Inter-organizational learning for sustained competitiveness and ecological sustainability – the case of beta-testing activities of alternative-fuel, fuel cell-driven public transport buses

Summary:

This doctoral research paper focuses on the occurrence and functioning of groups of organizations, which need to collaborate on inter-related innovations for sustainable development (SD) and ecological sustainability (ES).

First of all, approaches to corporate environmental management (EM) and to societal experiments and projects for SD and ES are here conceptualized as taking shape in *clusters of innovation for sustainability* (CISs), as opposed to essentially framing these activities at the level of and from the perspective of the individual company.

Furthermore, the study integrates various theories and perspectives on *strategic networks* or *alliances* by means of the integrating and overarching theoretical perspectives of *inter-organizational* and *network learning*.

These theories and perspectives are applied to and extended for the specific implications of SD and ES by incorporating and combining the following kinds of – *radical* – innovations:

- *Socially shaped, disruptive, systemic* technological innovations.
- Socio-structural innovations in which different *communities-of-practice* need to collaborate.
- Learning innovations, including *higher-order learning* between the involved organizations.

A conceptual framework is derived and empirically applied to demonstration activities of alternative-fuel, fuel cell (FC)-driven public transport buses.

Key words: clusters of innovation for sustainability; radical innovations; inter-organizational learning; beta-testing; alternative fuel, fuel cell-driven buses.

Table of contents:

1. Introduction:

This doctoral research paper is titled *'Inter-organizational learning for sustained competitiveness and ecological sustainability – the case of beta-testing activities of alternative-fuel, fuel cell-driven public transport buses'*. [1]

This – partially exploratory, partially explanatory – research focuses on the occurrence and functioning of groups of organizations, which need to collaborate on inter-related innovations for sustainable development and ecological sustainability.

The research is characterized by a number of novelties.

First of all, approaches to corporate environmental management (EM) and to societal experiments and projects for SD and ES are here conceptualized as taking shape in *clusters of innovation for sustainability* [2], as opposed to essentially framing these activities at the level of and from the perspective of the individual company as core actor.

Furthermore, the study integrates various theories and perspectives on strategic networks or alliances by means of the integrating and overarching theoretical perspectives of *inter-organizational* and *network learning* [3]. [Oliver and Ebers (1998), 574-575, 576-577, 557; Knight (2002), 428].
This integration pertains to the inclusion of the following aspects: (inter-)organizational antecedents, network processes and mechanisms, network structure, and inter-organizational learning processes and outcomes. [Koza and Lewin (1998), 256; Knight (2002), 428]

In addition, these theories and perspectives are applied to and extended for the specific implications of SD and ES by incorporating and combining the following kinds of – radical – innovations:

- *Socially shaped, disruptive, systemic* technological innovations.
- Socio-structural innovations in which different *communities of practice* [Brown and Duguid (1991), 40] need to collaborate.
- Learning innovations, including *higher-order learning* [4] between the involved organizations.

---

[1] The study is carried out within a research project called *'Clusters of Innovation for Sustainability (CIS) in a Globalizing World'*. This is one of four research projects in the research programme *'Clusters of Innovation for Sustainability'*, which is financed by the Dutch Organization for Scientific Research (NWO).

[2] CISs consist of companies, but can also include governmental agencies, knowledge centres and NGOs. The term denotes a set of organizations, which are or need to become linked in their efforts to become radically more sustainable.
Such clusters are regarded as *windows of opportunity*, whose potential can only be realized if the inherent constraints [Oliver (2001), 470-471] and challenges associated to them, are appropriately dealt with.

[3] This type of inter-organizational change is distinguished from *(inter-)organizational adaptation*, which implies mere *accommodation* [Roome (2001a), 15-16] to external institutional pressures from stakeholders. [Fiol and Lyles (1985), 803]

[4] *High(er)-order learning* involves consciousness about, making explicit and recognition of the different mostly implicit *worldviews*, *mental frames*, *interpretative schemes* and points of departure that various actors adopt in their collaboration, decision-making and activities. This is necessary, because 'the individual actors, being part of and having an interest in *socio-technical regimes* (STRs) [Geels and Kemp (2000), 4],

From this theoretical basis, a conceptual research framework is developed, which frames the theoretical and empirical study of the following two *significant* [Yin (1994a), 26] research questions:

1. '*Which* strategic resources *(i.e.* knowledge*) and* capabilities *are important for multinational companies (MNCs) to source and acquire through their participation in* inter-organizational learning *in* societal function [5]*-defined CISs ?'*
2. *'Which factors and processes are important to support these processes of inter-organizational learning in the context of societal function-defined CISs ?'*
   '*What is the particular role of* network learning *in this respect ?'*

The paper is structured as follows.

In chapter 2, I give a sketch of the setting of the studied research issues. This setting consists of two fundamentally important evolutions in the present business context: the challenges and implications of ES, and specific processes of economic internationalization.

In chapter 3, I elaborate on the theoretical underpinnings of the research.
In section 3.1, I give a brief evolutionary overview of the theories that are relevant to study specific aspects of what are variously called *strategic alliances*, *networks* and *partnerships*, *(international) joint ventures*, *learning alliances* and *networks*, and – in the context of sustainability – *action-learning networks*.
The relation of this overview to the various focal issues in this study, then leads to the adoption of and argumentation for the integrating theoretical perspective of *inter-organizational learning* [6] (section 3.2.1). The concept of *network learning* is here also introduced, and is conceptualized as the processes and related factors, which can support processes of inter-organizational learning (section 3.2.2). These two sections end with respectively my first and second research question.
This build-up feeds into the development of a conceptual framework, which contains the focal processes and factors (i.e. variables) addressed in the research (section 3.2.3).
Section 3.3 sets out what my research objectives are in terms of theory development, methodological design, and their empirical application to demonstration activities of alternative-fuel, fuel cell-driven public transport buses.

Chapter 4 covers the research strategy, design and methodologies to be adopted in the operationalization of the study's research questions.

Chapter 5, section 5.1 gives a global overview of transportation and related energy systems. Section 5.2 covers recent developments in hydrogen-fuelled fuel cell-driven technologies for automotive applications. The paper ends with an introduction to a historical pilot case study, which covers the demonstration of alternative fuel, fuel-cell (FC) driven transit buses in regular service. These *beta-testing* activities were championed by the California Fuel Cell Partnership (CaFCP), Sacramento, CA, the USA, and took place in two phases (2001-2002 and 2002-2003).

---

may perceive the problems, issues and possible responses through their own *epistemological lenses* and *mental frames*'. [Roome (2001b), 71]
See also Argyris and Schön (1978); Senge (1990); Sureringa et al. (1992); Knight (2002).

[5] This concept refers to activities that fulfil basic and other needs in society.
In general, three types of functions can be recognized: *generic* (e.g. energy provision), *intermediary* (e.g. transport and mobility) and *end-use* (e.g. housing, nutrition). [Geels and Kemp (2000), 3]

[6] *Inter-organizational learning* is regarded as a key process in networks. [Knight (2002), 427]

2. The setting: two fundamentally important phenomena:

Presently, the business context is increasingly characterized by two highly important phenomena: challenges of ecological sustainability, and processes of *economic internationalization* [7].
I briefly elaborate on both in sections 2.1 and 2.2 respectively.
In figure 4 (section 3.2.3), I show – as a synthesis – the high degree of similarity in the implications of the two phenomena.

2.1. The challenges of ecological sustainability – the approach of **transitions** [8] *to tackle* **persistent** [9] *environmental problems:*

In my research, I choose to focus on and take as a starting point the ecological dimension of sustainable development and of sustainability.

Various authors have written about environmental problems and their nature. These are variously characterized as *meta-* [Chevalier and Cartwright (1966); Pasquero (1991)] or *wicked problems* [10] [Rittel and Webber (1973)] occurring in turbulent environments and in a state of *turbulence* [11]. [Emery and Trist (1965); Trist (1983); Gray (1989); Carley and Christie (2000a), 155-156] These last two authors claim that society needs to tackle not only the direct human impacts on the natural environment, but also the indirect negative ones. [Carley and Christie (2000a), 155]

Some scholars further specify this claim. Clarke and Roome (1995) (1999) and Weaver et al. (2000a) contend that the current 'inherently polluting systems of production and consumption' [Weaver et al. (2000a)] need to become radically transformed. Roome (2001a) calls for approaches that address these systems' cumulative impacts on eco-systems. [Roome (2001a)]

---

7 The geographic location of *core* corporate economic activities is characterized by increased integration across national borders, resulting in more intense global competition. [Howell and Hsu (2002), 44]

8 A *transition* can be defined from multiple perspectives:
- Major changes in how *societal functions* (SF) are fulfilled.
- The change from one to another *socio-technical regime* (STR) [Emery and Trist (1965); Geels and Kemp (2000), 4] in a changing environment.
- A set of *co-evolutions* in multiple spheres: technology, structure, institutions, behaviour, culture and intentions.

9 [Geels and Kemp (2000), 1]. The persistent environmental problems of resource depletion, the greenhouse effect and climate change, and air pollution, all come together in what can be termed the 'energy challenge' [Howell and Hsu (2002), 48; European Commission, High Level Group for Hydrogen and Fuel Cells (2003), 2].

10 These problems – also called *problem domains* [Trist (1983), 269] – exist as problem sets, which consist of interconnected issues. The interconnections and complexities that arise in the systems which contribute to problem sets, are one of their defining characteristics. [Roome (2001b), 70]
The obvious connections between persistent environmental problems related to transportation, and traffic congestion are an example of this.

11 *Turbulence* can be seen as 'the loss of a stable state', which is worsened by the independent actions of many unrelated organizations. Waves of interconnected – environmental, economic and socio-cultural – global change contribute to increased turbulence, if stake-holding actors pursue their own aims and interests 'without reference to common organizing principles or common sets of beliefs' [Roome (2000), 174]

The above contentions require societal actors and researchers to adopt fundamentally different perspectives to encompass the relationship between organizations and the natural environment. Such perspectives are variously called *holistic* [Carley and Christie (2000a), 157], *integrated* [12] [Carley and Christie (2000a), 159; Boons and Berends (2001), 115] and *systemic* [13] [Biemans (1992); Clarke and Roome (1995), 197; Hartman et al. (1999), 256].

Such perspectives lead researchers to perform *inter-disciplinary* [Carley and Christie (2000b), 180], *multi-actor* [Vergragt (1988); Hartman et al. (1999), 255; Roome (2001a), 4], *cross-sectoral* [14] [Clarke and Roome (1995), 195; Hartman et al. (1999), 255; Carley and Christie (2000b), 181-183] analyses of the mentioned problems and of their solution.

I refer to sections 3.2 and 3.2.2, where various useful concepts from organizational analysis as well as appropriate principles and mechanisms – which inform the application of these concepts – are respectively proposed. [Carley and Christie (2000a), 158]

2.2. Economic internationalization of R&D3 [15]*:*

The geographic location and organization of *core* corporate *economic activities* [16] are characterized by increased integration across national borders, resulting in more intense global competition. [Howell and Hsu (2002), 43-44]

Quite recently, such internationalization [17] is particularly being observed in and around MNCs' activities in – technological – innovation, in R&D, and in related testing and demonstration activities. This evolution is believed to signal the rising importance of technological knowledge in conducting business. [Archibugi and Iammarino (2002), 317-318]

von Zedtwitz and Gassmann (2002) distinguish two different locational drivers of the internationalization of R&D3 [von Zedtwitz and Gassmann (2002), 569]:

- Access to – local – science and technologies [Florida (1997), 85-86].
- Access to – existing – markets.

---

12 Because of the nature of this type of environmental problems, 'issue orientedness' by societal actors is insufficient to appropriately address these.
The authors therefore propose an integrated perspective on issues, and cross-cutting networks as appropriate organizational forms. [Carley and Christie (2000a), 160-162]

13 This is an implication of turbulence.

14 This means that actors from private, public, academic and civil sectors of society are actively included in the analysis and in the actual change processes when and where needed, following the *law of requisite variety* [Carley and Christie (2000a), 157; Boons and Berends (2001), 117].
This law says that the complexity of – i.e. contextual and societal – problems need to be matched in problem resolution by the formation and functioning of equally complex organizational structures. [Carley and Christie (2000a), 157]

15 *R&D3* stands for Research and Development, Deployment and Demonstration. It refers to strategies, which recognize the importance of combining 'technology push' with 'demand pull' mechanisms to promote the diffusion of emerging technologies. [Barreto et al. (2003), 269]

16 R&D3, production, distribution, marketing and sales can all constitute *core economic activities* of companies. Ohmae (1987) calls these activities the *business chain*. [Ruigrok and van Tulder (1995), 133]

17 Not *globalization*, as this phenomenon is essentially limited to the three 'Triad' regions: i.e. Europe, North America and Japan. [von Zedtwitz and Gassmann (2002), 570]

Furthermore, this particular type of increased internationalization sees companies entering collaborations with partners, as opposed to looking for a majority control in targeted companies. Corporate strategic objectives – such as sustained competitiveness and value of the firm – motivate the growth of collaborative initiatives such as *strategic alliances* [Buckley et al. (2002), 113-114]. As these are observed to cross national borders [Buckley et al. (2002), 114], this development in turn is seen as further evidence of internationalization. [George (1995), 131-132; Narula and Hagedoorn (1999), 283-284]
Technological intensity [18] – i.e. of products and in industrial sectors – hereby greatly bears on the incidence of such alliance formation. [George (1995), 131]

Possible aims of participating companies to form alliances are predominantly to [Niosi (1999), 108-110]:

- Access new complimentary technologies, and complimentary knowledge.
- Give shape to learning processes, through which MNCs 'increase their stock of knowledge in foreign markets'. [19]
- Create new and improved products and processes in partnership with competitors, suppliers and clients [20], thereby accelerating the rate of – technological – innovation.
- Reduce risks and uncertainty for all partners.
- Finance costly R&D projects, while maintaining or even increasing the company's flexibility; reduce R&D costs [Howell and Hsu (2002), 45].
- Gain economies of scale in R&D.

In another literature review and survey on the subject of R&D internationalization, Edler et al. (2002) come up with the following main results, which synthezise the above propositions [Edler et al. (2002), 160-163]:

- R&D and technology are becoming cornerstones of corporate and business strategies.
- The internationalization of R&D is playing an important role in strategies of large companies – i.e. mainly MNCs.
- There is a growing tendency for MNCs to acquire technology from external sources.

[18] In *high-tech(nology)* products and industrial sectors.

[19] As a general conclusion, Niosi states that learning is a key element in (the development of) internationalization of R&D3. In the process, the most advanced MNCs are now trying to tap externally developed science and technology.
His findings thus seem to provide some evidence that learning also occurs in the case of sought 'access to science' [cf. von Zedtwitz and Gassmann (2002)].

[20] To this end, MNCs form or enter international technology alliances, as shown by empirical findings.
In the context of this research, this brings up the question to what extent MNCs participate in partnerships which increasingly also include corporate and non-corporate actors with knowledge outside the focal organization's existing *repertoire* [DiMaggio and Powell (1991); Oliver (1991); Clarke and Roome (1999), 297; Roome (2001b), 72].

3. Inter-organizational and network learning for sustained competitiveness [21] and ecological sustainability:

In this chapter, I elaborate on the theoretical underpinnings of the research.

In section 3.1, I give a brief evolutionary overview of the theories that are relevant to study specific aspects of what are variously called *strategic alliances*, *networks* and *partnerships* [22], *(international) joint ventures* [23], *learning alliances* and *networks* [24], and – in the context of sustainability – *action-learning networks* [25].
The relation of this overview to the various research issues in this study, then leads to the adoption of and argumentation for the integrating theoretical perspective of *inter-organizational learning* [26]. The concept of *network learning* is here also introduced, and is conceptualized as the processes and related factors, which can support processes of inter-organizational learning.
This build-up feeds into the development of a conceptual framework, which contains the focal processes and factors (i.e. variables) addressed in my research.

3.1. Evolutionary overview of relevant theories and perspectives:

Over the last fifteen years, various strands of literature have addressed the research topic of the new socio-economic structures [27] or distinct organizational forms [Knight (2002), 430], which are governed essentially by the principles of *collaboration* and *negotiation* [28] [Mayntz (1993); Ebers (1997); Osborn and Hagedoorn (1997), 266]. Therefore, the relations (i.e. *links* or *ties*) between organizations within these structures substantially differ in nature from respectively the ones on markets and the ones within (more) hierarchical organizations. [Powell (1990), 295]
The theoretical foundations in this type of research have steadily evolved and been extended over the years. [Osborn and Hagedoorn (1997), 262; Oliver (2001), 468; Sydow and Windeler (1998), 265]

---

21 Sustained or renewed competitiveness can be the eventual outcome for companies by going through and achieving the following sequence: knowledge and technology access, development and acquisition [Powell et al. (1996); Lei (1997); Kumar and Nti (1998); Narula and Hagedoorn (1999)] – competence building [Harrison et al. (2001)] – development of new products [Lei (1997); Kumar and Nti (1998)], product lines and businesses [Ding and Peters (2000)] – create economic value [Kumar and Nti (1998); Madhok and Tallman (1998)] and firm value [Hitt et al. (2000)].

22 For references: see Osborn and Hagedoorn (1997); Lei (1997); Gulati (1998); Larsson et al. (1998); Narula and Hagedoorn (1999); Gulati et al. (2000); Das and Teng (2000); Oliver (2001); Knight (2002).

23 For references: see Inkpen and Beamish (1997); Shenkar and Li (1999); Inkpen (2000); Buckley et al. (2002).

24 For references: see Powell et al. (1996); Khanna et al. (1998); Inkpen (2000).

25 For references: see Carley and Christie (2000b), 162-163, 168-169; Clarke and Roome (1995); Clarke and Roome (1999); Stafford et al. (2000); Roome (2001a).

26 *Inter-organizational learning* is regarded as a key process in networks. [Knight (2002), 427]

27 See the introduction of this chapter.

28 As these structures are characterized by – amongst others – the inherent tension between collaboration, and competition and conflict [Khanna et al. (1998)], processes of negotiation are absolutely necessary for their effective functioning.

At the outset, studies mainly focused on the economics of strategic alliances and of inter-firm networks by highlighting their potential to reduce R&D, production and related transaction costs. In taking this perspective, the option of entering such alliances was weighed against the option of organizing the economic activities within a single company. [29] The rational design of and motives of immediate economic efficiency for the organizational form were stressed. [Osborn and Hagedoorn (1997), 262-266; Madhok and Tallman (1998), 327; Sydow and Windeler (1998), 269]
Empirical research has showed though that participants also – and sometimes predominantly – enter alliances for other strategic reasons. Examples include fast market entry, enhanced legitimacy and inter-organizational learning. [Sydow and Windeler (1998), 269]

Consequently, researchers increasingly started to adopt perspectives of corporate and business strategy, of strategic management, and of organizational theory in their studies. [Osborn and Hagedoorn (1997), 266-269; Sydow and Windeler (1998), 269]
Hereby, the following research foci became important [Sydow and Windeler (1998), 270]:

- Demands of the external business environment.
- Selective forces of competition.
- In- and external contingencies in alliance design.
- The relevance of internal and external resources [30], and the difficulty to imitate the former.
- Technology development. [Osborn and Hagedoorn (1997), 268]
- The dependence of this organizational form on particular resources.

These two sets of theories and perspectives could still not account for and explain the vast diversity in actual occurrence of strategic alliances. This increasingly led to the additional adoption of what are called *inter-organizational field* [Osborn and Hagedoorn (1997), 269] or *network theory* [Sydow and Windeler (1998), 270)] perspectives.
The structural components of alliances, the *network position* [31] [Oliver and Ebers (1998), 576; Gargiulo and Benassi (2000), 183] of alliance partners, and an extended view on the nature of alliance ties have hereby become more closely studied. [Sydow and Windeler (1998), 270]

The reason for this is that alliance collaboration is characterized not only by individual organizations' search for survival and competitive success, but alliances also seem to be characterized by 'collective patterns of survival, growth and sustainability'. [Osborn and Hagedoorn (1997), 269]

---

29 In this respect, Hagedoorn et al. (2000) talk about the motive of 'industrial organization'.

30 This issue is referred to as the *resource-based view of the firm* [Pfeffer and Salancik (1978); Wernerfeld (1984); Lorenzoni and Lipparini (1998); Hagedoorn et al. (2000)]. These resources are controlled by other organizations, and therefore this phenomenon highlights the importance of access to different types of external resources. [Carley and Christie, 2000a, 159-160]
More specifically, it studies the development of knowledge [Javidan (1998); Madhok and Tallman (1998)], strategic options to technology, the development of related dynamic capabilities [Teece et al. (1997)] and of competence building [Javidan (1998)].

31 This refers to a central or more peripheral position in terms of power, dependency, etc.

The main academic predecessors of this research view were Emery and Trist (1965) and Pfeffer and Salancik (1978). The former viewed the inter-organizational field of a company as a characteristic of its environment; the latter introduced the resource-based view of the firm. [Osborn and Hagedoorn (1997), 269]

The body of current research which takes this perspective, tends to emphasize the following issues [Osborn and Hagedoorn (1997), 269]:

- Technology learning and development [Kogut (1988)].
- *Organizational learning* [32] [Hagedoorn (1993)].
- Social and individual dynamics.
- *Institutionalization* [33].

In section 3.2, I set out why and how the concepts of *inter-organizational* and *network learning* (i.e. *collaborative learning*) are well suited to study processes of multi-organizational change and innovation respectively within and by CISs.
Sections 3.2.1 and 3.2.2 conclude with respectively my first and second core research questions, and by highlighting what is the added value of the theory development. In section 3.2.3, these two sections culminate in the proposition of and argumentation for the conceptual framework, which guides the theoretical research as well as its empirical application to testing activities of a new generation of public transport buses.

3.2. Collaborative learning for sustained competitiveness and ecological sustainability within societal function-defined CISs:

In this section, I put forward and elaborate on the concept of *collaborative learning*. Although organizational learning within organizations can also involve collaboration [34], I use the term here to label learning processes that take place in the context of collaboration between legally distinct organizations.
Collaborative learning in this sense can involve both *inter-organizational* and *network learning*.

---

[32] *Organizational learning* in this context can be described as 'a focus on collaboration as a response by organizations to environmental changes, which demand improvement in their know-how, technological capabilities or both'. [Osborn and Hagedoorn (1997), 269]. It can also be described as 'a focus on how actors accumulate and use their own or others' experiences for decision-making or devising new courses of action' [Oliver and Ebers (1998), 577]. In the literature, alliances are regarded as being 'an important part of a learning process for companies, a process in which they discover new opportunities in a flexible setting of a multitude of changing partnerships' [Osborn and Hagedoorn (1997), 270]. Moreover, *learning in networks* is described as a 'social construction process wherein knowledge is created in a social community context' [Oliver (2001), 468].
I refer to Knight (2002), 432-433 for the dimensions of a more extensive conceptualisation of *organizational learning*.

[33] In the context of alliances and networks, the concept of *institutionalization* refers to [Osborn and Hagedoorn (1997), 270]:

- How and why common alliance practices emerge.
- How and why these are copied over time.
- How and why these eventually become generally accepted practice.

[34] This is the case when learning processes occur in teams or departments, or at the level of the organization as a whole.

In the context of SD and ecological sustainability, Carley and Christie (2000a) propose various concepts from organizational analysis, which can prove useful in this type of research.
Some of these are [Carley and Christie (2000a), 158]:

- *Resource dependency* of organizations, calling for collaboration and exchange. [35]
- The potential role of inter-organizational networks [Carley and Christie (2000a), 160-161] and *action-learning networks* [36] [Clarke and Roome (1999), 296; Carley and Christie (2000a), 162-163, 168-169; Stafford et al. (2000), 125] in various forms [Westley and Vredenburg (1997), 382], which are accompanied by processes of organizational development. [37]
- The roles of *consensus* and *conflict*, hinting at both the potential of and challenges associated with processes of collaboration. [38]
- Inter-organizational [Halme (2001), 101] or *collaborative* [Stafford et al. (2000), 134] *learning*. [39]

More specifically, the following disciplines and theories are effectively combined and integrated in the research:

- *Network theory*: to map and analyse the structure of, and the network positions and the nature of the network ties in the context of learning within societal function-defined CISs.
- Resource dependency, *competence theory* [40], and *strategic* and *international management* of R&D3: to analyse and interpret the motives, objectives, perspectives and strategies adopted by MNCs in their participation in *collaborative learning* in societal function-defined CISs.

---

35 In the context of SD and environmental management (EM), this requires companies to develop knowledge also outside of their common *repertoires* of knowledge and action. This need creates the ground for collaborative action by means of multi-party mechanisms. [Clarke and Roome (1999), 297]

36 *Action-learning networks* are non-hierarchical social systems, which [Clarke and Roome (1995), 192, and (1999), 297]:

- Span business organizations and stakeholders in society.
- Lay over and complement formal organizations linking individuals together by the flow of knowledge, information and ideas.
- Involve continuous learning, action and change in a complex series of continuously negotiated business and social experiments to enact the concept of SD.

37 In the face of complex problems and of a pressing need for action, non- or less-hierarchical social systems are regarded as the basic social form that permits an inter-organizational collaboration to develop. [see Astley and Fumbrum (1983); Pasquero (1991); Groenewegen and Vergragt (1991); Alter and Hage (1993); Westley and Vredenburg (1997)]
Carley and Christie (2000a), and Westley and Vredenburg (1997) further mention *partnerships, joint ventures* and *networks* as appropriate organizational forms.

38 These roles relate to the vested, partial interests of the involved actors, which result in a constellation of interests. [Roome (2001b), 71]

39 Drawing from general systems theory, organizations – and thus also inter-organizational structures seen as a distinct organizational form – need to learn to adapt their behaviour to changes in information flows, feedback and interdependency relations among the organizations. [Carley and Christie (2000a), 157]
Ding and Peters (2000) for example claim that 'discontinuous radical' – i.e. technological – 'innovation' requires distinct processes of inter-firm knowledge management.

40 *Competence theory* focuses on the development of and internal capitalization on rare, company-specific sets of know-how and skills, which are not product- or market-specific. Therefore, the company or some of its business units can build on *competences* for longer periods of time and in a broader range of activities. [Hamel (1994), 11-25]

- *Learning perspectives* [41]: to study and assess the processes and outcomes of sourcing, development, acquisition and management of strategic resources (i.e. knowledge) and *capabilities* in societal function-defined CISs.
- *Sustainability science*: to study and integrate the particular issues and aspects of radical, systemic approaches to innovation and learning for ecological sustainability.

In their overview of studies on inter-organizational relationships, Oliver and Ebers (1998) found that these focal theories and perspectives – the learning perspectives to a lesser degree – are most frequently built upon in this type of studies, and that they also have the closest connections to one another in multi-disciplinary studies. [Oliver and Ebers (1998), 574-575, 576-577, 557]
In section 3.2.1, I argue that collaborative learning constitutes a robust basis to tackle the deficiencies of, and integrate and overarch the foci of the respective chosen theories (as addressed in section 3.1).

3.2.1. Inter-organizational learning *within societal function-defined CISs:*

Knight (2002) describes *inter-organizational learning* as learning processes, which are based on – bi- and multi-lateral [Oliver and Ebers (1998), 551] – interactions between otherwise separate organizations. Through this interaction, these partners can realize their own respective objectives within the inter-organizational (i.e. CIS) context. [Knight (2002), 428]

Although this type of learning processes can be analytically distinguished from *intra-organizational* ones in terms of what are the *locus of learning* and the *learning context* [42] [Knight (2002), 437], both types are in fact linked and need eventually to become 'cross-fertilized' in order to gain insight in how organizations deal with the fundamental learning problems of *exploration* and *exploitation* [43] of various *learning outcomes* [44]. [Holmqvist (2003), 95]
This process of cross-fertilization is depicted in figure 6.

---

41 For references: see Fiol and Lyles (1985); Senge (1990); Roome (2001a); Halme (2001); Knight (2002).

42 Here, the *learning context* represents the setting in which the group of organizations is operating. [Knight (2002), 440]

43 For an organization to sustain itself, grow and be successful, general systems theory argues that they need to strive for a state of dynamic equilibrium through the exchange of new information (i.e. strategic knowledge and capabilities), material flows and energy.

44 *Learning outcomes* are 'changes in properties of organizations, such as systems, structures, procedures, culture and schemata', and changes in resources, knowledge and capabilities, 'which reflect and are reflected in changing patterns of action'. [Knight (2002), 432]
These outcomes constitute potential advantages of the alliance structure, because their realization is subject to a number of constraints [Oliver (2001), 470-471] and challenges [Osborn and Hagedoorn (1997), 261], which can result in *outcome discrepancies* [Kumar and Nti (1998), 361-363].

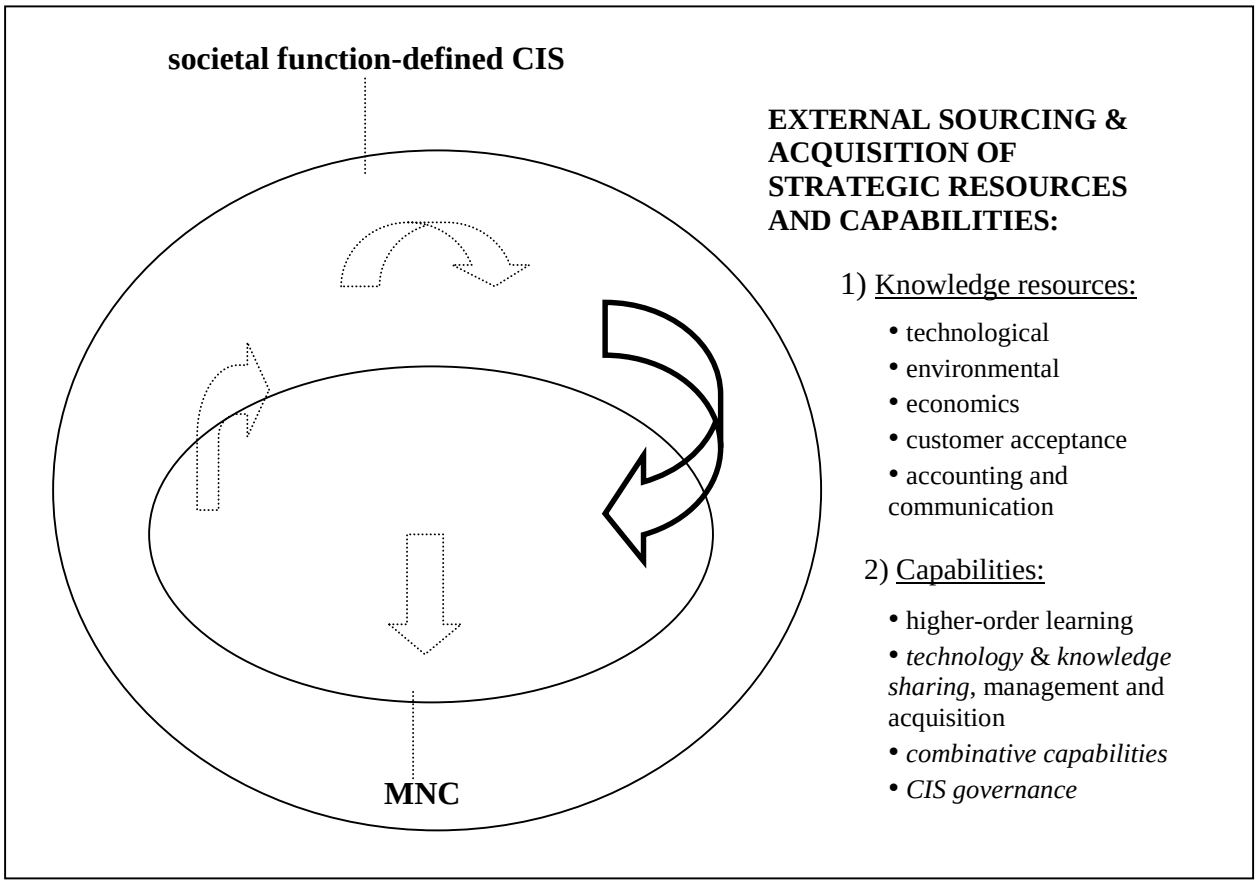
Both fundamental issues of learning are reflections of a *dynamic view* on learning processes. March (1991) and Nooteboom (1999) distinguish various *cycles of learning*, in which both problems are more or less prominent. [45] The first three cycles are the following [Oliver (2001), 469]:

- Initial *exploration*: the occurrence of radical innovation, and the introduction of related new practices.
- *Consolidation*: the innovations and practices may become a 'dominant design' through trial and error.
- *Exploitation*: their generalization leading to an increase in scale.

The last two cycles are *differentiation* and *reciprocation*, which are not relevant for this research.

In figure 1, I synthesize the knowledge resources and capabilities (i.e. the *learning outcomes*), which may be expected from inter-organizational learning within societal function-defined CISs.

Figure 1: External sourcing and acquisition of strategic resources and capabilities:



Source: own development

[45] Furthermore, Nooteboom (1999) argues that parallel *cycles of des-integration* of the alliance structures occur, which lead to shifts between the relative predominance of looser inter-organizational alliances versus that of tighter *intra-company networks.*
In this respect, he talks of *non-linear patterns of alliance formation* [Oliver (2001), 482-483], and of the *dynamic efficiency* of alliances [Uzzi (1996), 694; Oliver (2001), 469].

Any form of learning process and their outcomes can imply either *cognitive* or *behavioural* changes [Crossan et al. (1995); Knight (1997)], or preferably both types of changes in an integrated manner. [Knight (2002), 432]

The participants' capacity for higher-order learning is related to the activities, which have already been referred to in the introductory chapter of this paper.

Capabilities for *technology sharing* [Inkpen and Dinur (1998), 454] and *technology fusion* [Lei (1997), 208] can also represent important learning outcomes, especially when the collaboration takes place in technology-intensive and -diverse settings.
This is the case with technological innovation in societal function-defined CISs.

Combinative capabilities relate to the organization's capacity to link and integrate various individuals' capabilities, since these – amongst other factors – determine its *absorptive capacity* (see section 3.2.2) and actual knowledge absorption. [van den Bosch, et al. (1999), 556]
This capability can also be developed and harnessed within an alliance setting.

CIS governance activities can also result in increased capabilities for the organizations, which are responsible for processes of *network learning* (see section 3.2.2).
This is especially the case for *hub organizations*.

The above issues result in my first research question:

'Which strategic resources (i.e. knowledge) and capabilities are important for multinational companies (MNCs) to source and acquire through their participation in inter-organizational learning in societal function-defined CISs ?'.

3.2.2. Factors and processes that can support inter-organizational learning:

In adopting a network perspective on the study of these new organizational forms, Sydow and Windeler (1998) define the *organization of inter-firm networks* as 'the social interaction, in which agents – managers in particular – intentionally and *reflexively* [46] try to shape network processes and relationships in order to coordinate the activities in the network' [Sydow and Windeler (1998), 268].
This interaction has also unintended aspects, since the involved managers 'act – at least in part – under conditions not acknowledged by them' [Sydow and Windeler (1998), 268].

Furthermore, Carley and Christie (2000a) mention a number of principles and mechanisms, which can support inter-organizational learning for ecological sustainability [Carley and Christie, 2000a, 157]:

- *Constructive feedback.* [47]

[46] The notion of *reflexivity* refers to 'the capability of agents (and systems) to monitor and rationalize action, processes, and contexts with respect to what has happened, happens, and will happen or has to be done'. 'Processes and relations ínside the network companies, however, are not the primary target of these organizing activities'. [Sydow and Windeler (1998), 268]

[47] Examples include *problem reiteration* [Carley and Christie (2000b), 177], *circular innovation* [Carley and Christie (2000a)] and continuous performance improvement.

- The mentioned law of requisite variety.
- *Adaptive management* in order to achieve new *dynamic equilibria*. [48]
- The simultaneous focus on *substantive* [49] and *process* [50] *issues* [Carley and Christie (2000b), 175, 176]
- *Vision* [Carley and Christie (2000b), 176] and *leadership* [Hartman et al. (1999), 257]. [51]

Mechanisms, such as constructive feedback and adaptive management, can be adopted and implemented for the reflexive evaluation of the networks.
Sydow and Windeler (1998) describe *evaluation* as 'processes of interaction, in which managers try to control the outcome and eventually the process of organizing by reflexively monitoring the – contextually embedded – alliance activities and effects' against 'particular criteria' [Sydow and Windeler (1998), 269].
They further argue that this interaction should not only be governed by 'narrow' economic and efficiency considerations, because strategic networks are also formed and used for other strategic goals [Lazerson (1995), 34; Eisenhardt and Schoonhoven (1996), 136; Larsson et al. (1998)]. [Sydow and Windeler (1998), 269]

In the literature, also various specific factors and processes are mentioned as potentially important for the learning processes to be effective or successful.
The ones on which I will actively focus in this research, are showed in figure 2.

The first factor is variously called *strategic* [Hamel (1991); Inkpen (2000), 777] or *alliance intent* [Koza and Lewin (1998), 256]. In this study, this covers the motives or reasons of MNCs to participate in CIS-defined learning activities. [Koza and Lewin (1998), 256]
Difficulties can emerge from a lack of motivation to collaborate and learn within the alliance. [Larsson et al. (1998), 300-301]

The first process is called *network learning* by Knight (2002), which is defined as 'learning by a group as a group' [Knight (2002), 428, 435; Weaver et al. (2000b), 276].
Its outcomes are sometimes called *common benefits* [52] [Khanna et al. (1998), 194, 195; Inkpen (2000), 775-776], as opposed to *private benefits* in the form of inter-organizational learning outcomes.

---

48 In general systems theory, organizations are seen as open systems, which are differentiated from their environment by some kind of boundary.
In striving to survive, they tend towards a state of dynamic equilibrium with that environment through the continuous exchange of resources, material, information and energy.
The study of the dynamics of networks [Boons and Berends (2001), 115] can be regarded as an example of this.

49 Examples are the *radical* [Clarke and Roome (1995)], *socially shaped* [Clarke (1999), 425] transition to inherently environmentally friendly systems of production and consumption, and the central role of technical change therein [Vergragt (1988); Clarke (1999), 425].

50 Examples are processes of collaboration, and more specifically of learning [Clarke and Roome (1999)].

51 Examples are the vision that institutional development goes together with such processes, the recognition of areas of common interest, and a shared vision.

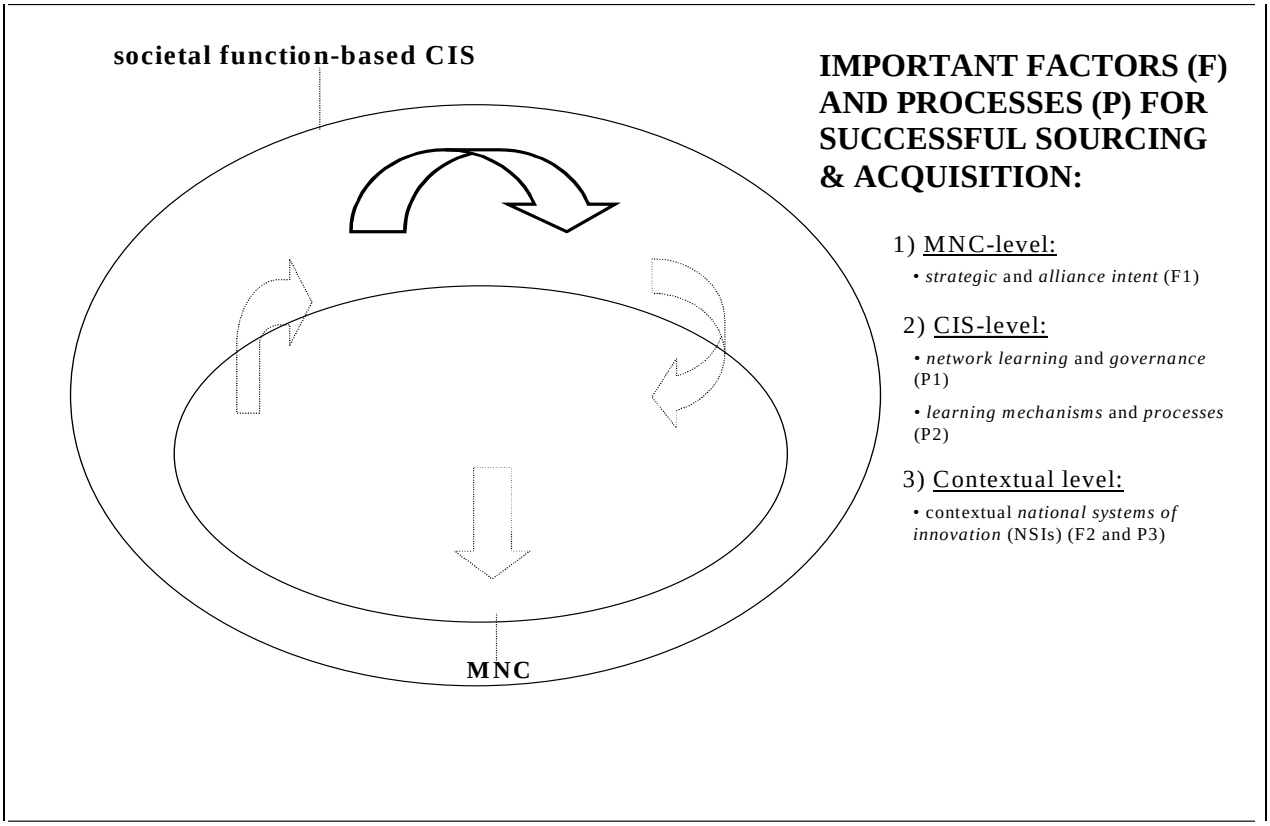
52 *Common benefits* are unavailable to a single partner without the alliance.
Inkpen (2000) claims that these primarily involve learning about the other partners, so that more efficient collaboration becomes possible. [Inkpen (2000), 776]

No consensus exists however about the *appropriability* of such common outcomes by the individual organizations. Inkpen (2000) claims that learning and application of knowledge to a common purpose outside the alliance is unusual in practice. [Inkpen (2000), 776]

This type of learning pertains to and is necessary to address the *inherent tensions* or *competing forces* [Das and Teng (2000), 77], which characterize the network or alliance and which often lead to *sub-optimal alliance behaviour* [Khanna et al. (1998), 205; Inkpen (2000), 775] or *process loss* [53] [Boons and Berends (2001), 118].

Larsson et al. (1998) also mention the 'inter-organizational learning dilemma', which most often arises when the partners predominantly aim for immediate maximization of inter-organizational learning outcomes. They are then 'squeezed' between this maximization and the need for the development of 'collective knowledge'. [Larsson et al. (1998), 288; Kale et al. (2000), 234]

Figure 2: Factors and processes, which are important for successful sourcing and acquisition:



Source: own development

[53] *Process loss* is the gap between the potential and the actual effectiveness of a group of organizations.

Other difficulties and challenges can emerge from the dynamics of power between the organizations, opportunism [Kale et al. (2000), 218], suspicion and *asymmetric learning outcomes* [54]. [Larsson et al. (1998), 285]

Such complications also lead alliance partners to the adoption of one or several of the following different *learning strategies*. [Larsson et al. (1998), 285]
These strategies also bear on the achievement of the projected outcomes [Larsson et al. (1998), 285], and are characterized by two dimensions: *receptiveness* of the partner, and *transparency* of the partner.

- Collaboration: high on receptiveness and transparency.
- Competition.
- Compromise.
- Accommodation.
- Avoidance.

The combination of substantive and process issues is found in appropriate *learning mechanisms* [Inkpen (1996), 123-124; Inkpen (2000), 777, 778].
A number of mechanisms of inter-organizational learning can be distinguished [Knight (2002), 431]:

- Awareness of the other organizations in the socio-economic structure.
- Joint plans.
- Sharing resources.
- Joint actions.
- Interaction processes and related structures. [Knight (2002), 437]
- Shared *narratives*. [Dunford and Jones (2000); Knight (2002), 437]

For reasons of completeness, I also mention the potential influence of *national systems of innovation* (NSIs) on the formation and the activities of specific CISs in distinct geographic locations.

Furthermore, a number of important *antecedents* [Oliver and Ebers (1998), 576] (i.e. factors) – at both the CIS- and MNC-levels – can be distinguished in theory, whose presence favours achieving the projected learning outcomes.
Depending on the particular CIS being studied in empirical research, the independent variables can be regarded as an antecedent, and conversely some antecedents can represent an independent, explicitly studied variable.
Relevant antecedents are showed in figure 3.

The first antecedent is called *goal congruence*. [Oliver and Ebers (1998), 556, 561-562] This concept denotes the degree to which the goals and interests of the various parties are ‘harmonious’ or ‘in agreement’. [Oliver and Ebers (1998), 576]

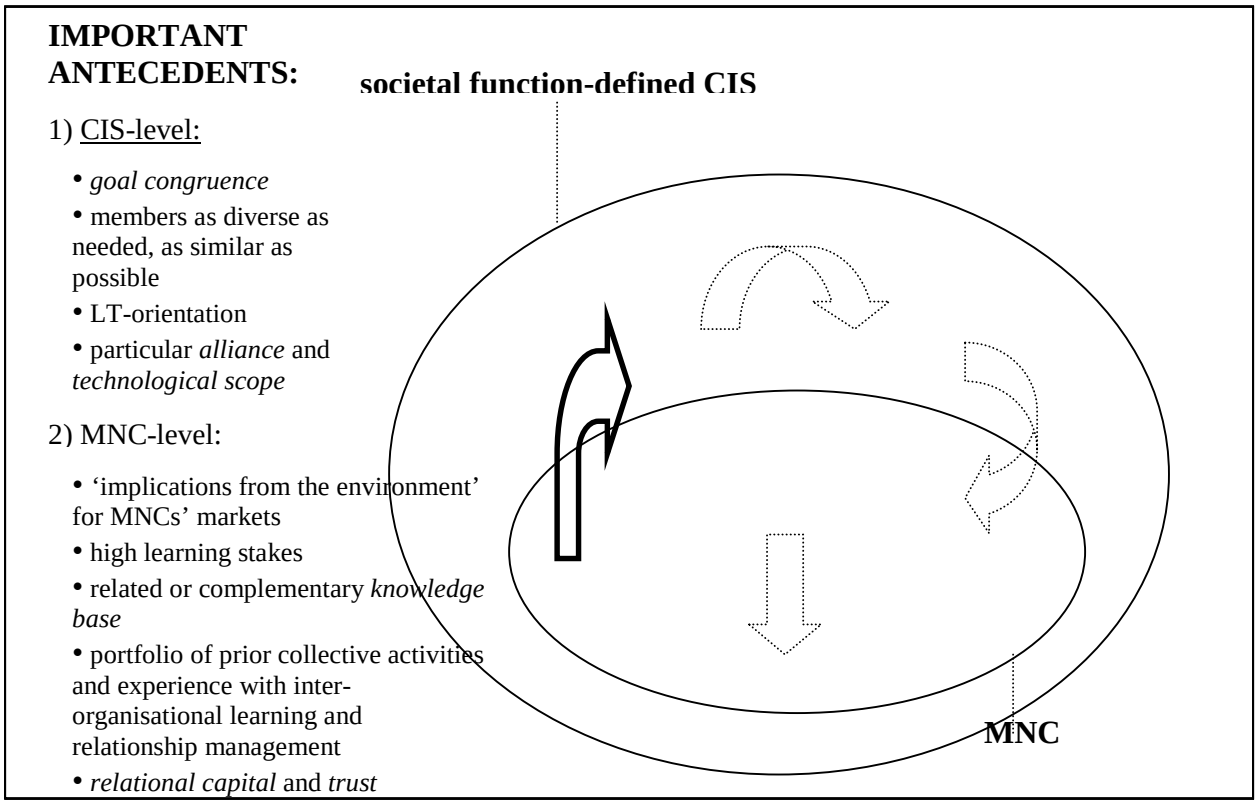
The next antecedents are *alliance scope* [Khanna (1998), 340; Khanna et al. (1998), 195] and *technology scope* [Inkpen (2000), 776].

[54] Since companies and other alliance organizations have different absorptive capacities and occupy different positions of power in the alliance, they will also learn to greater or lesser extent compared to one another.

The first variant of scope determines 'the need that the partners have agreed to target (perhaps through the introduction of a new product or the provision of a new service)'. This concept can also prove relevant in the context of societal function-defined R&D3 activities in CISs.
Inkpen (2000) argues that the factor *scope* can also be defined in other terms: amongst others by the dimension of the 'technologies' that stand at the core of the collaboration. [Inkpen (2000), 776]

The next important antecedent is the *absorptive capacity* of a company. [Cohen and Levinthal (1990), 128; Kumar and Nti (1998), 356; van den Bosch, et al. (1999), 553-554; Shenkar and Li (1999), 134-136; Oliver (2001), 468].
Cohen and Levinthal's argument stipulates that the greater this capacity of a company, the greater its capacity to learn. Hence, it is also better at both internal R&D and at conducting R&D collaborations with other organizations. [Oliver (2001), 468]
This capacity is determined by the following components: *knowledge relatedness* [Inkpen (2000), 777], *prior related knowledge* [van den Bosch et al. (1999), 551, 553-554] or an existing *knowledge base* [Powell et al. (1996), 120; Lei (1997), 208], as well as *knowledge accessibility*, *knowledge acquisition effectiveness*, *knowledge types*, *knowledge tacitness*, *knowledge stickiness* and *knowledge importance*. [Inkpen (2000), 777]

Figure 3: Important antecedents for successful sourcing and acquisition:



Source: own development

Furthermore, *portfolios* of joint or prior collective activities also support processes of collaborative learning: both in their development and in their actual evolution. [Powell et al. (1996), 119-121]

The last crucial factor is the development, harnessing or restoration of *social* or *relational capital* [Kale et al. (2000), 217; Ireland et al. (2002), 429] It has been often observed that the lack thereof led to highly sub-optimal learning outcomes or to the demise of the alliance.

The above issues result in my second research question:

> 'Which factors and processes are important to support these processes of inter-organizational learning in the context of societal function-defined CISs ?'
> 'What is the particular role of *network learning* in this respect ?'

3.2.3. Conceptual framework:

Figure 4 depicts how I see emerge a substantial set of similar challenges and drivers for companies from the phenomena of ecological sustainability and of (economic) internationalisation of R&D3. As an implication of both phenomena, I also argue that a – lower – degree of similarity exists in to be adopted perspectives, in the formation of appropriate inter-organizational structures, in the actors involved, in to be studied objectives, and in the alliance processes and dynamics.

In terms of the theoretical – multidisciplinary – bases for this research, these similarities require though that recent theories of international and strategic management become extended in view of the specific requirements of ecological sustainability.

First of all, the transition to inherently pollution-low or -free systems of production and consumption additionally calls for *radical* [55] [Allenby (2000), 213; Smith (2002), 17; Williams and Markusson (2002), 12] or *disruptive* [56] [Smith (2002), 16] kinds of *technical change* (*). [Weaver et al. (2000b), 254]
This type of technical change is commonly regarded as a critical perspective in approaches to SD and ecological sustainability. [Vergragt (1988); Clarke (1999), 425]
This in turn may require co-development and external acquisition by companies of new kinds of knowledge, technology and capabilities. Hereby, the focus lies on the processes that develop, configure and apply the technologies. [57] [Smith (2002); Williams and Markusson (2002), 12]

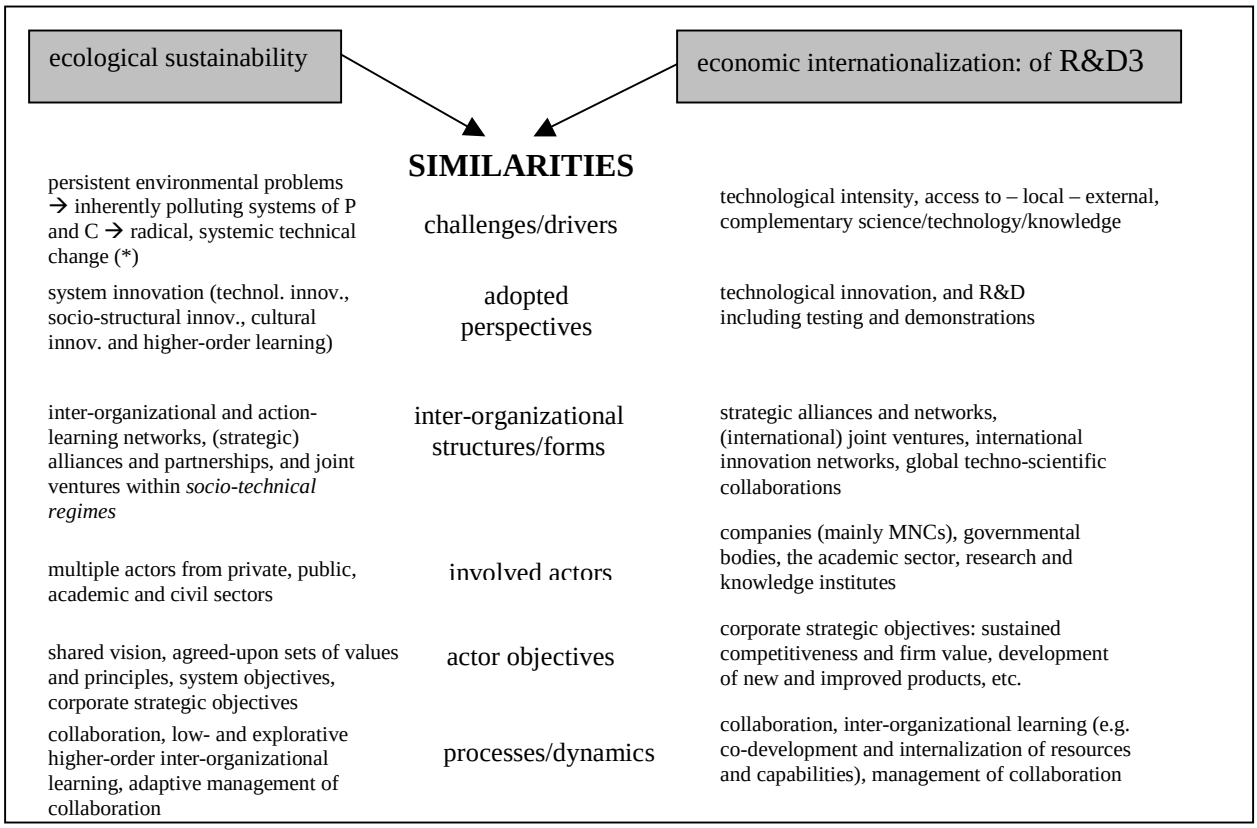
---

55 Changes occur in the core knowledge and operating principles, which underpin the key products. It is shown that these changes can be associated with far-reaching structural and institutional transformations across supplier and user industries. [Williams and Markusson (2002), 12]

56 Such technological change involves a replacement of existing norms of product design and production processes, and is essentially discontinuous with respect to a particular product or array of products. They normally imply not only new products, but also new systems of suppliers, and of education and training. [Smith (2002), 16]

57 Clarke (1999) and other authors before her [Callon (1987), 83; Simmons and Cowell (1996)] propose a more holistic conceptualization of technology, and of the related innovation processes and outcomes.

Figure 4: Similar implications of ecological sustainability and of the (economic) internationalization of R&D3:



Source: own development

Secondly, as companies increasingly need to source knowledge, technology and capabilities outside of their organizational boundaries, they enter collaboration processes with other societal actors.

Various factors favour the use of the mentioned new inter-organizational structures, which can guarantee an appropriate – i.e. situation- and time-bound – balance between flexibility and stability [Emery and Trist (1965)]:

- The uncertainty, complexity and turbulence attached to persistent environmental problems.
- The explorative nature of the initial stages of a transition to inherently pollution-low or -free systems of production (P) and consumption (C).
- The increasingly turbulent, open and risky [58] business environment of R&D3. [Howell and Hsu (2002), 45, 48]

They propose that attention is directed away from the technological artefact or system as such, and redirected towards 'the knowledge, relationships, values and assumptions that underpin technological choices and social behaviours, and to the moral and ethical validity of those choices'. [Clarke (1998), 147]

[58] High risks are involved in technological, business, micro-economic and reputational terms.

To this end, theories on strategic alliances and networks, and on joint ventures can be extended by using the concepts of inter-organizational and action-learning networks [Carley and Christie (2000a), 162-164, 175-176] as developed for the study and solution of persistent environmental problems in the context of *socio-technical regimes* (STRs) [Emery and Trist (1965); Clarke and Roome (1995), 192; Roome (2001a), 22; Rotmans et al. (2000), 3-5].

Thirdly, the above conceptualization of technology (*) likely requires the active inclusion of a greater variety of companies as well as of non-corporate actors from the public, academic and civil sectors of society, than is the case when not taking into account the challenges related to ecological sustainability.

Finally, a theoretical extension needs to take place in terms of studied objectives, and of ensuing processes and dynamics. Winn and Roome (1993) argue that ecological sustainability and its – implications for – business require strategic decisions and responses. [Winn and Roome (1993)]
Shared visions, agreed-upon values and principles – with regard to ecological sustainability – are to be developed and adopted, and *system objectives* to be addressed. [59]
This additionally calls for the study of *high-order* inter-organizational *learning* processes.

Figure 5 shows the greater variety [60] of companies as well as of non-corporate actors from the public, academic and civil sectors of society, that are to be actively included in the study of this type of system innovation.

The above extensions culminate in – what I regard as a radical form of – the concept of *system innovation* [61] in the context of SD-driven transitions in *societal (sub)functions* (SF) [62].
(Sub)system innovation for SD and ecological sustainability can thus be regarded as a set of processes in society which evolve around a complex set of multiple, continuously negotiated societal and business experiments and projects, which are developed and carried out within STRs. [Roome (2001a), 4]

---

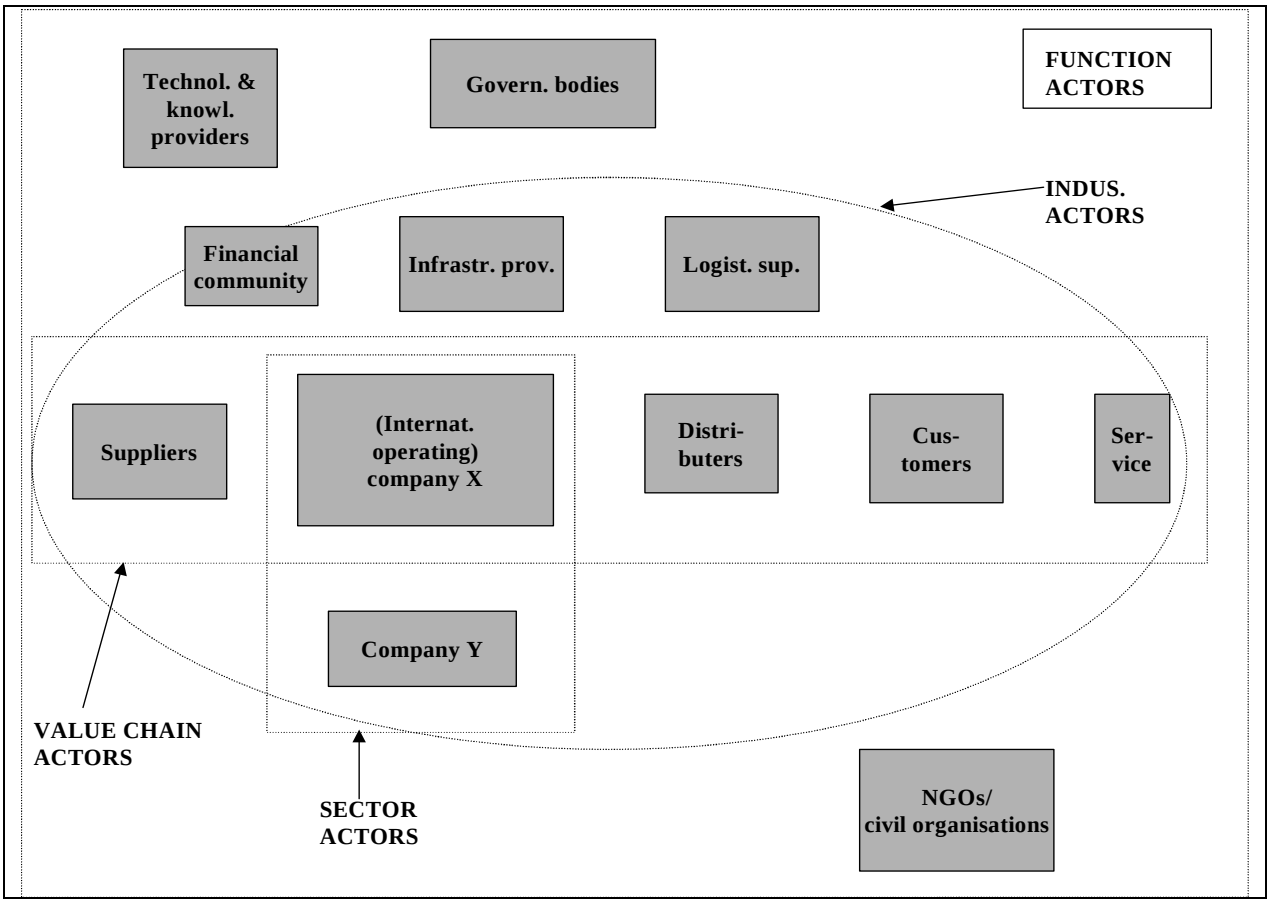
[59] *System objectives* need to be addressed in addition to and integrated with the strategic objectives of individual companies, and in addition to purely economic/business perspectives and considerations. The latter are studied in studies of strategic alliances, networks and joint ventures in the recent international and strategic management literatures.
Roome (2001b) cites the main reason for this need: 'organizations invariably define their goals in relation to their partial interest and to the specific perspective, they have in the resources of the system'. [Roome (2001b), 71]

[60] The variety is greater compared to the foci on industrial sectors and on *value chains*/*life cycles*.

[61] *System innovation* can be defined as 'organization spanning qualitative innovations that are achieved by various system participants, which require the input of different kinds of knowledge, and which pervasively alter the relations between system participants' [Rotmans et al. (2002), 3].
It thus goes further than merely achieving improvements along a given trajectory through for example material substitution or greater resource efficiency.
Nevertheless, system innovation is always constrained by *system effects* such as the costs of such pervasive changes, uncertainty, and the need 'to break old ties and to do away with old ways of doing things'. [Kemp (2002), 3]

[62] A *societal function* is an essential domain or sphere in socio-economic life to satisfy specific societal needs. [Geels and Kemp (2000), 3] Examples are transport and mobility, and energy provision.
An example of a *sub-function* within the mobility sphere is that of collective automotive mobility of people.

Figure 5: **Actively included societal actors in the study of a societal (sub)function, compared to that of an industrial sector or of a value chain:**

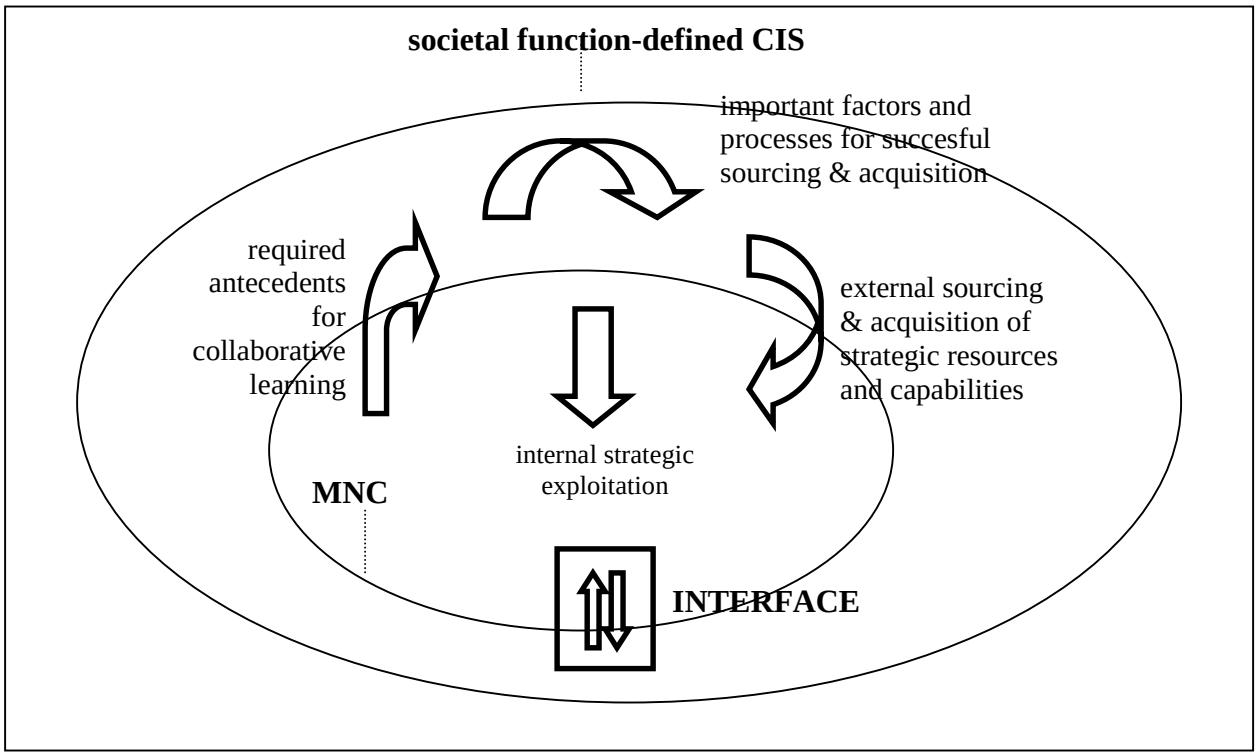


Source: **own development**

In particular, it requires companies to engage in collective action that links traditional business issues with environmental and social issues. [Clarke and Roome (1999)] In the literature, specific terms are used for such inter-organizational settings within STRs: *testbeds* [Roome, 2001a, 26], *breeding spaces* [Kemp (2002)], and *strategic niches* [Weaver et al. (2000b), 248; Kemp and Rotmans (2001), 1].

The above build-up leads to the proposition of the overarching conceptual framework in figure 6.

Figure 6: **Interdependent processes of external collaborative and intra-organizational learning:**



Source: **own development**

Because of the complexity of and vastness in operationalizing the research of these topics, I will focus my research mainly on the issues described in figures 1 and 2.

Section 3.3 sets out what my research objectives are in terms of theory development, of methodological design, and of their empirical application to demonstration activities of alternative-fuel, fuel-cell driven public transport buses.

3.3. Research objectives:

The objectives of this research are three-fold and relate to the following research components: theory development, methodology and the empirical research.
The respective objectives are to be achieved through continuous feedback and cross-fertilization between the components.

In terms of theory development, the aim is to develop an exploratory, testable conceptual framework, which is based on the perspectives of inter-organizational and network learning. In this way, various – more specific – theoretic topics related to strategic alliances and networks can be integrated and applied to the context of societal function-defined CISs.
These guiding concepts will hereby become systematically adopted and elaborated in-depth.

Methodologically, the objective is to deepen the existing, but rather superficial know-how on the operationalization of the study of learning processes and their observed learning outcomes.
Hereby, I aim to develop useful *markers* or *indicators*, which signal the relative quality of the learning antecedents, processes and outcomes in the societal function-defined CIS context.
In the process, the concept of *learning episode* is to be clarified and sharpened, and its operationalization to be improved.

The empirical objective of the research is to apply the framework to the specific setting of collaboration within societal function-defined CISs. Hereby, evidence of and experience with long-term orientations by (organizations of) CISs is to be developed.

4. Research strategy, design and methodologies:

In this chapter, I go into the question of how to operationalize the study of the two research questions (see sections 3.2.1 and 3.2.2):

- '*Which strategic resources (i.e. knowledge) and capabilities are important for multinational companies (MNCs) to source and acquire through their participation in inter-organizational learning in societal function-defined CISs ?'.*
- '*Which factors and processes are important to support these processes of inter-organizational learning in the context of societal function-defined CISs ?'*
  'What is the particular role of network learning in this respect ?'.

In section 4.1, I make the argumentation for using case studies as main research strategy, and I elaborate on the nature of the selected case studies. Section 4.2 covers the specific research (i.e. case study) design to be followed. In section 4.3, I give an overview of and introduction to the used methods for data gathering.

4.1. Research strategy:

In social research, various *research strategies* [63] can be followed in order to 'make sense of the phenomena' [Ragin (1994a), 55] which social researchers empirically study.

Yin (1994a) distinguishes the following research strategies [Yin (1994a), 13], which all have their own (dis)advantages in function of the specific purposes of a particular research:

- Case studies.
- Experiments.
- Surveys (and questionnaires).
- Histories.
- Analysis of archival information.

The differences between and the appropriateness of the respective strategies depend on three conditions [Yin (1994a), 13, 16-17]:

- The type of research question.
- The control the researcher has over actual events.
- The focus on contemporary or historical phenomena.

[63] A *research strategy* is defined as a research logic, which 'combines a primary research objective and a specific research method' and thereby 'constitutes a specific way of linking *ideas* and *evidence* to produce a *representation* of some aspect of social life' [Ragin (1994d), 191].
Breaking social phenomena into their constituent parts and viewing them in relation to the whole they form, by means of *analysis* results in the development of *ideas* or theoretical concepts.
Evidence are all data, information, events, etc. which can be gathered, observed and experienced through empirical research. [Ragin (1994a), 55-57]

He states that the strategy of case studies is preferred in the following circumstances [Yin (1994a), 13, 23]:

- 'How' and/or 'why' questions are asked.
  The first research question (i.e. a 'what' question) can here also be studied by means of this strategy, as it is essentially *exploratory* in nature. [Yin (1994a), 17]
- Little control of the researcher over behavioural events.
- Study of a complex contemporary phenomenon within some real-life context.
- No clearly evident boundaries between the studied phenomenon and its context.

These conditions are met in this study of inter-organizational learning processes as well as in its application to the demonstration activities of alternative-fuel, fuel cell (FC)-driven buses.

The strategy is here used for both *exploratory* and *explanatory* [Yin (1994a), 15-16] [64] purposes.
Both purposes are pursued, because the novelties and extensions, and the field in which the theoretical research is applied (see chapter 1) are exploratory in nature.
The exploratory aspects are more specifically that:

- The STR components of production and consumption systems are studied in an integrated manner.
- Factors and processes, which support inter-organizational learning are actively included as endogenous variables.
- The concept of the *learning episode* is further developed (see section 4.2).
- The developed conceptual framework is applied to 'exploration and market preparation activities' in the context of societal function-defined CISs.

The research is also explanatory, because various research variables are already known but their role needs to be clarified in this specific application.

The strategy is also essentially *cross-sectional* [Oliver and Ebers (1998), 575], because several parallel, simultaneously occurring cases are identified, selected, studied and compared.
Furthermore, the study is *qualitative*, since the case studies are limited in number and are characterized by many features or variables. [Ragin (1994a), 78; Oliver and Ebers (1998), 575]

In section 4.2, I set out the specific case study design adopted in this study. Hereby, the first three of seven features [65] of the case study research method are covered [Yin (1994a), 11]:

- *Problem definition* [66].
- Case study design.
- Preparation of data collection.

---

64 Yin (1994a) argues that the combination of exploratory and explanatory motives imply that 'the analyst's objective should be to pose competing explanations for the same set of events and to indicate how such explanations may apply to other situations'. [Yin (1994a), 16]

65 The four other features are [Yin (1994a), 11]:
- Collection of selected data and evidence.
- Analysis of the selected data and evidence.
- Interpretation of the selected data and evidence.
- Case study reporting.

66 The *problem definition* – or research question – involves both *substance* and *form*. [Yin (1994a), 19]
In this PhD research, the first takes the shape of inter-organizational learning and its supporting factors and processes; the second are here respectively 'what' and 'how' questions.

4.2. Embedded multiple-*case study design:*

Various definitions of a *research design* exist. In this study, it is specifically a *case study design*. In essence, such design is 'the logic(al sequence) that links the data to be collected (and the conclusions to be drawn) to the initial questions of the study' [Yin (1994b), 27, 28].
The case study design will also allow to define the theoretical domains to which my research conclusions can be generalized – i.e. 'whether the obtained interpretations can be generalized to a larger population or to different situations'. [Yin (1994b), 28-29]

Yin (1994b) mentions the following five 'components' of such design [Yin (1994b), 29-35], of which the first three are discussed below:

- The study's research questions.
- Its research propositions [67].
- Its *unit(s) of analysis* [68].
- The *logic* linking the data to the propositions.
- The *criteria* for interpreting the research findings.

The two central research questions were mentioned above in chapter 1, in sections 3.2.1 and 3.2.2, and in the introduction to this chapter.

To narrow down the vast quantity of available data and evidence to what is most relevant, the following research propositions are formulated in accordance with these two questions:

- ✓ Question 1:
  - P1: Various additional categories of knowledge are important for MNCs to source and acquire in societal function-defined CISs.
  - P2: *Formal, codifiable knowledge* is the predominant knowledge type among/nature of these knowledge categories.
  - P3: Formal, codifiable knowledge can be acquired by and transferred between CIS actors relatively easily, provided that appropriate learning, accounting and communication mechanisms are in place.
  - P4: *Informal, tacit and embedded knowledge* is difficult to source and acquire from other CIS organizations and from the CIS as a whole.
  - P5: Since *capabilities* are developed by and reside in individual agents which represent their respective CIS organizations, their transfer between CIS actors and to the participating CIS organizations is problematic.
- ✓ Question 2:
  - P1: *Strategic* and *alliance intent*, and related learning strategies of the CIS actors are crucial in a well-functioning collaboration, especially when the CIS is confronted with disruptive or rapid contextual changes, or with hold-up problems.

---

[67] The research questions in themselves do not point to what exactly should be studied and focused on. *Research propositions* are necessary, as these determine which issues exactly need to be investigated and which data and evidence are relevant and thus must be selected. [Yin (1994b), 30]

[68] The design component of the *unit of analysis* relates to 'the fundamental problem of defining what the 'case' is', and is generally 'related to the way the initial research questions are defined' (i.e. the form of the question). [Yin (1994b), 31]

- P2: The CIS' successful performance is highly dependent on agreed upon mechanisms and procedures of governance and network learning.
- P3: The CIS' successful performance is highly dependent on appropriate learning processes and mechanisms.
- P4: In the studied CIS settings, the role of the contextual national systems of innovation is stronger than this of internationalization forces.

Because only a limited number of real-life cases of FC-driven bus demonstrations presently exist, the number of case studies is limited.

In chapter 5, I introduce and elaborate on two historical case studies covering two real-life demonstrations of alternative-fuel, FC-driven buses in California (respectively between 2001-2002 and 2002-2003). These studies will function as *pilots* to fine-tune the research propositions, the focal (in)dependent variables and processes, and the selection of relevant data and evidence [Yin (1994c), 74].
The results of this pilot case study also allow to gain essential experience in, and fine-tune my *case study protocol* [69] [Yin (1994c), 64].

These lessons will be applied to the selection and study of two or three actual case studies, which are planned for 2004 and the first part of 2005.
During and after the completion of the respective case studies, the analysis and interpretation of the evidence will follow a *cross-experiment*, rather than a *within-experiment logic* [Yin (1994b), 48].

The *boundaries* of my case studies are determined by their *time boundaries* [Yin (1994b), 33], and by the selection of the CIS organizations which are relevant to this study.
In determining an appropriate length of time for each case, I make use of and further operationalize the concept of the *learning episode* [70] [Knight (2002), 447-449].
The relevance of and thus inclusion in the study of specific CIS organizations, is determined by their – active, associated and passive – participation in the demonstration projects. In principle, the included organizations are affiliated to one of the following categories (see figure 5):

- *Hub organizations*.
- Governmental agencies and ministries.
- Energy companies and their suppliers.
- Automotive companies and their suppliers.
- Public transport (i.e. bus) agencies.
- 'Intermediairies' such as research and technology institutes, and consultancies.

The third design component are the adopted *units of analysis*. These units represent the nature of the studied 'case'. [Yin (1994b), 31]

---

[69] The *research protocol* encompasses both the instrument by which the empirical research in the case study is operationalized, and the 'tactic in increasing the *reliability* of the case study research'. In this sense, it is 'intended to guide the investigator in carrying out the case study'. [Yin (1994c), 64]

[70] The dimensions of a *learning episode* are the following [Knight (2002), 448]: the learner network, episode time boundaries, the drivers and motivations for learning, the learning processes, the learning outcomes, performance implications, and associated organizational, group and individual learning.

In this research, multiple units are chosen and focused on. In general terms, these are:

- Factors, variables or 'stock values' (in terms of their relative level or amount), for which *indicators* or *markers* [Knight (2002), 446, 450] are developed.
- Processes and mechanisms.

I refer to figures 1 to 3 for concrete examples of these units of analysis.
Consequently, I adopt what is called an *embedded multiple*-case study design. [Yin (1994b), 41, 44]

Section 4.3 covers the various research methods, which will be used in the empirical research.

4.3. Methods used for evidence *gathering:*

In order to operationalize the theoretical and empirical research, I use both *qualitative methods* to study commonalities within, and *comparative methods* to study diversity between the case studies. [Ragin (1994b), 1994c]

In doing so, I mainly use *semi-structured interviews*, and *content analysis*. [http://www.herts.ac.uk/natsci/Env/envman/CourseProject/prj3/prj39 and 311.html, July 4, 2003]

The first method is appropriate in this highly exploratory study, because it: [71]

- Enables me to use a set of *open-ended* – mainly qualitative – *questions*.
- Leaves room for asking additional questions and *probing* questions about what is not known.
- Allows to look into the studied processes, into issues of meaning, and – if it is the case – into the 'atypical case'.
- Enables me to deflect from the initial subject area(s), if needed.
- Thus allows for focused, conversational, two-way communication.
- Thus combines the advantages of *structured* and *unstructured interviews*.

The *interview schedule* is developed as follows: [72]

- Inter-organizational and network learning processes constitute 'the overall issue'.
- The processes, mechanisms, factors and antecedents in figures 1 to 4 represent 'the broad range of themes'.
- A set of appropriate interview questions has been developed.
- Contacts with 'key informants' from the CaFCP Partners are being made using the *snowballing method* and the method of *theoretical sampling* [73]
  [http://www.staff.ncl.ac.uk/les.gofton/POSTGRAD.htm, July 4, 2003].
  The interviews for the pilot case study are planned for October 2003, and some of them have been confirmed by now.

---

[71] See http://www.herts.ac.uk/natsci/Env/envman/CourseProject/prj3/prj39.html, http://www.comp.lancs.ac.uk/sociology/PeterLinks/Survey/sld021.htm, http://www.staff.ncl.ac.uk/les.gofton/POSTGRAD.htm, http://www.fao.org/docrep/x5307e08.htm, July 4, 2003]

[72] See http://www.med.mun.ca/chps/Murray/Presentations%20-%20Winter2001/Int…/sld012.htm, July 4, 2003.

[73] *Theoretical sampling* is a method to select key informants by 'deliberately skewing towards certain social categories, occupants of certain social positions, or individuals'.

The second technique is also very useful in that it allows me to use and study relevant ‘secondary data sources’ such as archives, documents and websites.
If access, time and resources allow me, I will also use the technique of *participant observation* to clarify specific research issues.

In making use of the combination of these data gathering methods, I also aim to take the *action perspective* [Knight (2002), 449] of the involved CIS organizations, teams and individuals into account.

5. Historical pilot case study:

Alternative-fuel, fuel cell-driven bus demonstrations within the California Fuel Cell Partnership (CaFCP) [between 2001-2002 and 2002-2003]

In section 5.1, I first give a global overview of transportation and related energy systems in terms of their environmental properties.
Next, I focus on recent developments in hydrogen-fuelled fuel cell (FC) technologies for automotive applications (section 5.2).
Section 5.3 introduces and elaborates on two real-life demonstrations of alternative-fuel, FC-driven buses in California, the USA (respectively between 2001-2002 and 2002-2003). Their role in the research process is to use them as a *pilot case study* [74].

5.1. Global overview of transportation and related energy systems:

Current transport systems are highly effective in terms of technologies, yet highly – ecologically – unsustainable. Transport energy use presently accounts for around 30% of worldwide commercial energy consumption, and the growth in transport energy use over the past 25 years averaged 2,7% annually. Almost all of this energy is derived from *non-renewable sources*. Moreover, the transport sector is responsible for 30% of energy-related anthropogenic CO_2 emissions [Weaver et al. (2000b), 250], and for the more local environmental problems of air pollution [Cole (2002), 20] and noise. [European Commission, High Level Group for Hydrogen and Fuel Cells (2003), 2-3, 6-7]

For the last ten years [75], the number of corporate and governmental initiatives [European Commission, High Level Group for Hydrogen and Fuel Cells (2003) for example] to eventually replace the dominant technologies and related systems in the automotive sector has exponentially grown.
Since then, most major oil companies have followed suit in developing a complementary hydrogen infrastructure.

The issues related to the reduction of the environmental impact in the sector are very complex, partly because of the interrelations between the demand for and supply of transport vehicles and related services.

---

[74] *Pilot case studies* are essential in preparing for data collection: it helps the researcher to refine data collection plans in terms of the content of data to be collected, the procedures by which to actually collect the data, and possibly even conceptual clarification. In this way, the pilot case study can 'assume the role of a 'laboratory' for the researcher, allowing them to observe different phenomena from many different angles or to try different approaches on a trial basis'. [Yin (1994c), 74-75]

[75] See European Commission (2003) for examples in Europe during the last five years.
Since the first part of the 1990s, all major car manufacturers [Cole (2002), 22] have also been developing and implementing major R&D projects to model, simulate and build FC-driven prototypes. Most major oil companies have initiated similar projects for a related hydrogen infrastructure.

In order to substantially reduce this impact, four different broad 'solution directions' can be adopted, which are all likely to feature in the transition to a sustainable transport system. [Weaver et al. (2000b), 250-251]:

- Demand side management.
- Change *modal splits*, in order to reduce the needed number of vehicle-kilometres to satisfy the same transport demand whereby the most sustainable mode for each transport task is used.
- Increase vehicle loads and optimize the routes, in order to reduce the environmental resources needed for the same transport task.
- Change the technical properties of transportation technologies, so that these become *intrinsically (more) sustainable*.

When focusing on the presently dominant technologies, these are inherently unsustainable. The *well-to-wheel efficiency* [76] of the related energy chain is highly inefficient.
The dominant technologies are gasoline as *energy carrier*, and the internal combustion engine (ICE) as the technology to convert the energy – contained within gasoline – to the energy service of mobility. [Weaver et al. (2000b), 247]

Several requirements need to be taken into account in the decision which alternative technological direction to pursue [Weaver et al. (2000b), 247-248]:

- Sustainable mobility, based on efficient energy conversion technologies.
- A sustainable energy system, based on *renewable energy sources* (solar energy or hydropower for example) and clean *energy currencies* (hydrogen for example).
- A smooth transition to sustainability from the present unsustainable transport and energy configurations. This implies the minimization of mobility loss and disruption costs, and meeting environmental, economic, social and geo-political compatibility constraints.

Such combination of technologies is needed, because the requirement to use renewable energy sources inevitably leads to environmental inefficiencies in the early stages of the source-to-service energy chain. This loss in efficiency thus needs to be offset by additional gains in efficiency of the final conversion of the energy to end-mobility.
As transport in the developed world is characterized by high levels of mobility facilitated by well developed road networks, and by high levels of individual car ownership, the transformation of these current arrangements requires a transition to a radically different 'coherent and internally consistent systems solution'. [Weaver et al. (2000b), 249]

[76] The concept of *well-to-wheel efficiency* (or *source-to-wheel efficiency*) refers to the environmental efficiency – in terms of natural resources used, and of environmental emissions and impacts caused – of the combined stages in the *energy life cycle* as far as it is related to transportation. [Swedish National Road Administration (2001), vi, viii, 2]

The most important technological components of the transport system include the vehicles, vehicle propulsion technologies, the physical transportation infrastructure, technologies for traffic control, and the technologies for winning, refining and distribution. Since vehicle propulsion technologies have great influence on the upstream stages of the energy chain [77], they represent the core technology in the system. [Weaver et al. (2000b), 249]

As the source-to-wheel energy efficiency of the present transport system is very low [78], substantial efficiency improvements can be obtained through the – further – development of energy efficient technologies.
Because the ICE is a heat engine, there are physical limits though to this kind of improvements which cannot be overcome. [Weaver et al. (2000b), 253]

In order to develop an inherently low-polluting transport system, heat, renewables-based electricity, *renewable hydrogen* [Cole (2002), 14] and biomass-derived bio-fuels such as (m)ethanol are the only clean energy currencies to be used.
Since the cleanest and most efficient bio-fuels require *reforming* [Cole (2002), 6], electricity and hydrogen represent the two best options as *final energy currency*. [Weaver et al. (2000b), 254-255]

Electrical, electro-chemical or catalytic conversion technologies are the most efficient and are pollution-free, unlike the ICE. These technologies need to have much higher efficiencies because of the mentioned lower front-end environmental efficiencies of renewables.
These two energy currencies are in fact complementary [Barreto et al. (2003), 267], because [Weaver et al. (2000b), 255, 258]:

- Most renewable sources of energy are locked into electricity production, and electricity is not easy to store. Therefore these need to be converted into a storable chemical *energy buffer*. [Quakernaat (1995)]
- The conversion to hydrogen can also be *reversed* [Cole (2002), 19].
- The two carriers have fundamentally different characteristics, which enable them to be used in specific applications. [79]

Hydrogen and electricity are *secondary* – grid-delivered [Barreto et al. (2003), 277] – *energy carriers*, and their production consequently requires relatively high amounts of energy at high cost [Johansson et al. (1993)].
The chemical conversion to or production of hydrogen can be achieved through conversion and reforming of fossil fuels or biomass, or through *electrolysis* [Cole (2002), 6] of water with oxygen as the only by-product. Since recently, electricity can be directly and most efficiently be produced from hydrogen by means of electro-chemical conversion processes. [Weaver et al. (2000b), 258-259]

---

77 This is because each energy service technology is designed to work with a specific final energy currency. [Weaver et al. (2000b), 249]

78 It ranges between a maximum of about 16% and lower than 2%. The greatest loss of useful energy occurs in the conversion of gasoline to mobility in the ICE. [Weaver et al. (2000b), 253]

79 The essential difference is that electricity is the most appropriate energy carrier for short-distance and city transport, and hydrogen is best suited for long-distance transport. [Weaver et al. (2000b), 258]

Hydrogen as a fuel thus constitutes a versatile [80] energy currency, which is enhanced by the very fact that it can be produced – intermediately [Barreto et al. (2003), 276] – from a variety of fossil primary resources, and – in the longer term – from non-fossil primary resources. [Barreto et al. (2003), 267]

The key links in the *hydrogen energy chain* [Barreto et al. (2003), 271] are production, conditioning, transport, storage, distribution and final conversion to an energy service. [Weaver et al. (2000b), 259]

For production in transport applications, liquid natural gas (LNG) in particular can be used as a n intermediate fuel. The production cost of hydrogen from natural gas is also sufficiently low to compete with the current level of gasoline prices. [Weaver et al. (2000b), 259-260]

Hydrogen can be conditioned in three ways [Weaver et al. (2000b), 260], i.e. as a:

- Compressed gas (which is also a storage mode).
- Liquid (which is also a storage mode): at cryogenic temperatures, and transported and stored in insulated tanks.
- *Hydride*.

Although the inherent environmental characteristics of hydrogen as a fuel are superior to fossil fuels, their production and distribution cycle will always be less efficient than that of gasoline. As mentioned before, FC propulsion and drive systems are two to three times more efficient than ICEs and are thus required to overcome this lower upstream efficiency.

This would eventually allow to obtain an overall source-to-service efficiency of 28% by the hydrogen/FC-based system, compared to the maximum 16% efficiency of the current gasoline/ICE-based system. [Weaver et al. (2000b), 262-263]

5.2. *Recent developments in hydrogen-fuelled fuel cell technologies for automotive applications:*

Despite the huge potential of hydrogen-fuelled FC-driven transport applications [Barreto et al. (2003), 281], there presently exist technical – as well as safety [Cole (2002), 21; Barreto et al. (2003), 279] – obstacles in three broad areas [Weaver et al. (2000b), 269; Bevilacqua Knight Inc. (2001), 4-1 to 4-29]:

- The quality of the whole hydrogen energy chain, in terms of significant required performance and cost improvements [Barreto et al. (2003), 268].
- The problem of securing a fuel supply to the fuel cell.
- The power density of all hydrogen-fuelled FC-technologies is still too low to be practical for transport applications.

Apart from the mentioned efficiency and environmental advantages, FCs need not to be recharged as opposed to batteries. Furthermore, the former are quiet and can be designed for any desired power output. [Weaver et al. (2000b), 269]

[80] Supply infrastructures can be developed according to the feedstocks available in different regions.

For the use in vehicles, the *proton exchange membrane* (PEM) *FC* [Cole (2002), 7, 9] is seen as the best FC-technology option [Cole (2002), 7] by many engineers and practitioners, although this then poses the problem of high quantities of platinum needed. [Weaver et al. (2000b), 271]

Until 2000, three approaches had been followed in the development of practical demonstration vehicles [Weaver et al. (2000b), 271-272]:

- A straightforward PEM fuel cell using industrial-quality elemental hydrogen, carried on board the vehicle.
- A hybrid design combining a battery and a *phosphoric acid FC* [Cole (2002), 7, 10].
- A hybrid design combining a battery and an *alkaline FC* [Cole (2002), 7, 10].

In terms of *transition phases*, we are currently experiencing the *pre-development phase* of a possible transition to a sustainable transport system. [Rotmans et al. (2000), 2]
Within this phase, the phases of *modelling and simulation*, and of *prototype building and testing* [Weaver et al. (2000b), 274] have largely been completed. The next phase in pre-development [81] consists of *beta-testing*, demonstration or *pilot* [Bevilacqua Knight Inc. (2001), 3-4 to 3-7] projects of hydrogen-fuelled FC vehicles in real-life conditions.

Section 5.3 covers two examples of such finished demonstrations of public transport buses in California, USA.

5.3. The CaFCP's real-life demonstration of a new bus concept:

Only a sound combination of R&D3 activities [Levin et al. (2003), 1] with commercial development will allow to achieve the necessary substantial improvements in the two technology systems and in their cost structures. [Barreto et al. (2003), 268]

On April 20, 1999 eight charter members announced the California Fuel Cell Partnership (CaFCP). The Partnership 'originated from a mutual desire to demonstrate FC technology and promote the consumer market'. [California Fuel Cell Partnership (2001)]

The CaFCP's Steering Committee adopted an 'Environmental and Energy Statement of Intent' in July 2000 which goes as follows: *'The CaFCP is committed to promoting FC vehicle commercialization as a means of moving toward a sustainable energy future, increasing energy efficiency and reducing or eliminating air pollutants and greenhouse gas emissions'*. [California Fuel Cell Partnership (2001)]

Its organizational structure is composed of a central Steering Committee, an Executive Director, the Environmental Team, and the Communications Team.
Further down are five working groups of which the Bus Team, the Fuels Team and the Safety and Operations Team are the most relevant to contact for my pilot. [California Fuel Cell Partnership (2001), 8]

[81] This is just before or in the beginning of the eventual *take-off phase* [Rotmans et al. (2000), 2] or *initial market introduction* [Bevilacqua Knight Inc. (2001), 3-8 to 3-12].

In 1999, the first alternative fuel, FC-driven bus demonstration in the regular service of public transportation agencies, was started in California, USA under the auspicies of the CaFCP.
In the case of California, the demonstration of FC buses are part of a series of alternative-vehicle demonstration projects. The actual demonstration is done by three city or regional public transportation agencies [82].

Selected automotive transportation applications – i.e. public and private vehicle fleets [Levin et al. (2003), 1] – could hold the key to stimulate the initial growth of the hydrogen market as niche market.
This growth would increasingly justify the deployment of larger-scale production and transportation facilities, when demand develops and becomes more geographically dense. [Eudy et al. (2002), 1-2; Barreto et al. (2003), 268]

Since then, these testing activities are or are to be [Northeast Advanced Vehicle Consortium (2003), http://www.navc.org/planning.html] undertaken in various parts of the world [Walsh (2003), 3-4; Odaka (2003), 3-5] with the following – i.e. knowledge development – objectives [Baxter (2003), 6]:

- Demonstrate FC-based vehicle technology under different topographic conditions.
- Demonstrate FC-vehicle fuelling infrastructure under different climatic conditions.
- Explore the path to *niche*- [Barreto et al. (2003), 268] and eventually mass-market commercialization [Baxter (2003), 12].
- Study and compare the environmental properties of the various technologies from well-to-wheel.
- Increase public awareness and assess public acceptance of the application of these technologies in their daily use.

In view of the already invested amounts of capital, one can argue that the preparation and pursuit of FC-bus demonstrations involve considerable *sunk investments*. Moreover, the involved CIS organizations pursue strategies of keeping open several *transition paths*, of 'hedging their bets', and of increasingly preparing themselves to serve niche markets.

Testing typically occurs in multi-year projects, which are co-financed and otherwise supported by national and state governments and their agencies, and by the private sector.
For the pilot case study, I focus on the demonstrations, which were run by AC Transit [83] between 2001-2002 and 2002-2003. [Baxter (2000); California Fuel Cell Partnership (2001), 15]

In the context of its 'Fuel Cell Program' [Levin et al. (2003), 4-5], the following CaFCP Partners were involved in these two demonstrations [Alameda-Contra Costa Transit District (2003), 9-10]:

- Automotive Partner: DaimlerChrysler.
- Energy Partners: BP, Chevron/Texaco and Shell Hydrogen.

---

[82] These agencies are 'Associate Partners' within the CaFCP, and are SunLine Transit Agency (Coachella Valley), Alameda-Contra Costa Transit (East Bay Area) (or AC Transit), and Santa Clara Valley Transportation Authority. [California Fuel Cell Partnership (2001), 15]

[83] AC Transit is the 3rd largest transit agency and the 3rd largest bus-only operator in the USA. For a number of reasons, the agency can be regarded as a model demonstration site. The District's Board of Directors subsequently adopted a policy to pursue the development of the technology by seeking membership in the CaFCP and applying for multiple grants to fund its program. [Levin et al. (2003), 2-4]

- Fuel Cell Technology Partner: Ballard Power Systems.
- Government Partners: California Air Resources Board, California Energy Commission, South Coast Air Quality Management District, US Department of Energy (DOE-NREL), US Department of Transportation, US Environmental Protection Agency.
- Associate Partners: AC Transit, Praxair, Proton Energy Systems Inc.
- 'Intermediairy': University of California at Davis ('Hydrogen Bus Technology Validation Program).

Following its initial test of the ZEbus, AC Transit staff recognized the potential of FCs and the importance of taking a leadership role in developing the technology. [Levin et al. (2003), 3] Performance testing, and reliability and durability issues, education of the public and employee development were high on the agenda. [Alameda-Contra Costa Transit District (2003), 5, 12]

In terms of fuel stations, AC Transit's status is that it required fuelling and hydrogen-related building upgrades. [Baxter (2000)]

The evaluation of the program was carried out by the DOE's National Renewable Energy Laboratory, in collaboration with the University of California at Davis. [Alameda-Contra Costa Transit District (2003), 15]

Various federal and state governments and their agencies provided the substantial funding for the preparation and testing activities of AC Transit's 'Fuel Cell Program'. [Alameda-Contra Costa Transit District (2003), 8]

6. Used references:

Alameda-Contra Costa Transit District. 2003. Fuel cell development program. Presentation http://new.calstart.org/programs/chdvc/03presentations/ACTransitPresentation.pdf, July 19, 2003.

Allenby BR. 2000. The fallacy of 'green technology'. In *American Behavioural Scientist* 44(2): 213-228.

Archibugi D, Iammarino S. 2002. The globalization of technological innovation: definition and evidence. In *Review of International Political Economy* 9(1): 98-122.

Barreto L, Makihira A, Riahi K. 2003. The hydrogen economy in the 21st century: a sustainable development scenario. In *International Journal of Hydrogen Energy* 28(3): 267-284.

Baxter S. 2000. California fuel cell partnership. Driving for the future. Presentation for the *United Nations Development Program*. New York, NY, USA.

Baxter S. 2003. Fuel cells and hydrogen in California. Presentation at the *Power and Motion Symposium*. Sunnyvale, CA, USA.

Bevilacqua Knight Inc. 2001. *Bringing Fuel Cell Vehicles to Market: Scenarios and Challenges with Fuel Alternatives*. Consultant study report prepared for the California Fuel Cell Partnership. Hayward, CA, USA.

Boons FAA, Berends, M. 2001. Stretching the boundary: the possibilities of flexibility as an organizational capability in industrial ecology. In *Business Strategy and the Environment* 10(2): 115-124.

Brown JS, Duguid P. 1991. Organizational learning and communities-of-practice: towards a unified view of working, learning and innovation. In *Organization Science* 2(1): 40-57.

Buckley PJ, Glaister KW, Husan R. 2002. International joint ventures: partnering skills and cross-cultural issues. In *Long Range Planning* 35(2): 113-134.

California Fuel Cell Partnership. 2001. California fuel cell partnership. Driving for the future. Presentation. CaFCP: West Sacramento, CA, USA.

Carley M, Christie I. 2000a. Organizational ecology and innovative management. In *Managing for Sustainable Development*. Earthscan Publications Ltd.: London, UK.

Carley M, Christie I. 2000b. Developing action networks for environmental management. In *Managing for Sustainable Development*. Earthscan Publications Ltd.: London, UK.

Clarke SF. 1998. Sustainable technology management: the role of networks of learning. In *Sustainability Strategies for Industry. The Future of Corporate Practice*. Roome NJ (ed.). Island Press: Washington, DC, USA.

Clarke SF. 1999. *Knowledge Networks and Sustainable Technology Management: an International Study of Organizational Practice*. Doctoral thesis. Schulich School of Business, York University: York, ON, Canada.

Clarke SF, Roome NJ. 1995. Managing for environmentally sensitive technology: networks of collaboration and learning. In *Technology Analysis and Strategic Management* 7(2): 191-215.

Clarke SF, Roome NJ. 1999. Sustainable business: learning-action networks as organizational assets. In *Business Strategy and the Environment* 8(5): 296-310.

Cohen W, Levinthal D. 1990. Absorptive capacity: a new perspective on learning and innovation. In *Administrative Science Quarterly* 35: 128-152.

Cole JA. 2002. Hydrogen – the fuel of the future. Presentation to *COMET 2002*. University of Southern California: Los Angeles, CA, USA.

Das TK, Teng B-S. 2000. Instabilities of strategic alliances: an internal tensions perspective. In *Organization Science* 11(1): 77-101.

Ding HB, Peters LS. 2000. Inter-firm knowledge management practices for technology and new product development in discontinuous innovation. In *International Journal of Technology Management* 20(5-8): 588-600.

Dunwoody C. 2003. CaFCP fuel cell bus program: 2002 progress, 2003 plans. Presentation at the *International Symposium on Fuel Cell Vehicles*. Tokyo, Japan.

Dyer J, Nobeoka K. 2000. Creating and managing a high-performance knowledge-sharing network: the Toyota case. In *Strategic Management Journal* 21: 345-367.

Edler J, Meyer-Krahmer F, Reger G. 2002. Changes in the strategic management of technology: results of a global benchmarking study. In *R&D Management* 32(2): 149-164.

Emery FE. 1983. Referent organizations and the development of inter-organizational domains. In *Human Relations* 36(3): 269-284.

Emery FE, Trist EL. 1965. The causal texture of organizational environments. In *Human Relations* 18: 21-35.

Eudy L, Parish R, Leonard J. 2002. Hydrogen fuel cell bus evaluation. Proceedings of the 2001 *DOE Hydrogen Program Review*. US Department of Energy's National Renewable Energy Laboratory: Golden, CO, USA.

European Commission, High Level Group for Hydrogen and Fuel Cells. 2003. *Hydrogen Energy and Fuel Cells. A Vision of our Future*. Summary report. Office for Official Publications of the European Communities: Luxembourg.0000000

European Commission, Directorate-General for Research. 2003. *European Fuel Cell and Hydrogen Projects 1999 – 2002*. EUR 20718. Office for Official Publications of the European Communities: Luxembourg.

Fiol CM, Lyles MA. 1985. Organizational learning. In *The Academy of Management Review* 10(4): 803-813.

Florida R. 1997. The globalization of R&D: results of a survey of foreign-affiliated R&D laboratories in the USA. In *Research Policy* 26(1): 85-103.

Gargiulo M, Benassi M. 2000. Trapped in your own net ? Network cohesion, structural holes, and the adaptation of social capital. In *Organization Science* 11(2): 183-196.

Geels F, Kemp R. 2000. *Transities vanuit Socio-Technisch Perspectief*. Report for the study 'Transitions and Transition Management'. ICIS and MERIT: Maastricht, the Netherlands.

George VP, 1995, Globalization through inter-firm cooperation – technological anchors and temporal nature of alliances across geographical boundaries. In *International Journal of Technology Management* 10(1): 131-145.

Hagedoorn J, Link AN, Vonortas NS. 2000. Research partnerships. In *Research Policy* 29(4-5): 567-586.

Halme M. 2001. Learning for sustainable development in tourism networks. In *Business Strategy and the Environment* 10(2): 100-114.

Hamel G. 1991. Competition for competence and inter-partner learning within international strategic alliances. In *Strategic Management Journal* 12: 83-103.

Hamel G. 1994. The concept of core competence. In *Competence-Based Competition*. Hamel G and Heene A (eds.). John Wiley: Chichester, UK.

Harrison JS, Hitt MA, Hoskisson RE, Ireland RD. 2001. Resource complementarity in business combinations: extending the logic to organizational alliances. In *Journal of Management* 27: 679-690.

Hartman CL, Hofman PS, Stafford ER. 1999. Partnerships: a path to sustainability. In *Business Strategy and the Environment* 8(5): 255-266.

Hitt MA, Ireland RD, Lee HU. 2000. Technological learning, knowledge management, firm growth and performance: an introductory essay. In *Journal of Engineering and Technology Management* 17(3-4): 231-246.

Holmqvist M. 2003. A dynamic model of intra- and inter-organizational learning. In *Organization Studies* 24(1): 95-123.

Howell LJ, Hsu JC. 2002. Globalization within the auto industry. In *Research-Technology Management* 45(4): 43-49.

Inkpen AC. 1996. Creating knowledge through collaboration. In *California Management Review* 39(1): 123-140.

Inkpen AC. 2000. A note on the dynamics of learning alliances: competition, cooperation, and relative scope. In *Strategic Management Journal* 21: 775-779.

Inkpen AC, Beamish PW. 1997. Knowledge, bargaining power, and the instability of international joint ventures. In *Academy of Management Review* 22(1): 177-202.

Inkpen AC, Dinur A. 1998. Knowledge management processes and international joint ventures. In *Organization Science* 9(4): 454-468.

Ireland RD, Hitt MA, Vaidyanath D. 2002. Alliance management as a source of competitive advantage. In *Journal of Management* 28(3): 413-446.

Kale P, Singh H, Perlmutter H. 2000. Learning and protection of proprietary assets in strategic alliances: building relational capital. In *Strategic Management Journal* 21(3): 217-237.

Kemp R. 2002. *Synthesis Report of the 1st BLUEPRINT workshop* Environmental Innovation Systems. January 23-24, 2002. Brussels, Belgium.

Kemp R, Rotmans J. 2001. The management of the co-evolution of technical, environmental and social systems. Paper for the international conference *Towards Environmental Innovation Systems*. September 27-29, 2001. Garmish-Partenkirchen, Germany.

Khanna T. 1998. The scope of alliances. In *Organization Science* 9(3): 340-355.

Khanna T, Gulati R, Nohria N. 1998. The dynamics of learning alliances: competition, cooperation and relative scope. In *Strategic Management Journal* 19: 193-210.

Knight L. 2002. Network learning: exploring learning by inter-organizational networks. In *Human Relations* 55(4): 427-454.

Koza MP, Lewin AY. 1998. The co-evolution of strategic alliances. In *Organization Science* 9(3): 255-264.

Kumar R, Nti KO, 1998. Differential learning and interaction in alliance dynamics: a process and outcome discrepancy model. In *Organization Science* 9(3): 356-367.

Larsson R, Bengtsson L, Henriksson K, Sparks J. 1998. The inter-organizational learning dilemma: collective knowledge development in strategic alliances. In *Organization Science* 9(3): 285-305.

Lei DT. 1997. Competence-building, technology fusion and competitive advantage: the key roles of organizational learning and strategic alliances. In *International Journal of Technology Management* 14(2-4): 208-237.

Levin J, Miller M, Eudy L. 2003. Fuel cells for the transportation industry: developing a credible demonstration program on the path to commercialization. WHEC paper for AC Transit. US Department of Energy's National Renewable Energy Laboratory: Golden, CO, USA.

Lorenzoni G, Lipparini A. 1999. The leveraging of inter-firm relationships as a distinctive organizational capability: a longitudinal study. In *Strategic Management Journal* 20(4): 317-338.

Madhok A, Tallman SB. 1998. Resources, transactions and rents: managing value through inter-firm collaborative relationships. In *Organization Science* 9(3): 326-339.

March GJ. 1991. Exploration and exploitation in organizational learning. In *Organization Science* 2/1.

Narula R, Hagedoorn J. 1999. Innovating through strategic alliances: moving towards international partnerships and contractual agreements. In *Technovation* 19(5): 283-294.

Niosi J. 1999. The internationalization of industrial R&D. From technology transfer to the learning organization. In *Research Policy* 28: 107-117.

Nooteboom B. 1999. The dynamic efficiency of networks. In *Interfirm Networks. Organization and Industrial Competitiveness*. Grandori A. (ed.). Routledge: London, UK.

Northeast Advanced Vehicle Consortium. 2003. Fuel cell buses. http://www.navc.org/whohasbuses.html and http://www.navc.org/planning.html, July 19, 2003.

Odaka, M. 2003. R&D trend and subjects for safety and environment issues of FC buses. Presentation at the *International Symposium on Fuel Cell Vehicles*. Tokyo, Japan.

Oliver AL. 2001. Strategic alliances and the learning life-cycle of bio-technology firms. In *Organization Studies* 22(3): 467-489.

Oliver AL, Ebers M. 1998. Networking network studies: an analysis of conceptual configurations in the study of inter-organizational relationships. In *Organization Studies* 19(4): 549-583.

Osborn RN, Hagedoorn J. 1997. The institutionalization and evolutionary dynamics of inter-organizational alliances and networks. In *Academy of Management Journal* 40(2): 261-278.

Pfeffer J, Salancik GR. 1978. *The External Control of Organizations*. Harper and Row: New York, NY, USA.

Powell WW. 1990. Neither market nor hierarchy: network forms of organization. In *Research in Organizational Behaviour* 12: 295-336.

Powell WW, Koput KW, Smith-Doerr L. 1996. Inter-organizational collaboration and the locus of innovation: networks of learning in biotechnology. In *Administrative Science Quarterly* 41: 116-145.

Ragin CC. 1994a. The process of social research: ideas and evidence. In *Constructing Social Research. The Unity and Diversity of Method*. Pine Forge Press: Thousand Oaks, CA, USA.

Ragin CC. 1994b. Using qualitative methods to study commonalities. In *Constructing Social Research. The Unity and Diversity of Method*. Pine Forge Press: Thousand Oaks, CA, USA.

Ragin CC. 1994c. Using comparative methods to study diversity. In *Constructing Social Research. The Unity and Diversity of Method*. Pine Forge Press: Thousand Oaks, CA, USA.

Ragin CC. 1994d. Glossary/Index. In *Constructing Social Research. The Unity and Diversity of Method*. Pine Forge Press: Thousand Oaks, CA, USA.

Roome NJ. 2000. Globalization and Sustainable Development – toward a Transatlantic Agenda. In *Security, Trade, and Environmental Policy: a US/European Union Transatlantic Agenda*. Bonser C (ed.). Kluwer Academic Publications: Dordrecht, the Netherlands.

Roome NJ. 2001a. *Metatextual Organizations – Innovation and Adaptation for Global Change*. Erasmus University Rotterdam, the Netherlands.

Roome NJ. 2001b. Conceptualizing and studying the contribution of networks in environmental management and sustainable development. In *Business Strategy and the Environment* 10(2): 69-76.

Rotmans J, Kemp R, van Asselt M, Geels F, Verbong G, Molendijk K. 2000. *Transities en Transitie-Management. De Casus van een Emissie-arme Energievoorziening*. ICIS report. Maastricht, the Netherlands.

Ruigrok W, van Tulder R. 1995. Rival views of globalization. In *The Logic of International Restructuring*. Routledge: London, UK.

Shenkar O, Li J. 1999. Knowledge search in international cooperative ventures. In *Organization Science* 10(2): 134-143.

Smith K. 2002. Environmental innovation in a systems framework. Paper presented at the 1st BLUEPRINT workshop *Environmental Innovation Systems*. January 23-24, 2002. Brussels, Belgium.

Swedish National Road Administration. 2001. *Well-to-Wheel Efficiency. For Alternative Fuels from Natural Gas or Biomass*. SNRA: Borlänge, Sweden.

Sydow J, Windeler A. 1998. Organizing and evaluating inter-firm networks: a structurationist perspective on network processes and effectiveness. In *Organization Science* 9(3): 265-284.

Uzzi B. 1996. The sources and consequences of embeddedness for the economic performance of organizations: the network effect. In *American Sociological Review* 61(4): 674-698.

van den Bosch FAJ, Volberda HW, de Boer M. 1999. Co-evolution of firm absorptive capacity and knowledge environment: organizational forms and combinative capabilities. In *Organization Science* 10(5): 551-568.

von Zedtwitz M, Gassmann O. 2002. Market versus technology drive in R&D internationalization: four different patterns of managing research and development. In *Research Policy* 31(4): 569-588.

Walsh B. 2003. Fuel cell bus projects: what to expect in 2003. In *Fuel Cell Catalyst* 3(2): 3-4.

Weaver P, Jansen L, van Grootveld G, van Spiegel E, Vergragt PJ. 2000a. Capacity-building for sustainable technology development and innovation. In *Sustainable Technology Development*. Greenleaf Publishing Ltd.: Sheffield, UK.

Weaver P, Jansen L, van Grootveld G, van Spiegel E, Vergragt PJ. 2000b. Strategic niche management: the case of the mobile hydrogen fuel cell. In *Sustainable Technology Development*. Greenleaf Publishing Ltd.: Sheffield, UK.

Westley F, Vredenburg H. 1997. Inter-organizational collaboration and the preservation of bio-diversity. In *Organization Science* 8(4): 381-403.

Williams R, Markusson N. 2002. Knowledge and environmental innovations. Paper presented at the 1st BLUEPRINT workshop *Environmental Innovation Systems*. January 23-24, 2002. Brussels, Belgium.

Winn SF, Roome NJ. 1993. R&D management responses to the environment: current theory and implications to practice and research. In *R&D Management* 23: 147-160.

Yin RK. 1994a. Introduction. In *Case Study Research. Design and Methods*. Sage Publications: London, UK.

Yin RK. 1994b. Designing single- and multiple-case studies. In *Case Study Research. Design and Methods*. Sage Publications: London, UK.

Yin RK. 1994c. Conducting case studies. Preparing for data collection. In *Case Study Research. Design and Methods*. Sage Publications: London, UK.