelle de la dyade, des "compétences collectives" et des "visions du monde" des organisations partenaires, sont des prédicteurs fiables des résultats **concrets** de projets coopératifs de Recherche & Développement ?

(2) quelles combinaisons, à l'échelle de la dyade, des "compétences collectives" et des "visions du monde" des organisations partenaires, sont des prédicteurs fiables des résultats en termes d'**apprentissage** de projets coopératifs de Recherche & Développement ?

La définition précise des termes "compétences collectives" et "visions du monde" fait l'objet de chapitres ultérieurs de ma thèse (§E.3 et E.4). L'apprentissage recouvre : (1) la modification des compétences de l'organisation, (2) la création de connaissances par le projet et (3) le transfert unilatéral de connaissances d'une organisation vers son partenaire à l'occasion du projet.

Le champ d'investigation empirique de ma recherche porte sur les projets formalisés de Recherche & Développement, de durée finie, mobilisant deux partenaires basés en Europe, dans le secteur de l'électronique et des équipements de télécommunications.

La Recherche & Développement est définie par l'OCDE (2003). Les projets coopératifs étudiés sont formalisés et de durée finie, de manière à être observables à une date faisant sens : la fin du projet. L'Europe est choisie pour sa diversité culturelle sur une surface réduite. Le secteur de l'électronique et des équipements de télécommunications m'est bien connu, du fait de mon expérience professionnelle antérieure.

Les **éléments distinctifs** de ma recherche sont les suivants :

- la mesure des compétences et des cultures collectives, à partir d'une justification théorique
- la collecte de données auprès de paires de partenaires ayant contribué au même projet

- l'étude des effets de rétroaction du projet coopératif de R&D sur les compétences collectives des organisations participantes.

Dans cette recherche, je mobilise les **ressources théoriques** suivantes : la vision relationnelle de la firme (Dyer and Singh, 1998), l'économie des proximités (Pecqueur and Zimmermann, 2004) et l'économie des conventions (Favereau, 1988; Eymard-Duvernay, 1989; Boltanski and Thévenot, 1987; Eymard-Duvernay et al., 2004), dans une perspective générale d'économie évolutionnaire (Nelson and Winter, 1982; Dosi et al., 2000; Witt, 2008).

La vision relationnelle de la firme considère que les actifs contribuant de façon essentielle à son avantage concurrentiel sont son réseau de partenaires, et considère la dyade ou le réseau de firmes liées par des relations de partenariat comme l'unité d'analyse pertinente. L'économie des proximités considère que la proximité géographique, pour être efficace, doit être complétée par une proximité institutionnelle, organisationnelle et cognitive. L'économie des conventions, fort ambitieuse, considère le problème très général, et commun à l'économie, à la sociologie et aux sciences politiques, de la coordination entre acteurs. Selon cette école, la coordination n'est possible qu'autour de "*conventions*" qui stabilisent les comportements et rendent possible l'anticipation mutuelle de ceux-ci. Elles sont des conventions de qualité (Eymard-Duvernay, 1989), des "*mondes de production*" (Salais and Storper, 1992) ou, selon un modèle plus général, des "*cités*" (Boltanski and Thévenot, 1991). Selon cette dernière représentation, dans chaque 'cité', un "*principe supérieur commun*", bénéfique à l'ensemble de la collectivité, est considéré comme étant l'objectif le plus digne d'être poursuivi. Les acteurs contribuant le plus à ce 'principe supérieur commun' sont jugés être "*grands*" et mériter honneurs et avantages sociaux. Un 'principe supérieur commun' n'a de légitimité morale, et n'est justifié à fonder une 'cité, que s'il respecte un ensemble rigoureux d'axiomes. La rigueur de ces conditions fait que seules six (puis sept) 'cités' sont identifiées par les auteurs.

En économie évolutionnaire, les organisations sont définies par des entités internes stables, soumises à un processus général de variation aléatoire, de sélection et de rétention (Campbell, 1969; Campbell, 1974). Pour le courant dominant en économie évolutionnaire, ces entités internes stables sont les "*routines*", motifs de comportement semi-automatiques, inscrits par la répétition. L'évolution de ces routines est lente, ce qui explique la différence persistante de performance et de comportement des firmes.

Partie 1 : Élaboration des concepts théoriques

E.2 Compétences et cultures comme invariants d'une organisation

Ce chapitre cherche à justifier d'un point de vue théorique l'existence même de compétences et de cultures collectives dans une organisation, en partant de la racine même de ce que celle-ci est. Il répond à deux questions : (1) quelles sont les structures essentielles d'une organisation ? et (2) quels processus les stabilisent ?

Cette construction théorique a un triple but : (1) identifier les éléments intrinsèquement stables d'une organisation, et donc résistants au changement; (2) classifier les organisations à partir de leurs composantes stables ; et (3) justifier que l'on attribue à des organisations des notions jusqu'ici mal définies, comme des compétences ou des cultures d'entreprise.

Les structures universelles constituant les invariants stables d'une organisation sont pour moi : sa "***vision du monde***", inspirée de Aerts et al. (1994), stabilisée par un mécanisme d'Attraction, Sélection, Usure (Schneider, 1987) et son **réseau de communication finalisée**, stabilisé par des coûts irrécouvrables.

Dans ma définition, très générale, une organisation est un groupe de personnes qui agissent de manière coordonnée pour atteindre des buts à grande échelle, avec une division du travail et de la connaissance. "À grande échelle" signifie simplement : au-delà de ce qui est accessible à un individu seul. Il s'agit donc (1) d'un groupe, (2) qui a un programme de travail commun et (3) qui se coordonne pour le réaliser.

Le groupe que constitue l'organisation n'est pas né pleinement constitué dès le premier jour. Il est le résultat d'un processus d'agrégation progressive autour d'un (noyau de) fondateur(s). Pour être d'accord sur le programme de travail, le groupe doit s'accorder sur ce que j'appelle une 'vision du monde' : (1) une ontologie, (2) un périmètre d'action et (3) une axiologie.

L'ontologie est l'ensemble des entités jugées exister ou avoir une importance suffisante pour que l'on cherche à agir dessus. Le périmètre d'action est nécessaire pour des raisons de division inter-organisationnelle du travail : une organisation, du fait de la limitation de ses ressources, ne peut traiter toutes les questions relevant des objets inclus dans son ontologie, et doit donc se limiter. Le périmètre d'action, ou encore le métier de l'organisation, est défini par une légitimité technique-instrumentale de compétence et d'expérience, ou par une légitimité

légale-conventionnelle de lois, réglements, conventions et précédents. Enfin, une fois défini l'ensemble des actions susceptibles d'être réalisées par l'organisation, l'axiologie de celle-ci définit l'ordre de priorité dans lequel elles seront entreprises.

De même, la coordination de l'action requiert l'existence d'un réseau de communication finalisée dans l'organisation. Ce réseau est constitué de la répétition, selon le même motif, d'événements de transmission d'information sur les actions à mener, comprenant chacun : (1) la décision par l'agent A, (2) la transmission à l'agent B des spécifications nécessaires à son action, (3) l'action par l'agent B et (4) le compte-rendu par l'agent B. Les liens du réseau sont constitués des événements répétés de transmission d'information finalisée, ou 'messages', alors que ses nœuds sont constitués des agents dans l'organisation. Pour qu'une organisation fonctionne, un tel réseau doit exister.

Le mécanisme d'Attraction, Sélection, Usure décrit qu'un groupe se constitue par agrégation progressive d'une façon prévisible : (1) les personnes extérieures sont attirées par un groupe correspondant à leur personnalité; (2) elles sont sélectionnées par l'organisation selon leur degré de conformité à ses attentes; (3) elles quittent l'organisation, dans un mécanisme d'usure, s'il se révèle, expérience faite, qu'elles ne correspondent pas. Ce mécanisme, mis en évidence par Schneider, aboutit à une grande homogénéité et une grande stabilité des organisations. Je fais l'hypothèse complémentaire que cette homogénéité croit à mesure de la montée dans la hiérarchie.

Je considère que ce processus d'Attraction, Sélection, Usure s'applique à la 'vision du monde' du groupe. En effet, si la 'vision du monde' d'un nouvel entrant ne correspond pas à celle du groupe, il sera à l'origine de conflits permanents et irrémédiables sur son programme de travail : sur la nature des objets à traiter, sur les actions admissibles et sur leur ordonnancement. Ce nouvel entrant non conforme sera ou bien rejeté dès la phase de sélection, ou progressivement amené à quitter l'organisation, volontairement ou non, en cas d'erreur. Réciproquement, ce qui est stable dans un groupe d'individus ainsi agrégés est leur 'vision du monde' commune, même en cas de remplacement démographique complet, puisque c'est sur cette 'vision du monde' que s'applique le mécanisme d'Attraction, Sélection, Usure.

Le réseau de communication finalisée demande de son coté un investissement d'apprentissage ; entre deux nœuds, pour stabiliser le protocole, et à l'échelle du réseau entier pour définir la topologie globale, dans un compromis permanent entre efficacité et polyvalence. En effet, la maintenance en état opérationnel d'un lien entre deux nœuds requiert

de mobiliser de la mémoire et de la capacité humaine de traitement de l'information, qui sont toutes deux limitées : il est illusoire d'imaginer maintenir, dans une organisation de taille même petite, un réseau universel de liens efficaces entre tous ses membres.

Ces investissements d'apprentissage sont des coûts irrécouvrables : une fois investis pour la constitution d'un lien, ils ne peuvent être redéployés pour un autre lien qu'au prix d'une reprise complète du coût d'établissement du premier lien. Ce caractère irrécouvrable des coûts stabilise le réseau de communication finalisée inscrit dans l'organisation.

Les 'visions du monde' et les réseaux de communication finalisée sont donc stables. Leur existence ne dépend que d'hypothèses minimales sur les organisations : elle est donc d'application très générale.

La 'vision du monde' est une composante de la culture d'une organisation : j'ai donc démontré l'existence d'au moins une partie de celle-ci.

Le fait qu'un réseau de communication finalisée ne puisse pas être universel entraîne qu'il est nécessairement spécialisé. Il est capable de traiter de façon plus efficace les informations qui à la fois : sont présentes dans l'ontologie des protocoles individuels existant sur chaque lien, sont incluses dans le contexte considéré comme évident et allant de soi de ces protocoles (et qui ne demande donc pas à être répété) et enfin suivent des trajets courts dans la topologie du réseau. Si nous considérons provisoirement qu'une compétence est une capacité à réaliser certaines actions mieux que d'autres actions, j'ai démontré que les compétences collectives d'une organisation existent. Elles correspondent aux actions, caractérisées ci-dessus, qui élicitent les circulations efficaces d'information dans le réseau de communication finalisée. Comme ce réseau sous-jacent à l'existence des compétences collectives est lui-même stable, j'ai également démontré la stabilité de ces compétences collectives.

E.3 Compétences collectives

Ce chapitre a pour objet de rappeler les définitions des compétences collectives existant dans la littérature, et de proposer celle que j'utiliserai dans ma thèse.

Les compétences collectives sont décrites dans les perspectives suivantes : (1) de Management Stratégique, à l'échelle de l'ensemble de l'organisation, (2) d'économie évolutionnaire, à l'échelle du département / de la division, (3) de gestion des Ressources Humaines, à l'échelle individuelle ou de l'équipe. Ma revue de littérature sur les modes de mesure de ces compétences (détaillée au E5) révèle que les compétences peuvent être utilisées pour hiérarchiser les organisations entre elles le long d'une dimension de performance, ou pour les classer dans des catégories de nature hétérogène.

Dans la pespective de Management Stratégique, l'objet est de déterminer les sources pérennes d'avantage concurrentiel. Penrose (1959) a été la première à décrire la firme comme une réunion de ressources productives, qui s'appliquent à un nombre réduit de couples produit-marché accessibles. Ces observations n'ont été reprises que beaucoup plus tard. Barney (1991) introduit l'idée que la source pérenne d'avantage concurrentiel est la détention par la firme de ressources "*de haute valeur, rares, imparfaitement imitables, et non substituables*". Prahalad et Hamel (1990) définissent la notion de "*compétences cœur de métier*", à la source de la compétitivité de la firme. Teece et Pisano (1994), puis Teece et al. (1997) ajoutent l'idée que ces compétences doivent être "*dynamiques*" pour s'adapter aux évolutions de marché. Une clarification de ces concepts est apportée par Winter (2003), qui distingue les compétences de "*niveau 0*" assurant la survie de la firme au jour le jour, de celles qui lui permettent de s'adapter, et qui sont les dérivées temporelles d'ordre supérieur. Helfat et al. (2007) réduisent l'ambition des compétences en les décrivant simplement comme la "*capacité à réaliser une tâche d'une façon acceptable*".

Dans la perspective d'économie évolutionnaire, les compétences sont des routines pour lesquelles les acteurs sont dotés d'intentionnalité : la capacité à réaliser l'intention prévue (Dosi et al., 2000).

En gestion des Ressources Humaines, la compétence individuelle est le fondement du recrutement et de l'évaluation (Tyson, 2006). Le Boterf (1994) a formalisé ce concept, dans un modèle systémique, comme la capacité à réaliser une action en situation. Il étend son concept aux équipes.

Lorsque la compétence est comprise comme l'atteinte d'un niveau de performance, elle peut être assimilée à la proximité à une "meilleure pratique" (Grimes et al., 2007; Stratman and Roth, 2002; Ritter et al., 2002; Tu et al., 2006), ce qui suppose que celles-ci soient éternelles. Elle peut aussi être mesurée comme la capacité à atteindre un objectif fixé, accessible à tous, à faible coût (Dutta et al., 1999; Dutta et al., 2005; Murthi et al., 1996; Narasimhan et al., 2006). Enfin, elle peut être considérée comme la capacité à atteindre un objectif donné, quel que soit le coût, avec l'hypothèse que cet objectif n'est pas accessible à tous (Hitt and Ireland, 1985; Escrig-Tena and Bou-Llusar, 2005; Durand, 1988).

La discipline de la mesure de performance d'entreprise (Kaplan and Norton, 1992) pourrait être utilisée pour mesurer les performances. Cependant, les données ainsi enregistrées sont souvent spécifiques à l'entreprise considérée, et confidentielles, ce qui en restreint l'usage.

La définition des compétences collectives que j'utilise dans ma thèse est la suivante. Les **compétences collectives** d'une organisation sont la conjonction :

- de la capacité de l'organisation, considérée comme un tout, d'**accomplir bien** un ensemble d'**actions**
- et du **contexte** dans lequel ces actions sont entreprises.

Une "action" est une transformation de matière ou d'information. Elle est définie par son état final, et par les conditions aux limites des moyens utilisables pour l'atteindre. "Accomplir bien" signifie ici : à un niveau de performance suffisant pour avoir historiquement assuré la survie de l'organisation jusqu'à l'instant présent.

E.4 Cultures collectives

La culture collective d'une organisation est un des concepts les plus difficiles à cerner de la gestion. Je tente dans ce chapitre d'en donner une typologie utilisable pour ma recherche. Je commence par rappeler les définitions existant dans la littérature, ainsi que les typologies les plus fréquentes. Je justifie pourquoi je me restreins aux 'visions du monde', puis expose la typologie des 'visions du monde' que j'ai développée à l'occasion de cette recherche. J'en déduis le modèle parcimonieux de description de celles-ci que j'utiliserai dans la partie empirique de ma recherche.

Les définitions existantes de la culture collective d'une organisation (Parker, 2000; Schein, 1991; Trompenaars, 1996; Hofstede, 1991) convergent vers une structure concentrique, comprenant des manifestations apparentes à l'extérieur et des valeurs et convictions au centre.

Les typologies des cultures collectives que j'ai identifiées sont les suivantes. Schein (1991) considère qu'une culture est l'ensemble des réponses apportées par une organisation à des questions d'adaptation externe (5 thèmes) et d'intégration interne (6 thèmes). Harrison (1972) présente une typologie de quatre "*idéologies*" d'organisation, orientées respectivement vers le pouvoir, le rôle, la tâche et la personne. Miles et al. (1978) proposent une typologie de quatre "*stratégies*", comprenant les Défenseurs, les Prospecteurs, les Analystes et les Réactifs. Quinn et Rohrbaugh (1983) ont un modèle de "*valeurs en compétition*" comrpenant deux dimensions, l'objet de l'attention (interne ou externe) et le degré de contrôle (ou au contraire de flexibilité). Ils aboutissent à une typologie à quatre modèles. Hofstede (1991) définit un jeu de 5 dimensions, obtenues par agrégation ("*clustering*") *ex post* de réponses à un questionnaire, pour caractériser des cultures nationales. De même, Trompenaars (1996) identifie 7 dimensions de description des cultures nationales, toujours par agrégation à partir d'un questionnaire. Markus et Kitayama (1991) comparent les cultures occidentale et orientale, en assimilant les premières aux États-Unis, et les secondes au Japon. Amable (2005) identifie 5 (ou 6) "*modèles de capitalisme*", à partir de l'agrégation de données statistiques obtenues pour les 21 pays de l'OCDE. Enfin, Keirsey (1978; 1989), s'inspirant assez librement du modèle jungien de personnalité sur lequel je reviendrai ci-dessous, identifie quatre "*tempéraments*" : les Gardiens, les Idéalistes, les Artisans et les Rationnels.

Du fait de la complexité de la notion de culture collective, je me restreindrai dans cette thèse aux 'visions du monde', telles que définies ci-dessus. En effet, je m'intéresse à l'action collective, et à la manière dont une culture influence celle-ci.

Je propose un modèle unifié des 'visions du monde', qui est à la fois équilibré, général, comprenant un nombre limité de catégories et logiquement clos. Je me fonde à cette fin sur la convergence de travaux indépendants en sociologie économique (Boltanski and Thévenot, 1991), psychologie analytique (Jung, 1991) et anthropologie historique (Todd, 1996).

Boltanski et Thévenot (1991), puis Boltanski et Chiapello (1999) ont identifié sept "*cités*" dans leur modèle des "*économies de la grandeur*": Inspirée, Domestique, de l'Opinion, Civique, du Marché, Industrielle et par Projets. Jung (1991) décrit un modèle de personnalité selon lequel tous les humains maîtrisent à des degrés divers 8 fonctions psychiques : deux fonctions de Perception (la Sensation et l'Intuition) et deux de Jugement (la Pensée et le Sentiment), chacune d'elles pouvant prendre deux formes, Introvertie ou Extravertie. Pour Todd (1996), les structures politiques et idéologiques en Europe sont façonnées par les modèles familiaux, définis à une échelle régionale, et organisés selon deux axes : (1) la soumission à l'autorité du père, ou la liberté face à celui-ci et (2) l'égalité ou l'inégalité entre frères, en particulier au moment de l'héritage. Les combinaisons de ces dimensions aboutissent aux modèles souche (autoritaire - inégalitaire), nucléaire absolu (libéral - indifférent à l'égalité), nucléaire égalitaire (libéral - égalitaire) et communautaire (autoritaire - égalitaire). Chacun de ces modèles familiaux a engendré, selon moi, une pensée et une pratique économique propre : respectivement l'École Historique allemande (Schmoller, 1893-1894), l'économie classique (Mill, 1871), le saint-simonisme (de Saint-Simon, 1841) et les pratiques des districts industriels (Becattini, 1987) ou du *guanxi* chinois (Luo, 1997).

La typologie que je propose des 'visions du monde' repose sur une homologie entre celles-ci et 'cités' : l'ontologie est définie par les objets jugés importants dans la 'cité', le périmètre d'action et l'axiologie par la poursuite du 'principe supérieur commun'.

Je définis quatre 'cités' collectives, susceptibles de fonder des ordres sociaux complets, car chacun(e) peut y trouver une place, et quatre 'cités' individuelles, susceptibles de soutenir des vocations individuelles ou des communautés sociales fermées.

Les quatre 'cités' collectives sont définies par le tableau suivant.

Nom révisé de la 'cité'	**Tradition**	**Liberté**	**Visionnaire**	**Communautaire**
Nom initial de la 'cité' (Boltanski and Thévenot, 2006; Boltanski and Chiapello, 2005)	Domestique	Marché	Industrielle, Civique	Renommée, par Projets
Fonction psychique (Jung, 1923)	Sensation Introvertie	Sensation Extravertie	Intuition Introvertie	Sentiment Extraverti
Modèle familial (Todd, 1996)	"Souche" = autoritaire, inégalitaire	"Nucleaire absolu" = libéral, non-égalitaire	"Nucleaire egalitaire" = libéral, egalitaire	"Communautaire" = autoritaire, egalitaire
Principe supérieur commun	Perpétuation et amélioration incrémentale du patrimoine accumulé par les générations	Liberté individuelle et bien-être matériel	Conception et construction de la justice universelle et de l'efficacité technique	Cohésion du groupe
Danger contre lequel se prémunir	Décadence et dissolution	Servitude	Arbitraire	Dispersion et discorde
Métrique objective de la 'grandeur'	Éducation, savoir-faire, expeéience, sagesse	Richesse monétaire	Succès aux concours, taille de l'organisation	Nombre et réputation des membres du réseau personnel
Contribution des 'grands' au 'principe supérieur commun'	Écrins pour la perpétuation d'un trésor fragile hérité du passé	Objectifs d'émulation et modèles menés par la "*main invisible*"	Efficacité et cohérence de la conception, Pertinence de l'anticipation	Pôle d'attraction autour duquel le groupe s'agrège
Figure classique de l'Économie	Générations d'artisans qualifiés (List, 1856)	*Homo Economicus* (Smith, 1776)	Entrepreneur Schumpeterien (1934)	District industriel (Becattini, 1987)
Monde de production industrielle (Salais and Storper, 1992)	Monde Marshallien	Monde Industriel	Monde de l'innovation	Monde du réseau
Secteurs industriels typiques	Métallurgie, Machine-outil, Agroalimentaire de tradition	Biens de consommation, Grande distribution, Trading, Immobilier, Finance	Aéronautique, Espace, Nucléaire, Défense	Haute diversité (mode, décoration)
Fonctions dans l'organisation	Fabrication, Production, Manufacturing, Comptabilité, Assurance Qualité	Ventes de court terme, Marketing opérationnel, Trading de biens indifférenciés	Développement de nouveaux produits, Planification stratégique, Investissement à long terme	Resources Humaines, Relations commerciales de long terme
Mode d'innovation	Incrémentale, dans la même organisation	De rupture, à la recherche d'opportunités, mobilisant du capital externe	Planifié, technocratique, soutenu par l'État, à grande échelle	Haute variété, colonisation du marché par essaimage
Désordre de personnalité (American Psychiatric	obsessionnel-compulsif	paranoaique	anxiété généralisée	histrionique

Association. Task Force on DSM-IV, 2000)				
Expression de désaccord (Hirschman, 1970)	Défection tardive, forte loyauté, prise de parole limitée	Défection précoce, absence de loyauté et de prise de parole	Prise de parole permanente, loyauté et défection limitées	Forte loyauté, absence de défection, prise de parole rare

Tableau E4.4.1: les quatre cités collectives, leurs relations aux modèles familiaux, aux fonctions psychiques et à d'autres phénomènes des sciences humaines et sociales

Les quatre 'cités' individuelles sont définies par le tableau suivant.

Nom révisé de la 'cité'	**Morale**	**Créative & Innovante**	**Commandement**	**Scientifique & Academique**
Fonction psychique (Jung, 1923)	Sentiment Introverti	Intuition Extravertie	Pensée Extravertie	Pensée Introvertie
Nom initial de la 'cité' (Boltanski and Thévenot, 1987)	Inspirée	Inspirée	(inexistant)	(inexistant)
Principe supérieur commun	Valeurs morales absolues, fins supérieures	Renouvellement permanent	Décisions appropriées et prises à temps	Vérité, Connaissance
Danger contre lequel se prémunir	Matérialisme	Répétition, routine, sclérose, sterilité	Indécision, désordre, procrastination	Ignorance et préjugés
Métrique objective de la 'grandeur'	(aucune)	(aucune)	Nombre de personnes / ressources et budget sous sa responsabilité	Nombre, qualité et durée des citations
Description synthétique des 'grands'	Références morales	Innovateurs, createurs, pionniers, *trend-setters*	Managers, leaders, officiers	Découvreurs, experts, érudits
Contribution des 'grands' au principe supérieur commun	Exemples moraux	Ouvrir la voie de la nouveauté	Organiser et prendre la responsabilité des décisions collectives	Création de connaissance
Communautés fermées constituées autour des valeurs de la 'cité'	Monastères	Milieux créatifs de la mode, de l'architecture, du design, de l'art contemporain	Forces armées	Monde académique

Tableau E4.4.2: les quatre 'cités' individuelles et leurs fonctions psychiques correspondantes

Ces 'cités' peuvent entrer en conflit à des échelles d'organisation distinctes : individu, équipe de travail, organisation, secteur industriel, région.

Je me servirai de cette typologie pour construire une description parcimonieuse des 'visions du monde'. À cette fin, je reprendrai le questionnaire développé par Bridges (2000) en me concentrant sur deux dimensions du modèle de personnalité : (1) le mode de perception des informations, qui distingue entre l'Intuition (notée N) et la Sensation (notée S) et (2) le comportement dans le monde extérieur, qui distingue entre le mode J, organisé et planificateur, considérant que le monde est stable, et le mode P, spontané et adaptable, considérant que le monde est changeant. Cet outil donne accès à la présence dans les organisations des fonctions psychiques correspondant aux 'cités' Créative et Innovante, Visionnaire, de la Liberté et de la Tradition, qui sont pertinentes pour décrire les mécanismes de l'innovation. De surcroît, j'emploierai les dimensions des modèles familiaux pour décrire ces 'visions du monde' selon une perspective plus directement liée à ceux-ci.

Partie 2 : Étude empirique

E.5 Méthodologie

Ma position épistémologique, qui fonde mes choix de méthode dans cette thèse, est la suivante, et elle est inspirée de Latour (1999). L'objet de l'activité scientifique est d'élaborer des représentations mentales des phénomènes, ou "modèles", qui permettent d'anticiper lesdits phénomènes. Ceux-ci sont de toute nature, tant qu'ils sont accessibles à l'observation humaine, naturelle ou assistée d'instruments, et quelle que soit la nature de ceux-ci. La nature des phénomènes méritant l'étude, et le degré de précision avec lequel l'observation et la prédiction requierent d'être réalisées sont l'objet d'un débat permanent, public et légitime, en particulier selon les besoins de transformation intentionnelle (typique de l'activité d'ingénieur) physique, informationnelle ou sociale, de la société.

Ces modèles n'ont pas de prétention à etre la "vérité" ou à représenter la nature "en soi" (Kant, 1934), ils sont simplement des représentations mentales générant des prédictions des phénomènes observables (et jugés socialement pertinents), que la société (et l'activité d'ingénieur) juge suffisamment fiables et précises. Leur validité est provisoire, jusqu'à ce que de nouveaux phénomènes, plus généraux ou plus précis, les contredisent et les remplacent (Kuhn, 1962).

J'ai mené antérieurement une revue systématique de littérature sur les outils de mesure des compétences collectives d'organisations (Zibell, 2007). Les conclusions de cette revue de littérature (reproduite en Annexe A de la présente thèse) sont que le domaine est émergent, avec un faible nombre d'articles, mais en augmentation forte au cours du temps, sur les deux dernières décennies. Le domaine est également fragmenté : il n'apparaît aucun consensus, ni sur la nature des variables à mesurer, ni sur la manière de le faire. J'ai retiré de cette revue de littérature un ensemble d'idées et de méthodes susceptibles d'être utilisées dans ma recherche.

Les éléments-clefs de ma méthodologie de recherche sont les suivants. J'utilise un **questionnaire** présentant des choix **fermés**, afin que les résultats soient reproductibles plus facilement. Mon unité d'observation est la **dyade** formée des deux organismes ayant travaillé sur un **même** projet coopératif de Recherche & Développement. Les questions portent sur :

- les compétences liées à l'innovation (techniques et de gestion) de l'organisation du répondant

- la 'vision du monde' présente dans l'organisation du répondant
- les compétences liées à l'innovation (techniques et de gestion) de l'organisation du partenaire
- les résultats du projet coopératif de R&D.

Cette méthode donne une vue **triangulée** (Deshpande et al., 1993) des compétences **perçues** par les répondants.

Mon cadre d'investigation empirique est un ensemble de **quatre pays européens**, chacun représentatif d'un type familial (Todd, 1996), car je prends l'hypothèse que le type familial d'une région influence la 'vision du monde' des acteurs qui y sont établis : Allemagne (famille "souche"), Royaume-Uni (famile "nucléaire absolue" et "souche"), France (famille "nucléaire égalitaire" et "souche") et Finlande (famille "communautaire"). Mon investigation porte sur un seul secteur industriel, celui de l'électronique et des équipements de télécommunications.

Dans une perspective de productivité dans l'exploitation des données, j'utilise un outil de **questionnaire en ligne**. J'ai choisi l'outil libre **LimeSurvey** (2009), pour des questions de coût, mais aussi de souplesse dans la logique d'enchaînement des questions, et de possibilité de mise en ligne de questionnaires multilingues.

Afin de préserver la confidentialité de l'identité des partenaires dans les projets coopératifs de R&D étudiés, je n'interroge initialement qu'une seule organisation, en lui confiant la responsabilité de répercuter le questionnaire vers son partenaire, sans m'en révéler l'identité. Je mobilise de nombreuses techniques pour limiter la rationalisation *a posteriori*, et le biais d'instrument commun. J'assure également que les réponses des deux partenaires à un même projet sont indépendantes. Enfin, mes questions sont conçues de façon à ce que le répondant puisse y répondre de tête, sans avoir besoin de consulter de sources de données précises : ceci a pour objet de rendre la réponse plus rapide et aisée.

Mon enquête porte sur des projets **achevés**, ou dont l'achèvement est suffisamment proche pour que les résultats soient anticipables avec fiabilité. Lorsque plusieurs organisations ont participé au même projet, le partenaire sélectionné est celui avec lequel le répondant initial avait eu la coopération la plus étroite. L'entité collective considérée lors des questions sur les compétences ou la 'vision du monde' est l'unité opérationnelle ("*business unit*") d'une firme ou le département de recherche d'un organisme public de R&D.

Les variables sur lesquelles porte mon questionnaire sont les suivantes, pour chaque **organisation** considérée :

- ses **compétences** de **gestion** de l'innovation : le Marketing Stratégique (d'acronyme *StratMkt*, subdivisé en 4 sous-domaines), la gestion des Opérations de R&D (*RDMgmt*, 14 sous-domaines), la gestion Juridique et de la Propriété Intellectuelle (*LegalIP*, 4 sous-domaines) et les compétences de Conception Système (*Syst*, 3 sous-domaines)
- ses **compétences scientifiques et techniques**, spécifiques du secteur industriel de l'électronique et des équipements de télécommunications : la Physique (*Phys*, 4 sous-domaines), la Conception Matérielle (*Hard*, 6 sous-domaines), la Conception Logicielle (*Soft*, 8 sous-domaines), les technologies de Fabrication (*Manuf*, 11 sous-domaines)
- sa **'vision du monde'**, selon le modèle parcimonieux décrit ci-dessus (E.4) comprenant deux dimensions du 'caractère' d'une organisation (Bridges, 2000) et celles des types familiaux (Todd, 1996)
- certaines de ses **caractéristiques structurelles stables**, inspirées de Teissier du Cros (1976), et qui forment des éléments de contexte de l'exercice des compétences : le caractère privé ou public de l'organisation, son nombre d'employés, la taille et la durée typique de ses projets de R&D, le degré de sécurité requis pour ses produits (qui détermine souvent les procédures d'Assurance Qualité nécessaires)
- sa situation **géographique**.

Pour chaque **projet coopératif** considéré, les variables investiguées par le questionnaire sont les suivantes :

- des **conditions initiales** : le niveau de risque anticipé *ex ante* sur le projet, le degré de subvention par des organismes publics, l'identité de l'organisation leader
- le degré auquel chacune des sources suivantes a **motivé** le choix en direction de ce partenaire plutôt qu'un autre : présence de compétences de gestion, présence de compétences techniques et scientifiques, compatibilité stratégique, proximité géographique, compatibilité culturelle, expérience antérieure réussie.
- les **résultats** du projet coopératif : en termes d'**apprentissage** (création ou transfert de connaissances, modification de compétences) et en termes **concrets** d'atteinte de

9 jalons de développement et en terme de respect du budget et des délais de développement.

J'ai de surcroît proposé de nombreux autres éléments de questionnaire, qui portaient sur les compétences plus internes de l'organisation (non susceptibles d'être observées par un tiers externe), le déroulement du projet, la démographie de l'organisme, d'autres caractéristiques structurelles (de marché et de technologie), ainsi que des considérations de relation avec la région. Ces éléments étaient proposés à titre optionnel, afin de maintenir la durée de réponse au questionaire dans des limites acceptables.

Je justifie dans un chapitre dédié les raisons qui m'ont amené à conserver ou à rejeter dans mon outil de recueil de données les résultats de la revue systématique de littérature effectuée antérieurement.

Ma méthode de collecte de données a consisté à recueillir les identités de chefs de projets à partir de bases de données publiques de projets coopératifs de R&D. Ces bases de données recensent les projets qui ont été soutenus par la puissance publique. J'ai recueilli 514 contacts. La démarche générale de collecte de données, élaborée après une phase pilote d'essais et erreurs, a consisté en les étapes suivantes :

- envoi d'un courrier postal au chef de projet, lui exposant la recherche et lui demandant son accord pour participer
- un appel téléphonique de suivi pour vérifier son accord et lui donner les critères de sélection du projet et du partenaire
- deux relances par courrier électronique, une par courrier postal et une par téléphone.

Cette procédure était répétée pour le partenaire. Je conservais la trace de l'avancement dans ce processus sur une base de données des contacts.

Mes méthodes d'exploitation numérique des résultats étaient les suivantes. J'ai utilisé un tableur en logiciel libre **OpenOffice** pour effectuer des pré-traitements numériques sur les résultats bruts sortis de l'outil de questionnaire en ligne LimeSurvey, et convertir les valeurs qualitatives en des valeurs numériques conventionnelles, et pour convertir les lieux géographiques en des pays et des coordonnées. J'ai ensuite utilisé l'outil d'exploitation statistique en logiciel libre **R** (2009) pour effectuer les traitements statistiques suivants :

- calcul de la "meilleure estimation" de la compétence d'un organisme, à partir des estimations données par les deux partenaires, de la distance entre les compétences des

deux partenaires, dans l'espace multidimensionnel des compétences et de la combinaison de compétences des deux partenaires, toujours dans ce même espace multidimensionnel

- validation du caractère unidimensionnel de l'agrégation de certaines variables, en utilisant le coefficient alpha de Cronbach (1951)
- agrégation des variables suffisamment unidimensionnelles pour l'etre
- calcul de la distance géographique entre partenaires, et de la distance cognitive entre les "meilleures estimations" des compétences des partenaires et entre leur 'visions du monde'
- modèles linéaires et Probit ordonnés de prédiction des variables de résultat du projet, lorsque celles-ci sont reliées à des causes **symétriques**, à l'échelle du projet tout entier : jalons de développement, création de connaissance, respect des délais
- modèles linéaires et Probit ordonnés de prédiction des variables de résultat du projet, lorsque celles-ci sont reliées à des causes **asymétriques**, à l'échelle d'une organisation partenaire seulement : amélioration de compétence de l'organisation, transfert unilatéral de connaissance vers cette organisation, respect du budget.

Les méthodes choisies pour le calcul de la "meilleure estimation" de la compétence entre les estimations données par les deux partenaires sont choisies pour minimiser la variance.

E.6 Résultats de l'étude empirique

Ce chapitre présente le résultat de la collecte de données, une description de l'échantillon, la justification de l'agrégation des variables. Il donne ensuite une définition des variables de contrôle communes, des variables potentiellement explicatives introduites par ma recherche, ainsi que des méthodes utilisées pour la construction des modèles prédictifs. Je présenterai ensuite le résultat de ces modèles de prédiction des résultats d'un projet coopératif de R&D, d'abord à l'échelle du projet, en considérant symétriquement les 2 partenaires, puis à l'échelle de l'organisation participante, en les considérant de façon asymétrique.

Les données ont été collectées de juin 2008 à décembre 2009 inclus, avec une phase pilote en 2008. J'ai obtenu 120 réponses complètes sur 514 contacts pris, soit un rendement de 23,3 %, ainsi que 86 réponses incomplètes (issues d'une seule organisation dans le projet). Sur les 240 participants aux réponses complètes, 97 proviennent d'Allemagne, 67 de France, 35 du Royaume-Uni, 24 de Finlande, 17 d'autres pays.

Les organisations sont bien réparties en taille, depuis la TPE jusqu'au grand groupe. Les tailles de projet sont plutôt petites, avec un nombre d'employés impliqués en général inférieur à 10. Leurs durées sont homogènes, très concentrées autour de 13 à 36 mois. Les projets sont de risque moyen à haut, et outre ceux-ci 5 % de risque faible et 15 % considérés comme exploratoires. Le taux soutien public est concentré entre 25 et 75 %.

Les réponses à la partie optionnelle du questionnaire sont trop peu nombreuses pour être exploitables.

La validation par le coefficient Alpha de Cronbach amène à ce que 3 des 4 variables décrivant la 'vision du monde' peuvent être agrégées, tout comme les jalons commerciaux de résultat de projet, que les compétences et les améliorations de compétences peuvent être agrégées au niveau du domaine. En revanche, la dimension d'égalité du modèle familial n'est pas suffisamment unidimensionnelle pour être agrégée, tout comme l'atteinte des jalons technique du projet, et les différentes natures de création ou de transfert de connaissances.

Les variables de contrôle, communes à tous les modèles prédictifs, sont les suivantes. Ces variables sont celles généralement prises en compte par la littérature existante :

- la distance géographique entre les établissements des partenaires (*DistGeo*)
- la différence de nationalité entre partenaires (*DistNation*)

- la différence de statut juridique entre partenaires, selon qu'ils sont de droit public ou prive (*DistLegalStatus*)
- la différence de taille entre les partenaires, mesurée par le nombre d'employés (*DistSize*)
- le degré de soutien financier par des organismes publics au budget du projet (*PublicSupport*)
- le degré de risque technique estimé ex ante pour le projet (*TechRisk*)
- le degré de compatibilité stratégique entre les partenaires, exprimé par combien cette considération a pesé dans le choix du partenaire (*MotivStrategicCompatible*).

Les variables potentiellement explicatives introduites par ma recherche sont séparées entre variables symétriques et asymétriques.

Les variables symétriques sont les suivantes :

- la distance cognitive entre les 'visions du monde' des deux partenaires, exprimée selon les 3 dimensions restantes (*DistSN* pour le mode de perception des informations, *DistJP* pour le comportement dans le monde extérieur, *DistLib* pour la dimension de liberté du modèle familial)
- la distance cognitive entre les caractéristiques structurelles des deux partenaires (2 variables, notées *DistProjSize* et *DistProjDuration*)
- la distance cognitive entre les compétences des deux partenaires (8 variables, notées *DistXXX*, avec XXX l'acronyme de la compétence)
- la combinaison de compétences des deux partenaires (8 variables, notées *CombXXX*, avec XXX l'acronyme de la compétence)
- deux conditions initiales du projet : le degré auquel une expérience préalable positive avec le partenaire a motivé pour le choisir (*MotivPrevExperience*) et le désaccord au sujet de qui mène le projet (*DisagLeader*).

La distance cognitive entre les compétences rend compte de phénonmènes décrits comme leur compatibilité ou leur complémentarité, où ce qui est jugé important est ce qui est différent entre les partenaires. La combinaison de compétences au contraire décrit leur recouvrement, où ce qui est important est ce qui est commun aux deux partenaires.

Les variables asymétriques sont les suivantes :

- le niveau de compétences de l'organisation considérée (8 variables, notées *XXX*, avec XXX l'acronyme de la compétence)
- le niveau de compétences du partenaire (8 variables, notées *PartXXX*, avec XXX l'acronyme de la compétence)
- le degré auquel l'existence d'une compétences technique ou de gestion a motivé pour sélectionner ce partenaire dans le projet (*MotivTechCompetence* et *MotivGeneralCompetence*).

Pour chaque variable décrivant un résultat de projet coopératif de R&D, trois modèles prédictifs ont été développés : (1) le modèle avec les variables de contrôle seulement, (2) le modèle avec toutes les variables de contrôle et les variables apportées par la recherche les plus significatives et (3) le modèle avec les seules variables les plus significatives, pour lesquelles la probabilité que le coefficient soit nul est inférieure à p=5 %.

Les tableaux suivants résument les résultats des modèles 3, où ne sont retenues que les variables les plus significatives, qu'elles soient de contrôle ou introduites par ma recherche.

Variables explicatives		**Résultats concrets : jalons de développement**				
		Publications Scientifiques	Brevets	Démonstrateurs de laboratoire, Maquettes	Prototypes Functionnels	Agrégation de 4 jalons commerciaux
Variables introduites par la recherche	DistSN		- *			
	DistJP			+ *		
	DistPhys				- *	- *
	CombStratMkt	- **				+ ***
	CombLegalIP		+ **			
	CombSyst				+ *	
	CombPhys	+ ***				
	CombHard		+ **			
	CombManuf				+ *	
Variables de contrôle	DistGeo					
	DistNation					
	DistSize					
	DistLegalStatus	+ *				
	PublicSupport					
	TechRisk					
	MotivStrategicCompatible					

Tableau E4.6.1: Résumé des modèles prédisant les résultats concrets à l'échelle du projet.
"+" signifie " *influence positive*", "-" signifie " *influence négative*"
Codes de niveaux de significativité : ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

Variables explicatives		**Création de connaissances**					**Respect des délais**
		Scientifiques	Techniques	Marketing	Impasse	Opportunités imprévues	
Variables introduites par la recherche	DistSN			+ *			
	DistJP						+ *
	DistTeamSize					- *	
	DistStratMkt						- *
	DistRDMgmt						+ *
	CombStratMkt	- *		+ *			
	CombPhys	+ **					
	CombHard		+ *				
	MotivPrevExperience					- **	
	DisagLeader			- *			
Variables de contrôle	DistGeo						
	DistNation						- *
	DistSize						
	DistLegalStatus						
	PublicSupport						
	TechRisk				+ **		
	MotivStrategic Compatible						

Tableau E4.6.2: Résumé des modèles prédisant la création de connaissances et le respect des délais, à l'échelle du projet.
"+" signifie " *influence positive*", "-" signifie " *influence négative*"
Codes de niveaux de significativité : ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

Variables explicatives		**Modification du niveau de compétence**							
		Marketing Stratégique	Gestion operationnelle de la R&D	Juridique & PI	Conception Système	Physique	Conception matérielle	Conception logicielle	Technologies de production
Variables introduites par la recherche	DistSN	- *		- **			- **		- **
	DistLib					+ *			
	Compétences du partenaire				+ *	+ **		+ **	
	Compétences de l'organisation considérée					+ **	+ **	+ **	+ **
	MotivPreviousExperience			- *					
	MotivGeneralCompetence	+ *		+ *					
Variables de contrôle	DistGeo								
	DistNation								
	DistSize								
	DistLegalStatus								
	PublicSupport					+ *		+ *	
	TechRisk								
	MotivStrategicCompatible								

Tableau E4.6.3: Résumé des modèles prédisant les modifications du niveau de compétence à l'échelle de l'organisation.
"+" signifie " *influence positive*", "-" signifie " *influence négative*"
Codes de niveaux de significativité : ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

Variables explicatives		**Transfert de connaissance**			**Respect du budget**
		Scientifiques	Techniques	Marketing	
Variables introduites par la recherche	Compétence du Partenaire : Marketing Stratégique	- **	+ **	+ ***	
	Compétence du Partenaire : Conception Système				- *
	Compétence du Partenaire : Physique	+ ***			
	Compétence de l'organisation considérée : Conception Système	+ *			
	Compétence de l'organisation considérée : Technologies de production			- *	
	MotivTechCompetence		+ ***		
Variables de contrôle	DistGeo				
	DistNation				
	DistSize				
	DistLegalStatus				
	PublicSupport				
	TechRisk		- *		
	MotivStrategicCompatible				

Tableau E4.6.4: Résumé des modèles prédisant les transferts de connaissance et le respect du budget, à l'échelle de l'organisation.
"+" signifie " *influence positive*", "-" signifie " *influence négative*"
Codes de niveaux de significativité : ***: p-value ≤ 1 ‰; **: p-value ≤ 1%; *: p-value ≤ 5%; °: p-value ≤ 10%

E.7 Interprétation des résultats

Ma recherche comprend deux types de résultats : (1) ceux contrdisant ou modifiant les résultats antérieurs de recherche présents dans la littérature et (2) ma contribution à la compréhension des résultats de projets coopératifs de R&D.

Je n'observe **aucune influence** significative de la **distance géographique**, sur aucun des résultats de projet coopératif de R&D. Ceci contredit de nombreux résultats d'économie géographique, en particulier liés aux "*clusters*". Il est possible que les résultats antérieurs observent, comme moi, une densité de coopération fortement décroissante avec la distance géographique. Cependant, interpréter cette observation comme une manifestation de la plus grande efficacité de la coopération à courte distance géographique est contredit par mes observations. Mon interprétation est que la prévalence de relations à courte distance géographique a une origine historique et économique plutôt que géographique : initialement, il est plus facile et moins coûteux (en déplacement et en coût de transaction) d'identifier un partenaire et de travailler avec lui à courte distance géographique. Une fois la relation établie et qu'elle est satisfaisante, il n'est pas de motivation à la changer.

Je n'observe **aucune influence** significative de la **différence de nationalité**, sur aucun des résultats de projet coopératif de R&D, à nouveau en contradiction avec la littérature antérieure qui tendrait à considérer que cette différence a un impact sur la communication entre les partenaires, verbale et non verbale. J'interprète mon résultat comme la conséquence que la différence de nationalité est corrélée avec des différences de 'vision du monde', et que ce sont ces dernières qui sont en définitive pertinentes : lorsque mises en compétition avec les variables de nationalité, les variables de 'vision du monde' sont significatives, alors que celle de nationalité ne l'est plus.

Je n'observe **aucune influence** significative de la **différence de statut juridique**, ni de **taille** des organisations, ni de **compatibilité stratégique**, ni du niveau de **soutien public**, sur aucun des résultats de projet coopératif de R&D. Le degré de **risque technique** estimé ex ante n'a également d'influence significative que sur la révélation d'impasses et sur le transfert de connaissances techniques.

Je n'observe également **aucune relation "en cloche"** entre **distance cognitive** sur des domaines techniques et résultats des projets coopératifs de R&D. Lorsque la distance cognitive intervient, elle a une influence linéaire négative, et ne présente aucune influence

d'un terme quadratique. Ce résultat tient même en restreignant les projets à ceux considérés comme "à fort niveau de risque" et "recherche exploratoire".

Je n'observe également **aucune complémentarité** entre les compétences des partenaires, c'est à dire aucune influence positive de la distance entre leurs compétences.

Ma contribution positive à la prédiction des résultats de projets coopératifs de R&D est décrite ci-après.

J'observe tout d'abord que la **mesure** que je réalise de la compétence d'une organisation à partir de la **perception croisée** de celle-ci et de son partenaire est un **prédicteur fiable** du résultat du projet de R&D réalisé en commun, avec une relation naturelle entre la compétence mesurée et le résultat de projet coopératif de R&D à laquelle cette compétence contribue. Ce résultat n'est pas tautologique : l'élément du questionnaire porte sur les compétences générales et permanentes des organisations considérées, et l'effet observé porte sur un projet particulier, à un instant précis. Nous avons donc une **confirmation expérimentale** de la **validité** de la **méthode de mesure des compétences collectives** que je propose.

D'autre part, la **combinaison des compétences** est un prédicteur du résultat du projet, et non la distance cognitive. Cela signifie que ce qui est commun aux deux partenaires est plus important que ce qui les différencie.

La combinaison de compétences en Physique a une influence favorable sur les **publications scientifiques**, ce qui se comprend car cette discipline est au fondement du secteur industriel considéré, l'électronique et les équipements de télécommunications. Dans le sens opposé, les compétences en Marketing Stratégique, orientées plutôt sur le court terme, ont une influence défavorable sur l'atteinte de ce jalon.

La combinaison de compétences en Conception Matérielle et dans le domaine Juridique et de Propriété Intellectuelle ont une influence favorable sur les **brevets**, ce qui se comprend également car la conception matérielle est plus facilement brevetable et est plus spécifique à cette industrie que la conception logicielle, et car les compétences juridiques et de PI sont directement mobilisées par le dépôt de brevets. La distance cognitive en termes de mode de perception des informations (*DistSN*) a une influence négative sur le dépôt de brevets, ce que j'interprète comme le résultat de conflits dans l'appréciation du potentiel futur de la technologie.

La distance cognitive selon la dimension du comportement dans le monde extérieur (*DistJP*) a une influence positive sur la réalisation de **Maquettes et Démonstrateurs de Laboratoire**. J'interprète ce résultat paradoxal comme le résultat d'une synergie entre le souci de tenue des délais et de prise de décision de la préférence "J" et celui d'explorer toutes les sources possibles d'information, nécessaire dans un processus d'innovation, de la préférence "P". Cette synergie s'applique tout particulièrement sur un jalon demandant une grande créativité, qui doit cependant être productive.

La combinaison de compétences en Conception Système et en Technologies de Fabrication ont une influence favorable sur la réalisation de **Prototypes fonctionnels**, ce qui se comprend parce que ces compétences sont mobilisées pour la réalisation d'objets satisfaisant des contraintes de performance, d'environnement et de fabrication industrielle. Réciproquement, la distance cognitive en Physique a une influence négative, ce que j'interprète comme un conflit de valeurs entre des préférences pour le court et le long terme, cette dernière préférence étant liée à des compétences plus fondamentales en Physique.

La combinaison de compétences en Marketing Stratégique a une influence favorable sur l'atteinte des **jalons commerciaux** (prototype industriel, production pilote, lancement commercial et production à pleine échelle, succès commercial, création de société en essaimage), ce qui se comprend bien car cette compétence est mobilisée dans les phases postérieures du projet d'innovation, qui sont proches du marché. L'influence négative de la distance cognitive en Physique s'interprète comme ci-dessus.

La prédiction des **modifications de compétences** à la suite du projet coopératif de R&D mettent en évidence les influences suivantes :

- une influence positive des compétences préexistantes dans l'organisation considérée dans le même domaine, pour les compétences scientifiques & techniques (Physique, Conception Matérielle, Conception Logicielle et Technologies de Fabrication). C'est un effet **sélectif** de **capacité absorptive** (Cohen and Levinthal, 1990)
- un effet négatif de la distance cognitive selon la dimension de mode de perception des informations (*DistSN*) pour les compétences **concrètes**, difficiles à formaliser et demandant un apprentissage long et expérientiel (Marketing Stratégique, gestion Juridique & PI, Conception Matérielle et Technologies de Fabrication). Ces compétences sont en effet corrélées avec une préférence pour la fonction psychique de Sensation Introvertie, correspondant à la combinaison de la Sensation sur la dimension

de 'mode de perception des informations', et de la préférence pour le "J" sur la dimension de 'comportement dans le monde extérieur'. Lorsque les partenaires sont distincts selon la dimension de 'mode de perception des informations', l'échange de connaissances et de compétences de l'un vers l'autre est difficile pour ces compétences très expérientielles et concrètes, et ne peut être compensé par une formalisation de celles-ci

- un effet positif de la compétence du partenaire pour les compétences **formalisables** et abstraites (Conception Système, Physique, Conception Logicielle), qui sont exactement complémentaires de l'ensemble de compétences traité précédemment, ce qui traduit un effet **sélectif** d'**enseignement** du partenaire vers l'organisation considérée
- un effet positif du degré de soutien financier par des organismes publics pour les compétences techniques formalisables (Physique et Conception Logicielle), que j'interprète comme le fait qu'un soutien financier est plus facile à obtenir et à justifier lorsque les résultats techniques du projet sont plus faciles à formaliser et à exposer
- un effet négatif d'une expérience antérieure pour la compétence Juridique et de PI, que j'interpréterais comme un effet de **saturation**. Lorsque deux organismes ont déjà coopéré ensemble, ils ont appris leurs habitudes respectives lors de cette première interaction, et le fait de recommencer avec le même partenaire n'améliore pas significativement cet aspect précis de leurs compétences.

La prédiction de la **création de connaissances** met en évidence que la combinaison de compétences en Physique a une influence positive sur la création de connaissances scientifiques, en Conception Matérielle sur celle de connaissances techniques, en Marketing Stratégique sur celle de connaissances marketing, ce qui s'interprète de façon très directe par la relation entre la compétence et la nature de la connaissance créée. Le degré de risque technique a une influence positive sur la mise en évidence d'impasses, ce qui s'interprète à nouveau aisément, et le fait d'avoir travaillé ensemble précédemment a une influence négative sur la découverte d'opportunités inattendues, ce qui manifeste à nouveau un effet de saturation des apports d'une première coopération.

L'effet négatif de la combinaison de compétences en Marketing Stratégique sur la création de connaissances scientifiques s'interprète à nouveau comme l'effet d'une contradiction entre préoccupations de court et de long terme. Le désaccord sur l'identité du meneur de projet a

une influence négative sur la création de connaissances marketing, ce que j'interprète comme le fait que ce désaccord n'a d'influence que lorsque les enjeux commerciaux deviennent élevés.

La prédiction de **transfert de connaissances** met en évidence que les compétences du partenaire en Physique ont une influence sur le transfert de connaissances scientifiques, et en Marketing Statégique sur le transfert de connaissances marketing, ce qui s'interprète comme ci-dessus par le lien entre nature des compétences présentes chez le partenaire et nature des connaissances transférées depuis ce dernier. La compétence de l'organisation considérée en Conception Système a une influence positive sur le transfert de connaissances scientifiques, ce que j'interprète à nouveau comme un effet de **capacité absorptive**, mais qui serait **générique**, donc d'un genre différent de celui décrit par Cohen et Levinthal. Le niveau de risque technique a une influence négative sur le transfert de connaissances techniques, ce que j'interpréterais comme le fait qu'une organisation en position d'apprentissage cherche à minimiser le risque technique sur le projet qu'elle entreprend dans cette perspective pédagogique.

La prédiction du **respect des délais** dans le projet coopératif de R&D met en évidence une influence positive de la combinaison de compétences en Gestion Opérationnelle de la R&D, et de la distance selon la dimension de 'comportement dans le monde extérieur' de la 'vision du monde'. Le premier résultat s'interprète de façon directe par le fait que la Gestion Opérationnelle de la R&D comprend des compétences de gestion de projet, et en particulier de gestion des délais. Le second, comme un effet synergique déjà observé ci-dessus. La distance cognitive en Marketing Stratégique a une influence négative sur la tenue des délais de développement, ce que j'interprète à nouveau comme un effet de conflit de priorités. Enfin, la différence de nationalité a une influence négative, ce qui s'explique par les difficultés de communication évoquées à ce sujet.

La prédiction du **respect du budget** dans le projet met en évidence une influence négative de la compétence en Conception Système du partenaire. J'interprète ce résultat en apparence paradoxal de la manière suivante. Lorsque le partenaire a une forte compétence en Conception Système, il est plus difficile de reporter sur lui les conséquences d'une mauvaise anticipation des coûts de développement, en jouant sur les spécifications d'interface ou de performance des modules respectifs.

Le degré de motivation pour avoir sélectionné le partenaire pour ses compétences techniques a un effet positif sur le transfert de connaissances techniques, alors que si c'est pour ses compétences en gestion, cela a un effet sur l'amélioration des compétences en Marketing Statégique et en gestion Juridique et de la PI. Ces résultats tendent à prouver que les organisations savent chercher les sources de compétence dont elles ont besoin pour répondre à leurs besoins.

Enfin, je ne suis pas parvenu à expliquer quelques-unes des relations statistiquement significatives entre variables explicatives et résultats de projets coopératifs de R&D.

E.8 Conclusion générale

La présente thèse apporte un certain nombre de contributions à la connaissance.

D'un point de vue théorique, elle suggère des raisons pour lesquelles la 'vision du monde' et le 'réseau de communication finalisé' d'une organisation sont des éléments stables de celle-ci. Elle propose également une définition simple et opératoire des compétences collectives des organisations. Enfin, elle propose une typologie unifiée des 'visions du monde', qui peut être utilisée pour d'autres disciplines des sciences humaines, sociales et de gestion, telles que le marketing des choix de consommation et des causes caritatives, les sciences politiques au sens de l'interprétation des comportements de vote, la gestion des Ressources Humaines et en particulier de la motivation, le Management Stratégique des Fusions & Acquisitions et l'Économie politique des États, Unions politiques d'États et des collectivités locales.

Les résultats empiriques de ma recherche sont les suivants. D'une part, ils valident le modèle des 'visions du monde', en assurant le caractère unidimenssionnel des éléments de questionnaire correspondants, et en démontrant que ce modèle est opératoire pour prédire le résultat de projets coopératifs de R&D, alors même qu'il est placé en concurrence avec d'autres sources potentielles d'explication. Je constate également que ce modèle des 'visions du monde' n'est pas perçu, même inconsciemment, des praticiens, et qu'il mérite donc d'être diffusé. D'autre part, ces résultats valident la méthode que j'ai développée de mesure des compétences collectives d'une organisation, par croisement des perceptions de cette compétence dans l'organisation et auprès de son partenaire.

De manière plus générale, la représentation d'un espace cognitif fait de 'visions du monde' et de 'compétences collectives' (1) est fondé théoriquement, (2) peut être mesuré opérationnellement en utilisant le questionnaire que j'ai développé et (3) est validé empiriquement dans le cadre empirique spécifique de la prédiction des résultats de projets coopératifs de R&D.

Alors que la recherche fonctionne en général de façon cumulative, par amélioration marginale de résultats antérieure, la mienne est amenée à remettre en cause de nombreux résultats de l'économie géographique de la coopération inter-organismes. Ainsi, je montre que (1) l'histoire et l'économie, et non la géographie, sont à l'origine des zones de forte concentration de R&D (ou "*clusters*"), (2) les 'visions du monde' et les compétences collectives, et non les institutions ou la nationalité, sont pertinentes pour décrire un espace

cognitif, (3) ce qui est commun entre partenaires est plus important que les différences entre eux, (4) la distance entre les 'visions du monde' détermine la compatibilité entre organismes, mais non celle entre compétences, et enfin (5) l'effet des distances cognitives sur les résultats de projets coopératifs de R&D est linéaire, et non "en cloche".

Mes recommandations pour les praticiens héritées de cette thèse proviennent d'abord de ce que les résultats d'un projet coopératifs de R&D ne forment pas une variable unidimensionnelle. Il convient donc, pour améliorer la performance d'un projet coopératif de R&D, d'identifier parmi tous les résultats possibles considérés ici, ceux qui sont prioritaires, afin de choisir alors le partenaire susceptible de contribuer au mieux à l'atteinte de cet objectif. D'autre part, ma recommandation aux organismes publics serait de reconsidérer avec attention leur politique de soutien explicite à la coopération à courte distance géographique, en direction des "*clusters*".

Les limitations de ma recherche sont les suivantes. D'une part, elle ne porte que sur un seul secteur industriel, celui de l'électronique et des équipements de télécommunications, dans un contexte culturel européen, et sur un échantillon de taille raisonnable, mais que l'on peut toujours souhaiter étendre. Ma recherche ne porte que sur les paires de partenaires, et ne comprend pas de variables de taille de projet, ni de durée de celui-ci, alors qu'elles se sont révélé dans la littérature avoir une influence (Saad, 1998). Dans la mesure où la réponse à mon questionnaire était pleinement volontaire, je n'ai pas pu contrôler d'éventuels biais de sélection dans les organismes qui répondent effectivement, ni dans leur choix des projets coopératifs de R&D.

La poursuite de la recherche entamée dans cette thèse pourrait prendre les directions suivantes. D'une part, elle pourrait surmonter les limitations exposées ci-avant, et aborder d'autres secteurs industriels, dans d'autres pays et contextes culturels, sur un échantillon plus large, inclure les variables manquantes et s'appuyer sur un organisme officiel afin de limiter les biais de sélection. Elle pourrait aussi chercher à expliquer les quelques relations restées inexpliquées.

Une recherche complémentaire pourrait explorer plus en détail les données brutes que j'ai rassemblées, en étudiant chacun des sous-domaines de compétence, en particulier dans la Gestion Opérationnelle de la R&D, pour laquelle aucune des variables explicatives ne s'est révélées significative.

La méthode que j'ai introduite de description de l'espace cognitif pourrait être étendue, et inclure des compétences collectives autres que celles nécessaires à l'innovation, ou améliorée, en particulier dans la mesure de la dimension d'Égalité des 'modèles familiaux'.

La stabilité des réseaux de communication finalisée pourrait être mesurée et validée, par exemple à partir de l'exploitation de données de communications électroniques, et celle des 'visions du monde' par l'étude empirique de systèmes de gestion.

La relation entre 'vision du monde' et les contextes géographiques, industriels et fonctionnels où j'anticipe qu'ils soient prévalents, mériterait d'être approfondie.

Le lien entre contexte géographique et nature de l'innovation, que j'ai à peine abordé dans cette thèse, pourrait être poursuivi, afin d'explorer plus avant les notions comme celle d'écoumène (Berque, 2000).

Enfin, cette recherche ouvre de nouvelles perspectives pour la recherche concernant l'**hétérogénéité** des acteurs économiques et industriels. Elle met en évidence les variables pertinentes de description de cette hétérogénéité, et de premières règles de leur évolution au cours du temps, lors de la constitution de relations coopératives de R&D. Cette recherche contribue ainsi à l'explication de la stabilisation de constellations semi-permanentes de R&D.

Enfin, cette thèse contribue plus généralement à l'entreprise ambitieuse d'une Économie fondée sur la **coopération** et la **différenciation** des acteurs, en complément du paradigme dominant de la compétition mimétique.