Journal of Management Studies 41:2 March 2004
0022-2380

A Capabilities Perspective on the Evolution of Firm Boundaries: A Comparative Case Example from the Portuguese Moulds Industry*

Joao Mota and Luis M. de Castro

Instituto Superior de Economia e Gestao, Lisbon; Faculdade de Economia, University of Porto

ABSTRACT The issue of vertical firm boundaries continues to attract interest both for economics and management research. The transaction cost economics approach, emphasizing transaction-specific assets and opportunism in order to explain discrete 'make-or-buy' decisions, dominates the literature. Nevertheless, alternative perspectives, developed under the guise of the capabilities, competence or knowledge-based theories of the firm, have gained attention recently. They focus on the evolutionary dynamics of boundaries in the context of the division of labour among firms in an industry and on what is to be divided and co-ordinated – i.e. productive knowledge. The conceptual links between this line of research, which some refer to as neo-Marshallian, and the Industrial Networks approach are explored in this paper. The paper emphasizes both a vision of firms as sets of direct and indirect capabilities, developed and combined in different ways over time, and the connectedness between inter-firm relationships. The discussion is illustrated with the cases of two firms, which are contrasted in terms of the dynamic evolution of their boundaries. The analysis made supports the argument that firms' vertical boundaries reflect their relationships with specific counterparts and the way they address through time the division and integration of knowledge through the configuration of direct and indirect, counterpart specific, capabilities.

INTRODUCTION

The issue of vertical firm boundaries continues to attract a great deal of interest from economics and management research. The transaction cost economics approach (Williamson, 1985), emphasizing transaction-specific assets and opportunism in order to explain discrete 'make-or-buy' decisions, dominates this literature. Nevertheless, alternative perspectives have gained attention recently. A

Address for reprints: Joao Mota, ISEG – Instituto Superior de Economia e Gestao, Universidade Técnica de Lisboa, Rua Miguel Lupi, 20, 1249-078 Lisbon, Portugal (joaomota@iseg.utl.pt).

common feature of these approaches is a focus on the evolutionary dynamics of boundaries in the context of the division of labour among firms in an industry and what is to be divided and co-ordinated – i.e. productive knowledge (Loasby, 1999; Piore, 1992). This alternative approach has been developed under the guise of the capabilities, competence or knowledge-based theories of the firm.[1]

All the various approaches reviewed in this paper share an emphasis on the coordination and evolution of productive knowledge. The second and third sections seek to provide a rich picture of the mechanisms that help explain the dynamics of firms' vertical boundaries, by exploring the links between the capabilities view of the firm and the Industrial Networks approach (Axelsson and Easton, 1992; Håkansson and Snehota, 1995) which emphasizes the role of connected inter-firm relationships in the creation, access to and co-ordination of capabilities.[2]

The second section introduces the approach of Langlois and Robertson (1995), which looks at how two co-ordination mechanisms co-exist in an industry: the firm and the market. The firm is seen as constituted by core capabilities, which are tacit and idiosyncratic, and ancillary capabilities, which are common to several firms and easily transferable. The option of 'making' versus 'buying' is discussed with respect to the costs to access other firms' capabilities when needed, i.e. emphasizing both the need and the timing for access. This approach can be contrasted with a perspective that regards the firm as a singular set of direct and indirect capabilities, embedded in a network of relationships and using relationships as a means to influence the development and distribution of capabilities in that network.

The third section abandons the rigid distinction between core and ancillary capabilities and instead emphasizes the interdependencies between direct and indirect capabilities. Each firm seeks to build an 'external organization', a Marshallian notion recovered by Loasby (1991), of indirect capabilities that complements its set of direct capabilities.[3] The industrial networks approach addresses the dynamics of industrial systems, based on the role of interfirm relationships as a co-ordination mechanism (Axelsson and Easton, 1992; Håkansson and Snehota, 1995). The existence of long-lasting and connected relationships between firms, developed through a cumulative process of interaction, suggests a certain degree of stability, and hence structure in industrial systems (Easton, 1992). The existence of connectedness between relationships not only supports Loasby's view of the non-additive effects of indirect capabilities, but also highlights the importance of analysing the trajectory of a firm, taking into account the role of relationships in shaping that trajectory.

The fourth section presents the empirical context of a study carried out on the industry of moulds for the injection of plastics, located in the district of *Marinha Grande* in Portugal. The manufacturing of moulds involves complex interdependencies between sequential activities, which in Richardson's (1972) terminology

can be termed closely complementary, for the design and manufacturing of what is usually a uniquely specified product.

The fifth section describes the cases of two firms, which are contrasted in terms of the dynamic evolution of their boundaries, i.e. the evolution of the ranges of activities that they undertake themselves and the external capabilities that they access. The two cases illustrate how the dynamic evolution of firms' boundaries is intimately related with incremental adjustments in a complex, interdependent system (Winter, 1993).

The sixth section draws the conclusions from our empirical study. Our analysis supports the need for a new perspective on the dynamics of co-ordination mechanisms. Our concern is to explain how two successful firms, with similar starting points, operating in the same industry and location, facing the same contingencies, working for similar and occasionally the same clients, and following parallel technological trajectories, could follow widely diverging paths in the definition of their boundaries. Our argument is that firms' vertical boundaries reflect their relationships with specific counterparts and the way they address the division and integration of knowledge through configurations of direct and indirect capabilities.

A DYNAMIC VIEW OF THE EVOLUTION OF FIRM BOUNDARIES

One of the consequences of focusing on capabilities in order to discuss the mechanisms for their co-ordination is that it becomes apparent that the relevant costs conducive to vertical integration '. . . may go beyond those that arise in the course of defending against opportunism' (Langlois, 1998, p. 195). For example, Barney (1999) lists several costs that can be relevant when managers consider the creation or acquisition of capabilities, and opportunism is hardly the only consideration. Path dependence, causal ambiguity and social complexity are some of the attributes of capabilities, which can have an important impact on boundary choices. On the other hand, as Kay (2000) argues, decisions on the 'make or buy' of components are often delegated to lower levels of the hierarchy, while decisions on which capabilities the firm needs to retain, develop or discard tend to be formulated at the higher levels and frame the 'make or buy' decisions for individual items.

Langlois and Robertson (1995, p. 30) point out that most theories of the boundaries of the firm are static, in the important sense of taking the circumstances of production as given and investigating comparatively the properties of different types of contractual arrangements to co-ordinate production. Static approaches do not allow an adequate appreciation of interrelationships among capabilities in the evolution of the boundaries of firms (Barney, 1999; Poppo and Zenger, 1998). The notion that boundary changes should be seen as involving a system of connections is highlighted by Winter (1993, p. 191):

> Firms perform their function as repositories of knowledge largely by virtue of the extension in time of the association of inputs, especially human service inputs, with the firm. At any particular point in time, *the network of transacting patterns already in place substantially influences the costs and benefits of adjustments in governance modes for particular modes of transactions*. Thus, the process of change in a firm's way of doing things most typically involves incremental adjustment in a complex, interdependent system. Such a process may well produce progress, but it does not produce 'an answer' to any well specified question or list of questions as to how activity should be organized. (emphasis added)

Recently, Helper et al. (2000) reviewed the patterns of boundary evolution in the automobile industry, revisiting the paradigmatic GM-Fisher Body case.[4] Their argument revolves around the notion of 'pragmatic mechanisms', involving co-operative activities between automakers and their suppliers in order to deter opportunism and foster learning. As they put it: 'Boundaries are often placed (or repositioned) so that those for whom intense, frequent discussion is most productive are on the same project, which may or may not mean within the same firm' (op. cit., p. 484).

For Langlois and Robertson (1995, p. 2) co-ordination is critical 'for strategic uses that require new, and not always readily evident, combinations of resources', explicitly recognizing the impact of learning on the evolution of firm boundaries. The dynamics of codification, diffusion and access to knowledge help explain the logic of evolution of an industrial sector in terms of the division of labour between firms and markets.

The processes of learning, codification and diffusion of capabilities take time. At any point in time, there may be lags between the external capabilities a firm requires and those that the market is able to supply. Given the inexistence of external capabilities, the firm may have to develop ancillary capabilities due to the presence of what Langlois and Robertson (1995) call dynamic transaction costs. These are defined as 'the costs of persuading, negotiating, co-ordinating and teaching outside suppliers', or alternatively 'the costs of not having the capabilities you need, when you need them' (Langlois and Robertson, 1995, p. 35).

In the short term, and in a context where learning and codification take time, a firm may face difficulties to access the capabilities it requires and be forced to integrate backwards or forwards. By contrast, in the long run as tacit knowledge is spread and becomes partly codified, it may be expected that a '. . . tendency arises towards the generalized spread of capabilities that both breaks down idiosyncrasy and reduces [dynamic] transaction costs' (Langlois and Robertson, 1995, p. 43). This does not mean that the firm's own capabilities have to diffuse: '. . . outsiders may in fact learn to produce the same results using entirely different kinds of capabilities' (Langlois, 1995, p. 82, fn 23).[5]

In short, buying may become more interesting than making, as the combined production and transactions costs for a given input may justify the outsourcing of particular activities.[6] Nevertheless, vertical disintegration may not be easy due to the inertia caused by internal routines, which may have developed in the meantime. If vertical integration happens, 'subsequent organizational learning would take place (at least initially) within the framework of the firm, which may well affect the long-run pattern of integration' (Langlois and Robertson, 1995, p. 29).[7] In general, it is to be expected that '. . . the options for change at any given point are constrained by the nature of the environment at that point. Whether there is continuity, merger, or disintegration is a function of the cost structure at that time, which in turn depends on the existing distribution of capabilities and the degree of efficiency of markets' (op. cit., p. 45). Langlois and Robertson also note that the general tendencies are not inevitable '. . . and the exact course of events necessarily varies from industry to industry, or even from firm to firm within an industry' (op. cit., p. 43).

Langlois and Robertson's (1995) framework seems both to overemphasize 'frictions' in the diffusion of tacit knowledge and to assume a one way movement from tacit to codified knowledge, a view that stands in contrast to Lundvall (1996) and Nonaka (1994) amongst others. Even if some tacit knowledge is codified, Malerba and Orsenigo (2000) suggest that changes in its nature and content can be expected. As a consequence, '. . . the comparison between tacit and codified knowledge in terms of ease of transmission might be profoundly misleading and sometimes unwarranted, because one is comparing two totally different things' (op. cit., p. 293).

An approach centred exclusively on 'make or buy' decisions may take the object of transaction/production as given, thereby ignoring the possibility that those decisions, due to complex interdependencies between activities, may have meaningful and unexpected consequences for the internal organization of firms and the network in which they are embedded (Dubois, 1998) and that resources controlled by different firms can be combined in order to decide *what* will be exchanged (Araujo et al., 1999). In situations of inherent uncertainty, as Knight (1921) defined it, knowing and fixing the 'problem' doesn't guarantee the generation of an optimal design of a product or a process (Nightingale, 1998, 2000). Problems or challenges may arise and ongoing relationships, within and/or between firms, can be important to cope with that possibility by creating what Nightingale calls appropriate contexts or spaces of similarity. This suggests that the dynamics of boundaries should be studied by focusing on the network of relationships already in place (cf. Winter, 1993, p. 191).

Even if Langlois and Robertson's proposal regarding the interaction between tacit and codified knowledge is accepted, a firm may be confronted not only with teaching or learning from others, but also with attempting to influence the trajectories of other firms. Ignoring relationships as a co-ordination mechanism excludes

their role as a means to use and influence, and not merely access, capabilities the firm does not control.

DIRECT AND INDIRECT CAPABILITIES AND INTER-FIRM RELATIONSHIPS

Richardson (1972) stressed the importance of relationships between firms, by arguing that planned co-ordination does not stop at the boundaries of the firm. Complementary activities must be co-ordinated. However, such activities do not have to be similar in terms of the knowledge, experiences and skills, i.e. capabilities, which underpin them. These capabilities develop through long and idiosyncratic learning processes, as Penrose (1959) so well illustrated.[8] Richardson contended that relationships between firms allow the co-ordination of closely complementary but dissimilar activities, being thus a co-ordination mechanism alternative to hierarchy (directed co-ordination) and market (spontaneous co-ordination). The co-ordination of these activities should not be left to firms because they are founded on dissimilar capabilities, nor should it be left to the market, because they require a match of the plans of firms, both qualitatively and quantitatively.[9]

Loasby (1998b) introduced a complementary dimension to the notion of capabilities, avoiding an undue emphasis on the distinction between tacit and codified knowledge. He resorted, like Richardson (1975), to Ryle's (1949) distinction between *knowing that* and *knowing how*. While *knowing that* refers knowledge about facts and relationships, *knowing how* '. . . is the ability to perform the appropriate actions to achieve a desired result. It includes skill both in performance and in recognizing when and where this skill should be applied' (Loasby, 1998b, p. 165). This *knowing how* can often (but not always) be codified, even when codification occurs without an understanding of the reason why some procedures work. In this context, the contrast between tacit and codified knowledge may become less relevant since: 'A productive opportunity may well depend on a conjunction between "knowing how" and "knowing that". Even though the knowledge may be public, the connection may not be, and the ability to make such connections may provide a distinctive capability' (Loasby, 1998b, p. 177).

Loasby refines further the notion of capabilities by resorting to the distinction, advanced by Nelson and Winter (1982) between *knowing how to do something* and *knowing how to get something done*'.[10] He concludes that '. . . capabilities are know-how, both direct and indirect; they represent the kinds of knowledge . . . which are crucial to the performance of a firm, an industry and an economy' (Loasby, 1998b, p. 165). The issue of a firm's access to external capabilities and the availability of external capabilities are central for the understanding of the evolution of firms' boundaries, as in Langlois and Robertson (1995). However the implications of Loasby's perspective for the firm's scope of activities are substantially wider.

Firms are viewed as sets of direct and indirect capabilities '. . . which have been derived from a particular pattern of experience and which are oriented towards a particular, if ill-defined, set of possibilities' (Loasby, 1998a, p. 152), and there may be important differences on the extension to which firms seek to develop and use their indirect capabilities (op. cit., p. 154). In the context of the structure of indirect capabilities of a firm (its 'external organization'), closely complementary but very dissimilar capabilities may lead to strong and complex interfirm relationships. Because they intend to sustain differences in knowledge associated to different activities, firms may be willing to support the costs of maintaining these relationships. The resulting costs are more than compensated by the benefits from developing new skills, methods and products (Zajac and Olsen, 1993). In other words, a relationship is recognized as an asset able to generate a variety of resources, even in situations of high 'relational specificity' (Madhok, 1996; Madhok and Tallman, 1998).

It follows that the existence of diverse trajectories in an industry, in terms of the extension of firms boundaries, results not so much from the distribution of capabilities in an industry, but rather from the diversity of structures of indirect capabilities that allow access to other firms' capabilities. The issue, however, goes beyond the mere access and associated costs to existing capabilities. Firms can, more or less deliberately, affect the development of capabilities and the division of labour in an industry, by seeking to teach other firms and by influencing their development paths. For example, Lorenzoni and Lipparini (1999), in analysing the vertical disintegration processes on three Italian firms, illustrated how 'relational capabilities' may have a strategic dimension in supporting knowledge access and transfer, which accompanied changes on division of labour between firms. In this context the boundary between *inside* and *outside* becomes much fuzzier than Langlois and Robertson (1995) seem to assume in their framework.

Another implication of this perspective is that inter-firm relationships may have an important role in maintaining and developing the diversity of capabilities in the industry by avoiding hierarchical control and by stimulating specialization. As Loasby suggests, in a context where each firm has the need to access capabilities it does not control, derived from a particular pattern of experience, 'some of those capabilities may be destroyed by the attempt to control them' (Loasby, 1998b, p. 175). The advantages of maintaining diversity in capabilities should include variety within each *specialism* resulting from the presence of rival firms, since '. . . substantial diversity may be a major capability for the industry as a whole, widening the range of activities which can be undertaken and increasing the possibilities of improving some relevant kinds of knowledge' (op. cit., p. 175).

Loasby (1991, p. 41) notes, with regard to the structure of indirect capabilities, that 'such capital, of course, does not appear in the balance sheet . . . and it certainly is not suitable for aggregation'. This perspective is shared by the industrial network approach (Axelsson and Easton, 1992; Håkansson and Snehota, 1995),

namely through the notion of relationship connectedness. As each relationship exists in the context of other relationships, developments in any one relationship can affect and be affected by development(s) in other(s). The establishment, development and maintenance of a relationship always involves two parties, diverse in their capabilities and interests and it occurs in the context of other relationships with which it may be connected, both via the focal actor and its counterpart (Håkansson and Snehota, 1995). Connectedness among relationships suggests the interdependency between direct and indirect capabilities and the need for each firm to deal with specific counterparts and with the effects deriving from diversity at that level. It is also recognized that this incomplete system of interconnected relationships (Potts, 2000), develops and draws on particular mutual 'absorptive capabilities' (Cohen and Levinthal, 1990). In other words, the evolution of boundaries involves gradual changes in particular configurations of specific connections, which affect (and are affected by) the development and distribution of capabilities.[11]

In this context, the evolution of firms' vertical boundaries is understood to result less from the distribution of capabilities in the industry and rather more from their own structures of indirect capabilities, which allows them to access other firms' capabilities. Also, the issue goes beyond mere accesses to existing capabilities and associated costs, because indirect capabilities may also open possibilities to foster the learning of specific counterparts and, by influencing their development paths, to affect the development of their capabilities and the division of labour in the industry.

The notion of capabilities can thus be given a prominent role in the study of the division of labour in an industry and of how different specialisms can be integrated, particularly in what concerns the evolution of firms' boundaries. This implies the need to focus on the role of relationships in the creation, access to and co-ordination of capabilities. The following two sections of this paper complement this theoretical discussion with empirical observations. The fourth section provides an overview of the Portuguese moulds industry, emphasizing the complex interdependencies between activities to design and produce, often unique, artefacts. The fifth section presents two contrasting cases, which illustrate how the evolution of firms' boundaries should be seen in the context of direct and indirect capabilities, which tend to be counterpart specific, and their co-evolution over time.

THE PORTUGUESE MOULDS INDUSTRY

The Portuguese industry of moulds for the injection of plastics is a fertile ground to explore the notion of capabilities and their role on the evolution of firm boundaries. In this section, we will provide an overview of the complex interdependencies among several actors involved in the design and manufacturing of moulds for plastic injection.

The industry of moulds in Portugal originated in the 1940s, closely associated to the relationship between a small number of American buyers and *Aníbal H. Abrantes* (AHA), a small firm located in the town of Marinha Grande. This firm eventually became known worldwide as a reputable mould producer. In the following decades, AHA spawned a host of new firms, as technicians and engineers left to create their own enterprises. These new firms became, in turn, the sources of yet more firms through further spin-offs. Currently the industry includes 250 small and medium sized firms, employing a total of 7500 people. The industry is located in two geographical areas: Marinha Grande (MG) in central and Oliveira de Azemeis (OA) in northern Portugal. About 90 per cent of the industry's production is exported to customers in a variety of end-user industries and concentrated in the EU, USA and Canada. As a consequence Portugal has been for a number of years, one of the top ten world exporters of moulds for plastic injection.

Each mould is usually unique, or rather a unique combination of standard components (e.g. heating and cooling systems, injectors, etc.) and non-standard components (e.g. moulding surfaces). The uniqueness of each mould, even when the desired outcome has been clearly defined, contributes to the widely shared notion that the conception and the manufacturing of any mould is a challenge. This challenge includes the possibility of problems arising during the activities of manufacturing and testing of the moulds, with negative consequences for the relationships with customers. As one of our interviewees put it:

> Problems can always arise in the production of a mould and an activity [e.g. machining or grinding] which is planned for 20 hours may take up to 40 hours. Timely control of the evolution of the work is crucial to ensure credibility and delivery times – that is, to be up to the trust that the customer has placed on you when he awarded you the order.

Moulds can take several months to build and are diverse in complexity, size, tolerances, inter-changeability, throughput, etc. They are coupled to plastic injection equipment in order to produce plastic components, which are also varied in terms of number, technical characteristics, size, context of use, etc. The components produced using a mould can later be assembled with other components, either by the customer who ordered the mould or by other firms further downstream.

Figure 1 gives a schematic representation of the manufacturing process. This usually starts with a first contact with a customer where the characteristics and material composition of the component are specified, as well as the types of steels to be used for the mould, the characteristics of injection equipment to be used and the delivery date. The supplier will suggest a technical solution including drawings, a delivery date and a price. The parties usually negotiate these along with alternative solutions for different moulds that can be used to produce the intended

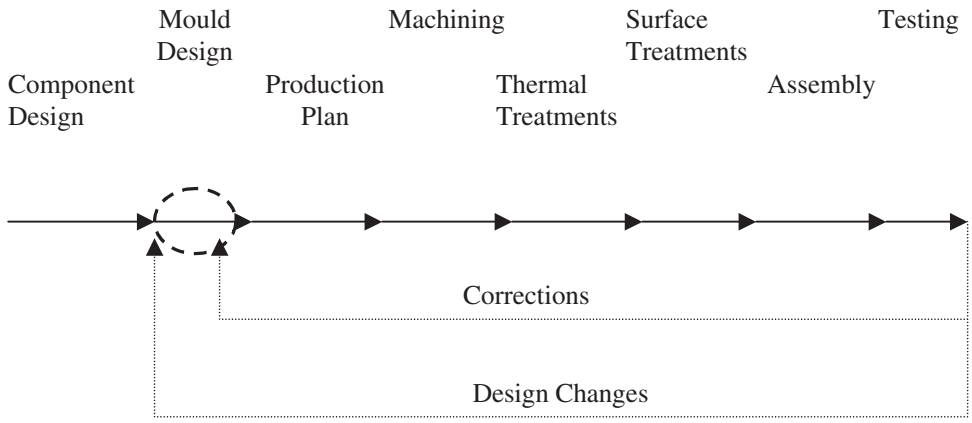

Figure 1. Mould industry – closely complementary activities

components. At the project stage, several downstream aspects have to be considered. For example, the machining processes that will be used depend on the characteristics of the types of steel chosen. After the blocks of steel with adequate dimensions for the specific mould are purchased, machining operations start, followed by thermal treatments. Thermal treatments may cause distortions and thus grinding operations follow. Next, there is the finishing of the moulding surfaces, according to the characteristics of the plastic components that the customer wishes to produce.

The mould is then assembled and a first assessment is made of the quality of the finished mould. Finally, the mould is tested on injection equipment, bearing in mind the characteristics of the customer's equipment and context of use in order to fine-tune the mould's working parameters.

Injection testing will find out whether the mould can produce components with the characteristics and at the pace intended by the customer. This usually gives rise to a further sequence of correction and tuning processes. Often, injected materials or some mould components do not behave as expected, which requires further corrections/operations, such as further machining and grinding. Besides, customers may ask for alterations, in which case some components will have to be redesigned and the mould has to go back to the production stage. This may happen immediately after the customer gets samples of the components he intends to produce, be it for aesthetic or functional reasons, or after a certain length of time when the mould has been used to produce components which can be tested in real operating conditions. Both corrections and alterations of moulds can impact on the flow of internal activities of a mould producer.

The co-ordination of such closely complementary activities may become more complex for several reasons. One of these may be the occurrence of orders involving several moulds. These may be related to each other in several ways, as much

as the final components are. Another source of complexity is orders involving a multiplicity of firms, i.e. various producers and one customer. This situation may arise due to the customer or to one of the producers outsourcing activities such as designing or machining to other firms or other actors such as the local technology centre.

TWO CONTRASTING CASES FROM THE PORTUGUESE MOULDS INDUSTRY

The focal firms studied, *Tecmolde* (TEC) and *Iberomoldes* (IB), and the analysis of their cases, can be seen as a structured focused comparison (Bennett, 1997), since this comparison is based on theoretical relevance in terms of the evolution of firms' boundaries and their empirical context, during a given period. The contrast between the two cases will allow us to illustrate the dynamics in the evolution of firms' boundaries by focusing on the development of and access to capabilities. The same selective theoretical focus guided the analysis for both cases. The data were obtained as part of a larger industry study, which involved several firms and other institutional actors connected to the industry (e.g. industry technology centre). Primary data were obtained through semi-structured interviews which are deemed particularly useful when '. . . highly sensitive and subtle matters need to be covered, and where long and detailed responses are required to understand the matters the respondent is reporting on' (Ackroyd and Hughes, 1992, p. 104). Three to four interviews were conducted in each firm, which were recorded and subsequently transcribed and analysed.

TEC and IB started their activities in 1968 and 1975 respectively, as engineering and marketing firms. They assured both commercial and technical intermediation between customers and manufacturers. They assessed and translated their customers' requirements into mould designs that were passed on to manufacturers. They had a similar origin, spun off from related progenitors, in the same location at roughly the same time. Still, they developed along distinctly different trajectories, regarding the definition of their boundaries and the ways they adopted to organize production, despite facing the same context, addressing the same international markets and using the same technology.

TEC is still an engineering and marketing firm. It currently employs about 40 people and it subcontracts manufacturing to about 60 local firms, mostly full-cycle manufacturers (i.e. they assure all activities connected to the production of moulds). TEC also subcontracts most mould designs (i.e. detailed drawings) to some ten local small specialist firms, which it actively promoted at the beginning of the 1990s. In contrast, IB started integrating manufacturing activities one year after it was created. Currently it is one of the largest world producers of moulds, employing nearly 600 people. Although IB and TEC see each other as rivals, their managers have a healthy respect for each other's contribution to the development

of the industry. Both firms are perceived in the industry as success cases. Interestingly, they turned over the same volume of business, roughly 25 million Euros in 1997. They also partly overlap in terms of products they have made for similar customers operating in the same industries. Over time, both firms have assured the design and manufacturing of a wide range of moulds, both in terms of sizes, technical complexity and tolerance, for a long list of customers including household names such as Alcatel, Nokia, BMW, Volvo, Compaq, IBM, Hasbro and Samsonite. Diversity stems not only from the variety of industries where customers operate, but also from the different operating ways of those customers.

One important source of variety has to do with the development of the components to be produced using the moulds. In some cases the component is produced in a linear sequence. In other cases it is developed through successive approximations to the final solution, sometimes involving radical changes to the design of the mould in the process. Another source of variety concerns the openness of customers to the participation of TEC and IB in product development, where mould producers can help with the design of the product, rapid prototyping, concurrent engineering, etc. Access to previous experience in coping with similar problems is particularly valued, especially because corrections and changes in moulds can have a range of serious implications both for the firms concerned and for other firms via connected relationships. These implications are compounded whenever there is interdependency between several final components or moulds projects.

Further sources of variety are different routines or standards in terms of delivery deadlines, for example. Shorter deadlines may result from customers' intentions to shorten the time between the development, production and market launch of new products. Orders may also show a variety of volume and frequency, ease of communication between parties, interrelationship of their activities with those of their own customers, etc.

TEC: Subcontracting Relationships

TEC was created in 1968 by a former project head of *Calazans Duarte* (CD), one of the earlier firms in Marinha Grande, itself spun-off from AHA. The firm was created after an episode with an English customer who in 1962 asked the founder of TEC to monitor the production of several moulds he had ordered from a variety of local subcontractors. This customer faced quality and delivery problems. This episode and the knowledge acquired on the strengths and limitations of local firms, were instrumental for the development of TEC's knowledge about the potential for intermediation activities. TEC had to promote changes in the working procedures of subcontractors and the firm was able to stick to this approach as the number of its customers grew. TEC involved a large number of local subcontractors in the production process of moulds for its customers. Often,

TEC approached these subcontractors immediately after they were created. New firms were often set up by technicians specializing in a variety of activities from mould design to assembly, who left established firms to create their own. Currently, TEC resorts to about 70 local manufacturers to whom it sub-contracts the orders it receives from a wide range of customers. Its current portfolio numbers 35 customers who are diverse in most respects, but similar in the volume of moulds they order.

These orders cannot be accommodated by one only firm, unless it is as large as IB, or it has like TEC, a deep understanding of the capabilities of local subcontractors and the ability to subcontract orders with minimum risk. Some customers are very demanding in terms of delivery times, quality, price and relationship practices. Others are equally demanding in aspects, such as the special attention to the contexts where the moulds will operate. This was the case with a number of Russian customers, an early export market success for TEC. The relationships with Russian customers required significant adaptations in terms of the solutions adopted for the moulds and the communication procedures between the parties involved. In this situation, as in many others, TEC's adaptation spread to local subcontractors.

The setting and development of relationships with a diversity of customers went hand in hand with a setting and development of relationships with a variety of local subcontractors. TEC's viability and survival is critically dependent on its continuing access to local manufacturers and on the nurturing of its own capabilities to access external capabilities. It must be stressed that TEC's decision not to acquire production facilities is seen by its managers to be an essential factor of the favourable perception of TEC's strategies for allocating orders to subcontractors.[12] In some cases, TEC places orders according to its perception of the fit between the required capabilities to fulfil that order and the capabilities and interests it perceives on the part of a subcontractor. For example, access to *Somoltec* (SOM), one of the local subcontractors, has been possible through placing orders congruent with SOM's interest in reducing variety in its portfolio of relationships and the range of moulds it produces.[13]

In other cases, it may be necessary to foster the development of subcontractor capabilities to produce certain types of moulds. For example, TEC could only accept orders from Tupperware after it could ensure that six local subcontractors developed the required capabilities, given the tight specifications of the components required by Tupperware. In general, orders include several moulds that must be allocated to subcontractors. Thus it may be necessary to ensure that the performances of those subcontractors are broadly equivalent and that their practices can be standardized to some extent, as all the moulds for a given customer must meet similar quality standards.

One of the relevant criteria is the level of priority that the subcontractor accords to TEC, assessed from an analysis of the subcontractor's behaviour over time

regarding quoted prices, delivery times, promptness in responding to queries and past performance. Another criterion is the degree of TEC's involvement with the subcontractors regarding the match between orders and the subcontractor's capabilities and TEC's intentions regarding the development of the relationship with that subcontractor. TEC avoids confronting a subcontractor with an excessive variety of moulds and too many orders from the same customer. It also seeks to limit its own participation on the subcontractor's order book.[14] Needless to say, it is not always possible to fulfil all these criteria.

The attempt to limit the subcontractor's involvement with the same customer or with TEC itself has to do with the possibility that unexpected events may jeopardize an order and, more important, the notion that the subcontractor will benefit from having some variety of customer relationships in its portfolio. In fact, TEC acts not only as an allocator of orders but also as an allocator of downstream relationships. According to its Managing Director, the development of TEC's own capabilities in mould design and the development of the capabilities of its subcontractors (i.e. variety within each specialism), both benefit from the indirect learning processes that result from the relationships of its subcontractors with other customers and from the diffusion of knowledge throughout the network of relationships where TEC is embedded. The Managing Director of TEC stressed that it would be undesirable to try to substitute this capital by the integration of manufacturing activities.

IB: A Strategy of Vertical Integration

IB was created in 1975, seven years after TEC, by two former directors of AHA, one from the marketing and the other from the project area. The political turmoil that followed the 'carnation revolution' of 1974 in Portugal, resulted in a dramatic fall in the orders placed by export customers, especially American firms, to several local producers. IB's founders took this as an opportunity to set up a firm to do the marketing and technical intermediation between customers and manufacturers.

However, as in TEC's case, IB's leaders faced severe gaps between the capabilities that they regarded as needed to fulfil customers' orders and the capabilities available in the manufacturing infrastructure they intended do access. And they found it impossible to access (or compete for access to) other local manufacturers who possessed the capabilities IB required. They had to make do with manufacturers who did not possess them. Thus, one of IB's founders and subsequently IB engineers got actively involved with their subcontractors' production activities. This meant inducing them to adopt new working practices, to acquire specific capital equipment whose operation demanded the development of new capabilities, and to introduce procedural changes deemed necessary for the fulfilment of the delivery dates and quality levels required. This positioning of IB as a con-

tractor and technical mediator was unexpectedly successful, and resulted in a growing order book. At this stage, IB imagined that its commercial and technical intermediation would become more difficult over time. It would require increasing efforts in co-ordinating the production of moulds in several subcontractors simultaneously. Also, they found increasing difficulties in persuading subcontractors to develop appropriate capabilities in a number of fields, namely in the use of electro-erosion machining equipment. The adoption of such equipment would allow the exploration of new alternative approaches to the generation of solutions in the activities of mould design and production, in the improvement of the quality of some components and in the reduction of delivery times.

In 1976, IB started a process of creating specialized firms for specific production activities and soon afterwards, it started acquiring local firms. At the same time, it made an enormous in-house training effort, especially in the aftermath of one of those acquisitions. They also produced technical standards, administrative procedures and undertook other efforts essential for the speedy training of technicians from scratch and for easing communication and co-ordination inside the newly created group of firms. In other words, they gradually developed a system of internal coordination and an administrative framework (Penrose, 1959).

Currently, the IB group of companies has about 40 customers, operating in several industries and placing very diverse demands on IB. The diversity found within IB's portfolio of relationships has been mostly internally absorbed. Some of the companies, previously specialized in activities such as grinding and machining, gradually became specialized in specific types of moulds largely according to mould dimensions. The group seldom resorts to sub-contracting and when this happens, access to firms that IB considers as having the capabilities needed is not always easy.[15] Subcontractors apparently do not value the fact that a major manufacturer like IB resorts to them only for occasional subcontracting. The managers of those firms seem to value regularity of orders, the prospect of stable relationships and the possibility of developing particular direct capabilities, benefits that they do not perceive as forthcoming from interacting with IB.[16]

In the recent past, the firm has faced orders in excess of its capacity. This is seen to result from the development of relationships with traditional, long-standing customers. Parallel efforts to reduce the number and diversity of customers freed resources for investment on relationships with some preferred customers, which contributed to the unexpectedly large increase in the number and volume of orders. Efforts to deepen relationships included: (1) attempts to use concurrent engineering and (2) the participation of IB's technicians in component design. Both developments require a close articulation of activities and resources from the parties involved. The automobile industry deserves a special mention because in this case, components are mostly developed by trial and error. This means that after moulds are designed and produced the resulting components are tested, sometimes in real operating conditions. As a consequence, components can

be substantially altered requiring new manufacturing operations usually at short notice. This could have dramatic consequences on orders in progress for other customers. The industry in general, and IB in particular, have been considering simulation and fast prototyping technologies in order to pre-empt potential problems resulting from the design of those components or from the design of moulds.

ANALYSIS OF THE CASES

Both cases represent two distinct ways of dealing with the design and manufacture of moulds, despite both firms operating in the same broad market and industrial context.[17] The analysis of the cases suggests that there is no universal rule regarding vertical integration or disintegration if we cease to look exclusively at asset specificity and opportunism and decide to pay attention to how capabilities develop within interdependent systems where connections and sequences of action matter (Kay, 1997, 2000; Winter, 1993).[18] IB's trajectory of integration of production activities was initially driven by the inadequate distribution of capabilities found in the manufacturers it could access and the difficulties it had in influencing and co-ordinating the development of such capabilities. Throughout its development process IB progressively complemented the development of its technical intermediation capabilities with the development of its in-house mould fabrication capabilities. Before the late 1990s IB does not seem to have fully appreciated the consequences of the latter for its access to subcontracting from other local manufacturers. Then, after a relatively long period of near self-sufficiency, IB found that its internal capacity was not enough for the increase induced in the volume of orders it gained. It also found that those manufacturers perceived as having the adequate capabilities to accommodate its excess orders, were not receptive to them.[19] It seemed extremely difficult to revert to the approach that the company followed in 1975. To some extent, this is additional evidence to support the notion that the remaking of a network of direct and indirect capabilities once extinct, 'may be a formidable challenge' (Loasby, 1998b, p. 180).

Complementarity in the development of direct and indirect capabilities in TEC's case is substantially different from that of IB's. TEC's suppliers' capabilities developed in parallel to those of TEC itself. TEC always could access and influence their diversity mostly through the relationships it established, maintained and developed piecemeal. TEC remained an engineering and marketing firm. It has assumed mainly a technical intermediation role crucially dependent on *knowing who* are the subcontractors who possess the required capabilities to fulfil a given order and how to address gaps between required and existing capabilities. Keeping its activity strictly in the areas of engineering and marketing may have been helpful for TEC not to be seen as a direct competitor to local producers. But crucially, TEC's consistent strategy, and its willingness to address the restrictions this strategy imposed, seems to have sustained the development of an impressive set of

capabilities amongst its subcontractors. The development of fruitful relationships with local manufacturers might have been harder to achieve, had TEC's approach been inconsistent or less transparent.

As Loasby (1998a) suggests, important differences are to be expected in the mix between direct and indirect capabilities in a population of firms. Access to external capabilities is not instantaneous and the activities requiring coordination involve tighter or looser interdependencies between directly related firms (and sometimes with indirectly related parties too). The notion of indirect capabilities requires, in this context at least, the knowledge of who can provide what, timely and as specified.

Furthermore, these capabilities are not a mere set of routines developed in order to access an undifferentiated population of other firms. We have shown that indirect capabilities include knowledge of specific counterparts, their idiosyncrasies as well as the potential and limitations of their capabilities. The capability to teach others how to do something and the capability to absorb new knowledge from others are also relevant aspects to understand the trajectory of firms, as the cases demonstrate. Our findings show that indirect capabilities tend to be specific to each firm and developed over time, and thus to reflect the capabilities of the parties and their interdependencies with other firms. The question is thus not merely to access an existing pool of well-understood capabilities through subcontracting, when the need arises.

The cases also show that there is often a need to assess and influence the development of capabilities of specific counterparts, and that the appreciation of the possibilities for action therein is intimately related to a particular configuration of capabilities or system of connections. Thus, maintaining long-lasting relationships may have as much to do with stability as with change, namely how parties exploit and adapt their capabilities through interactions in the context of each relationship. For example, given the characteristics of a project and its relationship with a customer, TEC may opt to promote interaction amongst specialists from the customer and subcontractor sides, to allow the confrontation of different knowledge bases, deemed essential to ensure the production of components timely and according to specification.

At another level, we found that the strategies of the focal firms had both deliberate and unintended effects in the stock of existing capabilities available in the industry. This becomes particularly evident if the trajectories of both firms are seen as reflecting different approaches to the control of, and access to capabilities. As far as demand heterogeneity is concerned, we have shown that both firms may involve others in absorbing this heterogeneity, with relationships being a privileged mechanism to access and/or influence the capabilities of such firms.

IB's case illustrates a preference for internal absorption of heterogeneity, both through internal growth and increasing specialization of the companies that make up IB's group. In contrast, TEC opted to develop its role as a contractor and rela-

tionship broker with other local actors, as an alternative means to deal with heterogeneity. This shows the possibility both to learn from and through others, and to give counterparts the opportunity to access the cumulative knowledge that TEC has developed for dealing with problems specific to each component, order or customer. Thus, relationships allow, over a period of time, access to and the diffusion of a diversity of experiences obtained by a variety of actors in the context of the relationships they have with third parties – Nooteboom (1992) called this a 'cross-firm economy of learning'. The connectedness and spill over of knowledge across a variety of inter-firm linkages can lead to an inter-firm ecology of learning, where learning takes a network and distributed character. If relationships have a number of connections, these connections enable a variety of learning opportunities – e.g. between people with varying skills and backgrounds (Håkansson et al., 1999).

The trajectories of the two focal firms show that the sets of relationships they conduct help to integrate and access a variety of external capabilities, to transfer and to combine knowledge from different sources, to keep the diversity of the relationships portfolio in check and to increase external participation in design activities. In other words, the trajectory of each firm not only reflects its relationships with specific counterparts, but also its options on how to deal with heterogeneity in their customer portfolio. This perspective has implications for the potential of diversity that a firm can access in an industrial sector. The creation of new knowledge in an industrial sector depends not only on the number of firms in that sector, but also on the existing forms of interaction among them and the connectedness of interfirm relationships.

CONCLUSIONS

This paper approached the evolution of firm's boundaries by adopting the perspective that what is to be divided and co-ordinated is productive knowledge, and by appealing to the notion of counterpart-specific indirect capabilities. We argued that the existence of distinct trajectories in terms of the evolution of firms' vertical boundaries is due less to the distribution of capabilities in an industry that can be universally accessed, and more to the structure of indirect capabilities which allows access to external capabilities. Direct and indirect capabilities co-evolve and influence each other over time. However, the configuration of direct and indirect capabilities that each firm accumulates and develops is subject to inertia and path-dependence. This is also partially a consequence of the impact of the roles, capabilities and interests of specific counterparts on the trajectory of a firm.

The cases also illustrate how the boundaries of the firms are the product of an interaction amongst a range of factors, rather than discrete decisions based on comparison of the costs of 'making' versus 'buying'. In emphasizing both capability development and a view of the productive system in which connections matter, boundary choices cannot be aggregated as a series of discrete decisions.

The trajectories of both focal firms seem to have been marked by their differing choices on how to deal with the tensions resulting from mismatches between existing and desired future capabilities. For IB, vertical integration became a response to the difficulties of accessing external capabilities and coping with the heterogeneity of demand. In TEC's case, the ability to access external capabilities and a readiness to teach and develop the capabilities of specific subcontractors became institutionalized as a response to the heterogeneity of demand. IB's response to heterogeneity of demand led to a finer division of labour within its group of companies. TEC's response to the same challenge was to fine-tune the criteria according to which it selected and allocated orders to subcontractors. Both responses taken together suggest that firms may choose vertical boundaries not as a response to discrete transactions, but rather as part of the development of their capabilities both direct and indirect, for coping with specific classes of transactions.

Finally, the pattern of industrial development suggested by Langlois and Robertson (1995), in which large integrated firms give way to growing disintegration, may be more tortuous due to the interaction of structures of indirect capabilities. For example, TEC's relationships with a host of local manufacturers may have contributed, at least indirectly, to reduce the options for IB (the issue of access to SOM's capabilities illustrates this point). This suggests that Langlois and Robertson's sequence was reversed in this case. TEC's example, however, also led to the formation of new engineering and marketing firms, some of which have proved successful. Our study does not, of course, provide a sound basis to comment on the pattern of industrial development suggested by Langlois and Robertson (1995). However, it lends weight to the argument that time sequences matter and, as Loasby (1998b) suggests, reinforces the need for further research on the role of diversity for the generation of capabilities in a system of interconnected relationships.

NOTES

*A preliminary version of this paper was presented to the 16th IMP Conference, Interactions and Relationships, 7–9 September 2000, Bath, UK.

The authors wish to thank four anonymous referees for their constructive criticisms and very valuable suggestions, which were most helpful in improving this paper. Gratefully acknowledged are also the extensive and deep comments received from Dr Luis Araujo from the University of Lancaster (UK). The usual disclaimers apply in both cases.

[1] A more discriminating comparison of these perspectives is outside the scope of this paper. For a recent review of the capabilities view of the firm see Dosi et al. (2000). For an overview of knowledge-based theories of the firm see *Organization Science*, **7**, 5, 1996 and *Strategic Management Journal*, **17** (SISI), 1996 and **21**, 3, 2000.

[2] Foss (1999) classed these approaches under a neo-Marshallian umbrella. He argued that '. . . underlining the Marshallian vision and the network approach is a picture of 'the market' or 'the industry' as much more than a collection of self-sufficient firms. That is to say, the industry/the network is more than the sum of the capabilities of firms' (op. cit., p. 7).

[3] Direct capabilities are equated with *knowing how to do something* and indirect capabilities with knowing *how to get something done by others* (Loasby, 1998a).

[4] In this respect, see also *Journal of Law & Economics*, **43**, 1, 2000.

[5] It would be tempting to argue that for these authors changes in asset specificity are accompanied by changes in dynamic transaction costs. However, Langlois and Robertson (1995, p. 30) put it very clearly: 'The point is not that the effect of learning on transaction costs, let alone on the shape of organization, is obvious. Rather, the point is that one cannot have a complete theory of the boundaries of the firm without considering the process of learning in firms and markets'. Thus, a hold-up view, as an explanation for integration, 'is not necessary because, in the presence of uncertainty and a divergence of expectations about the future, arm's-length arrangements can be costly even without highly specific assets (op. cit., p. 36).

[6] Focusing the technical interdependencies, Sturgeon (2002) suggests that in the electronics industry the growing codification and standardization in linkages between stages in the value chain has supported the emergence of modular production networks, without excessive build-up of asset specificity and mutual dependence, that are distinct from relational networks which show high relational specificities.

[7] As Langlois (1995, p. 92) put it: 'The pattern of organization we observe at any time may depend not only on what firms knew in the past but on how they were organized in the past . . .'. He also notes that these two notions are obviously related: 'in many ways, knowledge *is* structure' (op. cit., p. 92, fn 42).

[8] Richardson (1972) replaced Penrose's (1959) notions of 'resources' and 'productive services' by 'capabilities' and 'activities'. By emphasizing the use and creation of new knowledge over time, Penrose (1959) argued that the productive resources controlled by the firm should not be seen as a fixed set of attributes, available as public knowledge, but as a bundle of possible services.

[9] Williamson (1991) also distinguishes between spontaneous and intended adaptations, when looking at hybrids. However, the similarity is more apparent than real, given the persistence of a variety of arrangements in terms of the degree of asset specificity (Sturgeon, 2002). In Williamson's framework they would be condemned to disappear 'because they combine inconsistent features' (op. cit., 1991, p. 271).

[10] A simple definition of capabilities is: 'To be capable of something is to have a generally reliable capacity to bring that thing about as a result of intended action' (Dosi et al., 2000, p. 2). Indirect capabilities, in turn, can be regarded as the capabilities required to organize access to complementary and dissimilar capabilities held by third parties. These may include, for example, the knowledge to specify and acquire inputs from the market, and to assimilate and use knowledge generated by third parties (Cohen and Levinthal, 1990), as well as knowledge needed for devising, testing and integrating inputs and systems (Granstrand et al., 1997).

[11] The rearrangement of the set of connections within a productive system is also central in Allyn Young's (1928) explanation of increasing returns, involving reconfigurations on firm's boundaries and propagation of quantitative and qualitative changes in the system. For other recent examples of taking connectedness seriously see Dyer and Singh (1998) and Powell (1998).

[12] The Managing Director of TEC put it this way: 'We do not give out a distorted idea of who we are. We do not have factories. The manufacturer knows that we deal well with this and knows that I need him. Sooner or later I have to go there.'

[13] SOM was founded in 1978 and in its early years it relied greatly on orders from intermediaries including TEC, IB and two others. Gradually it established direct relationships with a variety of final clients while foregoing intermediaries with the exception of TEC. More recently, it reduced the variety of its client portfolio and deepened its relationships with a restricted number of them. TEC is the only engineering and marketing firm amongst the set of remaining clients.

[14] 'To have 400 or 500 moulds done per year is not a problem [for us]. The manufacturers' availability is there but, for a question of, say, strategy, I do not like to have a manufacturer engaged in more than 25 per cent [of its capacity] with TEC . . . When we have all the orders a manufacturer gets, he is dependent, say, totally on TEC. That is bad . . .'

[15] 'At present we have a problem of capacity, precisely because of our greater closeness to clients, and a sharper perception of their needs. The problem is that we are rejecting orders because we do not have capacity to do them or to guarantee that more things can be made outside the group with quality.'

[16] SOM's case, previously referred as one of TEC's suppliers, can illustrate this situation. This firm has been favouring the design and manufacture of complex moulds of small and average dimension, only in the context of lasting relationships capable of assuring them a regular flow of orders.

[17] Our study was not designed to measure the comparative effectiveness of the alternative governance solutions provided by these two firms, at different points in time.
[18] Our study showed how diverse paths gradually increased the differences between both firms, which grew larger over time. We cannot elaborate on the relative endowment of capabilities of these two firms when they first initiated their activities.
[19] As mentioned in the third section, some manufacturers subcontract several activities among themselves. SOM, for example, regularly resorts to six local producers whose capabilities are 'at our level'.

REFERENCES

Ackroyd, S. and Hughes, J. (1992). *Data Collection in Context*. London: Longman.
Araujo, L., Dubois, A. and Gadde, L.-E. (1999). 'Managing interfaces with suppliers'. *Industrial Marketing Management*, **28**, 5, 497–506.
Axelsson, B. and Easton, G. (Eds) (1992). *Industrial Networks: A New View of Reality*. London: Routledge.
Barney, J. B. (1999). 'How a firm's capabilities affect boundary decisions'. *Sloan Management Review*, **40**, 3, 137–47.
Bennett, A. (1997). 'Research Design Tasks in Case Study Methods'. Paper presented at the Macarthur Foundation on Case Study Methods, Belfer Center for Science and International Affairs, Harvard University, October.
Cohen, W. and Levinthal, D. (1990). 'Absorptive capacity: a new perspective on learning and innovation'. *Administrative Science Quarterly*, **35**, 1, 128–52.
Dosi, G., Nelson, R. R. and Winter, S. G. (Eds) (2000). *The Nature and Dynamics of Organizational Capabilities*. Oxford: Oxford University Press.
Dubois, A. (1998). *Organising Industrial Activities Across Firm Boundaries*. London: Routledge.
Dyer, J. H. and Singh, H. (1998). 'The relational view: cooperative strategy and sources of interorganizational competitive advantage.' *Academy of Management Review*, **23**, 4, 660–79.
Easton, G. (1992). 'Industrial networks: a review'. In Axelsson, B. and Easton, G. (Eds), *Industrial Networks: A New View of Reality*. London: Routledge, 3–27.
Foss, N. (1999). 'Networks, capabilities, and competitive advantage', *Scandinavian Journal of Management*, **15**, 1, 1–15.
Granstrand, O., Patel, P. and Pavitt, K. (1997). 'Multi-technology corporations: why they have "distributed" rather than "distinctive core" competencies', *California Management Review*, **39**, 4, 8–27.
Håkansson, H. and Snehota, I. (1995). *Developing Relationships in Business Networks*. London: Routledge.
Håkansson, H., Havila, V. and Pedersen, A. C. (1999). 'Learning in networks'. *Industrial Marketing Management*, **28**, 5, 443–52.
Helper, S., MacDuffie, J. and Sabel, C. (2000). 'Pragmatic collaborations: advancing knowledge while controlling opportunism'. *Industrial and Corporate Change*, **9**, 3, 443–88.
Kay, N. (1997). *Pattern in Corporate Evolution*. Oxford: Oxford University Press.
Kay, N. (2000). 'The growth of firms'. In Foss, N. and Mahnke, V. (Eds), *Competence, Governance and Entrepreneurship*. Oxford: Oxford University Press, 187–206.
Knight, F. (1921). *Risk, Uncertainty and Profit*. Boston: Houghton Mifflin.
Langlois, R. (1995). 'Capabilities and coherence in firms and markets'. In Montgomery, C. A. (Ed.), *Resource-Based and Evolutionary Theories of the Firm: Towards a Synthesis*. Boston, MA: Kluwer, 71–100.
Langlois, R. (1998). 'Capabilities and the theory of the firm'. In Foss, N. and Loasby, B. (Eds), *Economic Organization, Capabilities and Co-ordination – Essays in Honour of G. B. Richardson*. London: Routledge, 183–202.
Langlois, R. and Robertson, P. (1995). *Firms, Markets and Economic Change – A Dynamic Theory of Business Institutions*. London: Routledge.
Loasby, B. J. (1991). *Equilibrium and Evolution: An Exploration of Connecting Principles in Economics*. Manchester: Manchester University Press.
Loasby, B. J. (1998a). 'The organization of capabilities'. *Journal of Economic Behaviour & Organization*, **35**, 2, 139–60.

Loasby, B. J. (1998b). 'The concept of capabilities'. In Foss, N. and Loasby, B. (Eds), *Economic Organization, Capabilities and Co-ordination – Essays in Honour of G. B. Richardson*. London: Routledge, 163–82.
Loasby, B. J. (1999). *Knowledge, Institutions and Evolution in Economics*. London, Routledge.
Lorenzoni, G. and Lipparini, A. (1999). 'The leveraging of interfirm relationships as a distinctive organizational capability: a longitudinal study'. *Strategic Management Journal*, **20**, 4, 317–38.
Lundvall, B. A. (1996). 'The Social Dimension of the Learning Economy'. Danish Research Unit for Industrial Dynamics, Working Paper no. 96–1.
Madhok, A. (1996). 'The organization of economic activity: transaction costs, firm capabilities, and the nature of governance'. *Organization Science*, **7**, 5, 577–90.
Madhok, A. and Tallman, S. (1998). 'Resources, transactions and rents: managing value through interfirm collaborative relationships'. *Organization Science*, **9**, 3, 326–39.
Malerba, F. and Orsenigo, L. (2000). 'Knowledge, innovative activities and industrial evolution'. *Industrial and Corporate Change*, **9**, 2, 289–314.
Nelson, R. and Winter, S. (1982). *An Evolutionary Theory of Economic Change*. Cambridge, MA: Harvard University Press.
Nightingale, P. (1998). 'A cognitive model of innovation'. *Research Policy*, **27**, 6, 689–709.
Nightingale, P. (2000). 'Economies of scale in experimentation: knowledge and technology in pharmaceutical R&D'. *Industrial and Corporate Change*, **9**, 2, 315–59.
Nonaka, I. (1994). 'A dynamic theory of organizational knowledge creation'. *Organization Science*, **5**, 1, 14–37.
Nooteboom, B. (1992). 'Towards a dynamic theory of transactions'. *Journal of Evolutionary Economics*, **6**, 4, 281–99.
Penrose, E. (1959). *The Theory of the Growth of the Firm*. Oxford: Basil Blackwell.
Piore, M. J. (1992). 'Fragments of a cognitive theory of technological change and organisational structure'. In Nohria, N. and Eccles, R. (Eds), *Networks and Organisations: Structure, Form and Action*. Boston, MA: Harvard Business School Press, 430–44.
Poppo, L. and Zenger, T. (1998). 'Testing alternative theories of the firm: transaction cost, knowledge-based, and measurement explanations for make-or-buy decisions in information services'. *Strategic Management Journal*, **19**, 9, 853–77.
Potts, J. (2000). *The New Evolutionary Microeconomics: Complexity, Competence and Adaptive Behaviour*. Cheltenham: Edward Elgar.
Powell, W. (1998). 'Learning from collaboration: knowledge and networks in the biotechnology and pharmaceutical industries'. *California Management Review*, **40**, 3, 228–40.
Richardson, G. (1972). 'The organization of industry'. *The Economic Journal*, **82**, September, 883–96.
Richardson, G. B. (1975). 'Adam Smith on competition and increasing returns'. In Skinner, A. and Wilson, T. (Eds), *Essays on Adam Smith*. Oxford: Clarendon Press, 350–60.
Ryle, G. (1949). *The Concept of Mind*. London: Hutchinson.
Sturgeon, T. (2002). 'Modular production networks: a new American model of industrial organization'. *Industrial and Corporate Change*, **11**, 3, 451–96.
Williamson, O. E. (1985). *The Economic Institutions of Capitalism: Firms, Markets and Relational Contracting*. New York: Free Press.
Williamson, O. E. (1991). 'Comparative economic organization: the analysis of discrete structural alternatives'. *Administrative Science Quarterly*, **36**, 2, 269–96.
Winter, S. (1993). 'On Coase, competence and the corporation'. In Williamson, O. and Winter, S. (Eds), *The Nature of the Firm. Origins, Evolution and Development*. New York: Oxford University Press, 179–95.
Young, A. (1928). 'Increasing returns and economic progress'. *Economic Journal*, **38**, 152, 527–42.
Zajac, E. and Olsen, C. (1993). 'From transaction cost to transaction value analysis: implications for the study of inter-organisational strategies'. *Journal of Management Studies*, **30**, 1, 131–45.