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VERTICAL LINKAGES AND INNOVATION

Gamal Atallah, University of Ottawa and CIRANO
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Working Paper 2006-05

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IC 60081

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Abstract

It has long been suspected that the organization and ownership of firms could affect the innovation performance of industries in Canada by influencing economic incentives to generate new products and processes. This paper provides a general overview of the theoretical and empirical literature on the relationship between the organization of firms and industries and their performance in terms of innovation. To this end, the paper examines the evidence of vertical linkages across the supply chain from the points of view of innovation, research and development collaboration, and knowledge flows. In doing so, the paper reviews the evidence on the effects of ownership and concentration, the importance of the nature of the vertical relationship between upstream and downstream firms, and the role played by appropriability and knowledge spillovers in the organization for the performance of innovation activities, among others. The paper also looks at the role of multinationals and the extent to which this type of organization benefits host countries in terms of innovation activities. Although no unifying policy conclusions emerge from this literature, the paper offers broad micro-economic policy recommendations such as the importance of good micro-economic policy for innovation activities, a sound micro-economic environment for research and skills development, and the importance of facilitating collaborative arrangements between firms in innovation related activities. Finally, the paper indicates that institutional differences between countries should be taken into consideration for the identification of comparative technological, organizational, and institutional advantages.

Key words: innovation, research and development, industry organization, supply chains, vertical arrangements, firm ownership

Résumé

On pense depuis longtemps que l'organisation et la propriété des entreprises ont peut-être des répercussions sur la performance des industries canadiennes en matière d'innovation en influant sur les incitatifs économiques en faveur de la création de produits et de procédés. L'auteur donne un aperçu de la documentation théorique et empirique sur le lien entre l'organisation des entreprises et des industries et la performance de celles-ci en matière d'innovation. Ainsi, il examine la présence de liens verticaux dans la chaîne d'approvisionnement du point de vue de l'innovation, de la collaboration en recherche-développement et des flux de connaissances. De plus, il se penche sur les effets de la propriété et de la concentration, l'importance de la nature du lien vertical entre entreprises en amont et en aval et le rôle du pouvoir d'exclusivité et des retombées du savoir au sein de l'organisation pour ce qui est de l'exécution d'activités novatrices, entre autres. L'auteur examine également le rôle des multinationales et la mesure dans laquelle ce genre d'organisation profite aux pays d'accueil sur le plan des activités novatrices. Bien qu'aucune conclusion de portée générale n'émerge de cette documentation, l'auteur formule de grandes recommandations en matière de politique économique, notamment l'importance d'une politique micro-économique judicieuse pour les activités novatrices, d'un environnement micro-économique sain pour la recherche et le développement des compétences et de la facilitation de la conclusion d'ententes de collaboration au chapitre des activités liées à l'innovation entre les entreprises. Enfin, selon l'auteur, il faudrait tenir compte des arrangements institutionnels entre les pays pour cerner les avantages comparatifs technologiques, organisationnels et institutionnels.

Mots clés : innovation, recherche-développement, organisation industrielle, chaînes d'approvisionnement, accords verticaux, propriété d'entreprise

SUMMARY

The vertical organization of an industry affects its capacity to generate new products and processes. Although there exists a large literature dealing with different facets of the relationship between vertical organization and innovation, there is no unifying framework for the study of this topic. This paper provides a general overview of the theoretical and empirical literature, identifies the main findings, examines differences between industries and countries, and points to the research gaps. In particular, we examine the literature on vertical linkages across the supply chain, from the points of view of innovation, collaboration, and information sharing. The effect of ownership and market concentration on vertical organization and innovation, the types of hierarchical relationships between upstream and downstream firms, the impact of different vertical relationships on different types of innovations and the role of appropriability and knowledge spillovers are studied. Also, the strategies of allocating R&D by multinationals between home and host countries and the extent to which it benefits the host countries are examined.

Understanding the level and distribution of innovation activities along the global vertical supply chain can help governments attract R&D-related FDI in areas most suitable to the local economy, and from firms and countries most likely to find this investment profitable. Policy should support the R&D activities of local suppliers, make them more attractive to foreign firms, increase their absorptive capacities, and in turn encourage multinationals to engage in joint research with them. Also, features such as a good support infrastructure, a good environment for specialist research, engineering skills, and awareness of the importance of collaboration make it easier to attract foreign manufacturing and more particularly foreign R&D. Moreover, institutional differences between countries should be taken into account in the identification of their comparative (technological, organizational, and institutional) advantages.

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1. INTRODUCTION[1]

The vertical organization of an industry affects its performance, including its capacity to generate new products and processes. The importance of innovation in the supply chain for the Canadian Government is highlighted by the creation of the *Retail Supply Chain Industry Panel* by the Federal Government in 2002 to "contribute the perspective of the industry to Canada's Innovation Strategy."[2]

Although there exists a large literature dealing with different facets of the relationship between vertical organization and innovation, there is no unifying framework for the study of this topic. A general overview of the issues studied in the literature will help identify the main findings and regularities, understand the differences between industries and countries, and point to the research gaps. This paper examines the literature on vertical linkages across the supply chain, from the points of view of innovation, collaboration, and information sharing. Based on the available theoretical knowledge and empirical evidence, the paper will identify the main factors determining the organization of the production of knowledge,[3] as well as its level and intensity, along the supply chain. The literature on the topics covered here is large and interdisciplinary, as it relates to economics, management, and technology. Therefore, the review is not exhaustive, but rather points to the important developments in the literature. The experiences of many Canadian and non-Canadian industries will be used to illustrate the different concepts.

The paper is organized as follows. Section 2 will examine the advantages and disadvantages of different levels of vertical integration for innovation. In section 3, we will analyse hierarchical relationships between upstream and downstream firms and the effect of firm dependency on innovation. Section 4 will study the impact of market concentration on upstream and downstream R&D. The effect of vertical relationships on the different types of innovations will be the topic of section 5. The role of appropriability and knowledge exchange and their interaction with vertical R&D

[1] The authors would like to thank Sanaul Mostafa for research assistance.

[2] At the industry level, an example is provided by Microsoft, which works with the automotive industry on innovation across the supply chain, and has recently launched the *Peak Performance Initiative*, designed to improve services, collaboration and performance across the supply chain (Microsoft Corporation, 2005).

[3] Throughout the paper, the terms "knowledge", "innovation", "information" all refer to innovation-related information.

cooperation will be examined in section 6. Section 7 will study how multinationals allocate their innovation activities between the home and host countries, and the extent to which they benefit the host country technologically. Conclusions, policy issues and suggestions for future research will be presented in the last section.

2. OWNERSHIP

This section addresses the effect of ownership on the relationship between vertical organization and innovation and on the organization of R&D. Even as internal R&D has been the dominant research mode for large firms throughout the twentieth century, technology trade (through licensing, R&D cooperation, outsourcing) has been on the rise during the last quarter of the past century. This increase in technology trade can take the form of horizontal linkages (with competitors), vertical linkages (with suppliers/distributors), or non-trade related organizations (with public research laboratories, universities, research institutes). Understanding the vertical organization of R&D, as well as its relationship to vertical linkages more generally, requires situating it within the overall rise in external research relationships and in tradability of technology. Thus, understanding the determinants of firms' decisions to develop technology in-house, buy it on the market, or develop it jointly with other organizations, is key to understanding the vertical organization of innovative activities.

Production-oriented firms undertake generic value-adding activities along the value chain. These include *primary* (inbound logistics, production, outbound logistics, sales, marketing and maintenance) and *support* (administrative infrastructure, human resource management, research and development and procurement) activities (Porter, 1985). R&D as a support activity is seen as the driver of innovations within firms. The literature recognizes that successful innovation requires R&D activities to be combined with other functions of the value chain (Pisano, 1991).

From the perspective of a firm, the scope of the value chain need not be binding. The firm chooses its scope by determining which activities are performed in-house and which are performed externally. In other words, a firm seeks to position itself along a value chain, which also encompasses forward and backward relationships. A firm, part of a value chain, is increasingly concerned about technological advancement and innovation which does not stop at the firm's level but rather encompasses the industry as a whole.

When firms are understood to be embedded in the value chain, a rational decision on their boundaries of operations along the value chain is a core issue, realizing the fact that ultimately the whole value chain matters for the growth of the industry and thus for the long-term growth and profitability of the firm. In other words, by fixing its boundaries the firm also defines the nature and scope of its vertical relationship (backward and forward). The choice of boundaries is also a decision on the nature and scope of its ownership.

It will be useful at this stage to distinguish between the different concepts used to represent the organization of activities within and outside the firm. The *value chain*, introduced by Porter (1985), is a series of activities whereby goods and services are transformed (usually from low-value raw materials to high-value products) within a company. These activities include primary activities (design, production, marketing, distribution) and support activities (accounting, human resources, R&D), and can be comprised within a single firm, or divided among several (usually vertically related) firms. When the value chain crosses many jurisdictions, it becomes a *global value chain*. The global value chain concept was introduced in the 1990s, sometimes under the label of *global commodity chains* (see, for example, Gereffi and Korzeniewicz, 1994). In an *integrated value chain* (or integrated value system), firms coordinate the flow of goods and services to optimize the efficiency of the chain, acting as an extended enterprise ((Papazogulu et al., 2000; Childe, 1998). This involves improved cooperation and communication between firms, relying heavily on information technology, especially electronic commerce and the Internet. The *supply chain*, a chain of activities executed by two or more firms to respond to customer orders (purchasing, transportation, logistics, etc.), can be seen as the precursor of the integrated value chain. Firms are moving from *supply chain management* to (global) *value chain integration*.

2.1 Types of vertical relations and ownership

Depending on the internalization and externalization of certain parts of the value chain, the vertical relationships of a firm can be broadly classified into vertical integration, vertical disintegration, and hybrid approaches (sometimes also called *virtual* *integration*) (Robinson and Casalino, 1996). Vertical integration includes those elements of the value chain over which it has property rights and thus also control. A firm can expand the scope of vertical integration through acquisitions, mergers and creation of new entities to internalize additional elements.

The firm may also opt for the externalization of certain elements of the value chain. A firm may externalize certain functions because it wants to focus and specialize on certain core activities. In this case, the firm has no ownership rights on the assets and processes of the disintegrated/externalized elements of the value chain, except that it maintains a buyer-seller relationship with other firms performing that function. Technology procurement (licensing, patents), selling out of existing plants, outsourcing, and sub-contracting, are examples of disintegration.

For activities outside the boundaries of the firm, the issue of the nature of the vertical relationship arises. Although the firm has externalized certain elements of the value chain, it may prefer maintaining certain degree of ownership or control, which leads to a hybrid structure between integration and disintegration. This category captures a wide range of vertical relationships. Procurement of minority/majority shares, partnership agreements with other firms, sponsoring, resource sharing, co-financing, networking, joint-venture, alliance building, etc. are possible forms of such relationships. Understanding the strengths and weaknesses of each structure is essential to the analysis of the location of R&D activities along the value chain.

2.2 Advantages and disadvantages of different vertical relationships

All three vertical structures have their advantages and disadvantages. Here the focus is on the effects of the level of integration of innovation activities.

2.2.1 Vertical integration

Advantages of vertical integration are manifold: It protects intellectual property rights, brings more bargaining power of the producer with the suppliers and encourages investment (Acemoglu et al., 2005). Many factors support the integration of R&D activities and entities performing those activities. From an innovation perspective, the coordination of basic research with development activities is necessary to benefit from scientific and manufacturing breakthroughs. Normally, the large vertically integrated firm can materialize this and exploit innovation. Japanese and Korean conglomerates are making use of many American discoveries and are considered to be the engine of growth (Robertson and Langlois, 1994). The vertically integrated firm has a direct contact with the market and knows about consumer's preferences, which can be used for research and product development and thus for product innovation. Subcontracting of key or core functions can have a negative effect on innovative capacities (Freel, 2000a). Large market size seems to encourage internal R&D (Love and Roper, 2002).

It is easy to find examples of successful innovation through vertical integration.[4] The U.S. automotive and chemical industries are two examples: these two industries have been historically characterized by high levels of vertical integration and high R&D intensity.[5] In both industries, firms were large enough to benefit from economies of scale through internal R&D, they possessed the knowledge required to perform R&D internally, a high level of vertical integration of the supply chain was perceived as necessary to achieve a global competitive position, and technological cooperation with competitors was not seen as key to success.

Suppliers are unlikely to invest in R&D which is specific to a particular buyer. Just as asset specificity creates the potential for hold-up for production factors, it makes outsourcing of R&D projects involving specific assets problematic. Search and negotiation costs must also be incurred in the outsourcing of an R&D project. At the same time, the outsourcing of R&D shares the same benefits as outsourcing in general: economies of scale and of specialization. Therefore, the transaction cost theory is part of the explanation of the vertical organization of R&D. This theory predicts that generic, low-risk R&D projects will be outsourced, whereas complex and risky projects will be executed in-house.

Technology contracts are highly incomplete. There is a high degree of uncertainty associated with the outcomes of the research process. Inputs to the research process are

[4] Some of the empirical studies considered in this paper use cross-industry data, while some other studies focus on one or a few industries. Care is required in generalizing the analysis and conclusions to other industries, especially in the case of case studies. Typically, industries with similar technological characteristics (traditional vs. high tech) exhibit similar characteristics.

[5] Although the U.S. automotive industry was characterized by subcontracting and long term contracts prior to World War II (Schwartz, 2000).

often hard to observe (in both quantity and quality), and the degree of success of the research project is not always verifiable (observable and measurable by a third party). The scope for opportunism in terms of underinvesting resources, leaking information to third parties, or inflating the potential of the new technology is particularly high for new technologies. All those factors increase the transaction costs of arm's length technological relationships, and explain why firms have often relied on internal technology development, even at the expense of duplications (many firms working on the same technology and developing it independently) and inefficiencies (the firm may develop a technology that is inferior to what is being developed elsewhere, or may develop the technology at a higher cost).

Citing the example of the health care industry, Robinson and Casalino (1996) argue that vertical integration has a potential for coordinated adaptation to changing environmental circumstances. Unity of control and direction towards the same goals and strategies are helpful in this regard. Research findings suggest that vertical integration is more likely if the firm is technology intensive.

Vertical integration of the R&D function is more likely in a market where the firm enjoys a relatively high market share. The idea is to become more competitive and protect the property rights arising from their research (Love and Roper, 2002). Piga and Vivarelli (2003) find that holding (controlling) firms have a tendency to position the R&D activity at a central level, i.e. have a centralized innovation strategy. On the other hand, firms selling most of their production to a small number of influential buyers are unlikely to integrate R&D. Similarly, a firm with a concentrated ownership structure and who needs both process and product R&D tends to seek external R&D partners.

The evolution of the pharmaceutical industry illustrates many of the issues arising in the vertical organization of R&D. There is a wide variety of R&D practices in this industry, including forward vertical integration by new biotechnology firms, backward integration by established firms, and various forms of collaboration (Pisano, 1991). Pisano observes that vertical integration is increasing in the biotechnology industry while collaborative arrangements continue to play a significant role. Firms, particularly the established and new technology-based ones pursue both forward and backward linkages (R&D capabilities, marketing and distribution). Established and new technology-based industries are integrating vertically because of high transaction costs attributed to other arrangements, complexity of process development and scale-up, and problems of protecting intellectual property rights. It is furthermore observed that biotechnology firms are no more run as an "R&D boutique". Instead, they are becoming a manufacturing industry. They are gaining more independence and ability to attain an improved share of manufacturing and marketing rights to products, and reducing their dependence on external partners.

Recently, the dominant trend in this industry has been toward more integration of the R&D function (Tapon, 1989; Tapon and Cadsby, 1996). This is due to many factors: a change in the way new drugs are tested and developed, technological linkages between the R&D stages, the need to work jointly with universities who possess the relevant expertise, and the market failures associated with contracting out R&D.

With regard to integration of the R&D function, the main criticism is the possible bureaucratization of the research and development processes. The R&D unit is seen as vulnerable to decreasing returns to scale. In order to achieve the economies of scale an internal R&D unit requires maintaining a beyond medium size set-up capable of conducting research activities ranging from fundamental research to product development. Normally the large firms are assumed to possess these capacities. The smaller ones may confine their research activities only to product development activities.

2.2.2 Vertical disintegration

The rationale for vertical disintegration is partly based on the disadvantages of vertical integration. Technological development, globalization and competitive pressure demand more flexible and disintegrated structures (Acemoglu et al., 2005). In addition, new firms face resource constraints and established firms may not be able to acquire capacities for further integration (forward and backward) (Pisano, 1991).

Some recent developments have tilted the trade-off toward external procurement and joint development. As the complexity of technology increases, firms realize they do not always possess all the competencies (and cannot acquire them) to master all the dimensions of a new product/process. Subcontracting can contribute to the diffusion of tacit knowledge when that knowledge is embodied (in people, technology, or products).

The greater ease with which technology can be traded creates the scope for an increase in the number of specialized (independent and upstream) technology suppliers (Arora et al., 2001).

In contrast to Schumpeter's view that characterizes large firms as the promoters of growth and progress, large firms are now seen less as a generator of innovation and more as an institutional response to innovation and growth through economies of scale. For innovation, a large number of competing firms with capacities to coordinate specialized divisions of labour is needed. They are in a position to work at the same wave length and undergo a continuous trial-error learning process with alternatives before an innovation is materialized. A vertically integrated large firm is unlikely to deliver this (Langlois, 1990).

Disintegration provides the room for specialization and promotes innovation. It allows management to focus on manufacturing and marketing. A survey among 228 small manufacturers in West Midland reveals that innovators make use of vertical linkages. A survey among 100 innovative SME shows that 89% of them maintain at least one crucial external link (Freel, 2000a).

Modularity, defined as breaking up of a complex system into discrete pieces which then communicate through standardized interfaces (Langlois, 2000), increases the need for vertical coordination. Taken further, modularity in product design leads to modularity in organizational design, as exemplified by the supply of flat panel displays to notebook computer manufacturers (Hoetker, 2002). In this case, outsourcing and new product development decisions become even more closely interconnected (Mikkola, 2000). Modularity also plays an important role in innovation in the audio components industry (Robertson and Langlois, 1992).

But modularity has its limits. Bargigli (2005) investigates the limits of modular networks by comparing *verticalised* firms, who produce in-house all the components of the final product, with *deverticalized* firms, who buy components from the market, based on a set of agent behaviour-based simulations. His results show that there is trade-off between complexity and the deverticalized innovation process. Modular networks reduce the sunk costs of investment and induce scale advantages through interaction with suppliers and customers. They also offer a higher speed of innovation due to specialization and at the same time reduce communication and coordination costs using open technological standards and codified information. However, the stability of the innovation architecture is required to guarantee the success of such networks. When it is hard to separate out sub-tasks of problems due to complex interdependencies, or when uncontrolled conditions affect sub-tasks in a complex way, the quality of results will decrease and the deterioration is proportional to the complexity of the problem. Bargigli also shows that verticalization is relatively better for all levels of complexity for the initial stages of product development (when the returns to innovation are assumed low and there is a high probability of failure).

Using the example of the semiconductor industry, Langlois (1990) shows that the rapid growth and development of the sector was made possible by external economies. The large firms fell relatively behind and remained dependent on external suppliers. The size, diversity, rapid development, and unknown character of the market for microcomputers suggest that a single firm can hardly develop in a decentralized market without relying extensively on external knowledge acquisition. The modularity of products in the microelectronics industry is seen as another reason for decentralization (Hoetkar, 2002). It allows the choice from a wide range of suppliers. IBM's disintegration can be understood in this way.[6]

An independent supplier serves a variety of customers, and can internalize the best practices in its products or services. It can also materialize economies of scale, which allows it to offer competitive prices. Independent research-intensive suppliers require strong IPRs to survive. Without strong patents, however, the investment in specialized firms who promote innovation is less likely. Strong IPRs facilitate the contracting out of R&D, and hence should favour external R&D over internal R&D (Arora and Merges, 2004).

The decision of new start-ups (which exist solely due to their new technology) is whether they should combine manufacturing operations with their research facilities and compete with existing larger firms, or whether they should license the new technology to existing manufacturers and focus on research. Their decision determines the

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[6] Vertical disintegration can affect not only the level, but also the composition, of R&D. For instance, the breakup of AT&T has resulted in a decrease in basic and applied research, but an increase in innovation activities as measured by patents and R&D (Rao, 2001).

configuration of the industry: either R&D or manufacturing are vertically integrated, or R&D is performed upstream by independent firms and then licensed to downstream producers. When licensing is chosen, small start-ups will have to live with their limited bargaining power and the imperfection of technology contracts. When, on the other hand, they opt for integration, they will have to acquire the complementary assets (manufacturing and marketing capacity) and compete head to head with larger firms with deep pockets (Arora et al., 2001).

Decentralization of the R&D function is now a common practice, although there are transaction problems and difficulties in transferring the technology. A growing technology market provides the opportunity for joint-ventures, licensing, partnerships, etc. Firms, depending on their position along the supply chain, can participate as buyers or sellers of technology. Managing innovation under a disintegrated R&D function involves monitoring of the technology markets and taking the challenge of finding the best option (Arora et al., 2001). On the other hand, the literature is critical about the "anti-commons" approach of disintegration. Fragmented intellectual property rights may hinder the innovation process. Many basic inventions, if protected for too long, may suppress other inventions.

For example, contractual R&D in the bio-technology sector is said to be difficult because a contract cannot sufficiently specify the scope (what product and process technologies to be commercialized), the form of deliverables (in what form will the relevant technologies be offered), the mode of performance assessment, the timing of achievement and the distribution of property rights (who owns the technology) Disputes may arise because collaboration agreements leave many issues open (Pisano, 1991).

2.2.3 Hybrid approaches

Firms may find the scope of vertical integration too wide and of disintegration too narrow. Therefore, they can opt for alternatives, which will allow them to keep a certain degree of control over that segment of the value chain. Joint ventures, partnerships, cooperation agreement, resource sharing, alliances, networking, etc. are examples.

Robertson and Langlois (1994) question whether either large vertically integrated firms or networks of specialized producers are the right responses. They find that the range of suitable alternatives is large and can vary. They also argue that the relative desirability of a certain structure depends on the nature, scope of technological change in the industry and effects of various product life cycle patterns. Robinson and Casalino (1996) find the context of innovation is complex and varied. Firm size, industry type, domestic versus international business, technology intensity, the degree of competition, product life cycle, legal context (intellectual property rights), etc. determine the right pattern of ownership along the value chain.

There is an increase in the "distributedness of innovation processes" in parallel to the increasing distributedness of production processes (Cooms and Metcalfe, 2000). This calls for governance structures which cross firms' boundaries. In particular, it has called for the emergence of *nexus agents* who coordinate knowledge creation and transmission across the network (Acha and Cusmano, 2005; Baranes, 1998). In this scheme suppliers play a greater role and also assume greater risks related to new technologies, assuming a more integrating role. The upstream petroleum industry constitutes an illustration of this phenomenon. The U.S. steel industry is another industry where there has been an increase in "coordination integration" (Williams and Griffin, 1996), in part due to the technological maturity of the industry. Surprisingly, the steel industry was characterized by these same decentralised vertical research arrangements between 1880 and 1910 (Knoedler, 1993).

The network form of coordination among players along the value chain is a loose and flexible entity without any hierarchy. The firms as members of the network can interact and exchange information, knowledge and competence in a timely manner and contribute to accelerated innovation. This type of inter-firm relationship favours distributed learning and system innovation along the value chain. It also tests internal expertise and learning capabilities. A networking concept of governance across firm boundaries will allow coordination among the relevant agents.

Hybrid approaches allow firms to specialize to the extent possible and maintain a working relationship with the value chain. For example, a firm may decide to opt out from basic research and concentrate more on applied research or on product and process development. It may collaborate with research organizations for basic research and can thus maintain linkages with the research agenda as a whole.

Hybrid approaches can bring many advantages to firms. For example, if a firm participates in the equity of the supplier, the firm exerts a certain control over his behaviour, which reduces uncertainty. In the case of a joint venture, the firm can articulate its agenda and negotiate with the partner from a strong footing. Moreover, the firm will have better sectoral information if it is in a network, it can advocate for more quality and innovation along the value chain to ensure the growth of the industry as a whole. A firm alone might not be in a position to achieve this.

A minimal level of participation is always required from both the producers and future users of the innovation. Rich and intense relations between users and producers, including training and joint development, are part of this relationship. Such a hybrid approach can be superior to both hierarchy -which limits incentives- and a purely commercial relationship -which minimizes interactions and where one of the parties (either the producer or the user) provide all the specifications of the new technology (Jacquier-Roux and Bourgeois, 2002). This hybrid approach requires specific mechanisms to avoid opportunism and safeguards. For example, vertical coordination is key to R&D and innovation in the U.S. and Canadian agri-food supply chains (Hobbs and Young, 2001); and Internet is one component of the technological innovation process along the supply chain in this industry (Green and Hy, 2002).

The use of external technologies requires firms to monitor their technological environment in order to identify the relevant technologies. Moreover, the development of internal absorptive capacities requires firms to actually perform R&D internally in order to develop the competencies to monitor their environment (Cohen and Levinthal, 1989). In addition, internal R&D increases the bargaining power of the firm engaged in licensing negotiations (Gans and Stern, 2000). Hence internal and external R&D can sometimes be complements, rather than substitutes.

Many factors determine the mix of internal and external R&D. The empirical evidence suggests that small firms tend to rely almost exclusively on either internal or external R&D, while large firms, and firms for whom absorptive capacity is important (proxied by the importance they give to internal information) tend to use a combination of both (Cassiman and Veugelers, 1998). Hybrid approaches suffer from some of the disadvantages of vertical disintegration. However, these disadvantages can be less severe here, as the firm can maintain a higher degree of influence over its partners. Since hybrid approaches often produce legally independent entities entrusted with a specific part of the value chain, conflicts of interest may arise, particularly in the case of a joint venture.

The Japanese *keiretsu* model of R&D collaboration between manufacturers and their suppliers ensures improvements of custom and semi-custom made products. The core firm transfers technology to the subcontracting firms and the scope of cooperation ranges from R&D activities to the process of designing and production of new products and producing them. Such collaboration may include that one or more directors from the core firm become shareholders in the subcontractor's firm. This type of vertical relationships is seen as innovation-friendly, long-term and conducive for competition (Suzuki, 1993). It is recognized in Europe and the U.S. as the major factor behind Japanese international competitiveness in the automobile sector.

3. HIERARCHICAL RELATIONSHIPS, DEPENDENCY AND THE SOURCES OF INNOVATION

The main issue in this section is what kind of hierarchical relationship exists between supplier firms and producing firms and how it affects the innovation behaviour of firms. Several authors have addressed the issue of supplier/customer dominance from different perspectives.

In a survey among British firms, Pavitt (2000) observes that in the traditional sectors of manufacturing and agriculture suppliers have a dominant status. The producing firms are rather small in size and have negligible R&D and engineering capabilities. The participation of the small firms in the innovation process is limited. They follow a cost minimization principle using the technology provided by the supplier. Process innovation seems to dominate the innovation dynamics in this case. The textile sector, for example, experiences a high proportion of process innovation. The producing firms have a high degree of dependency on external sources for process technology. In short, one could conclude that the main thrust of innovation activity (at least process innovation) remains with the suppliers if the sector faces a high number of small producing firms.

The situation is often different in high-tech sectors. For example, a survey among 93 suppliers of telecommunication services shows that suppliers have their own R&D

capability in addition to being engaged in collaborative R&D arrangements (Laamanen, 2005). Laamanen defines dependency in terms of a large portion of sales of a supplier made to a small number of clients, and finds that dependency can have a negative effect on supplier performance during industry downturn. He suggests that a supplier should perform R&D independently in addition to collaborative R&D with downstream firms, in order to reduce its vulnerability to the business cycle. This is because independent R&D makes it easier for the supplier to sell to other firms/industries. Moreover, having its own R&D is seen as positively related with the technological depth of a supplier's offerings and performance. The rationale for own R&D is also based on the need for absorptive capacity of the staff members. Internalization of part of the R&D function will include recruitment of staff members who can improve the technical knowledge of the firm, can assess knowledge and technology from external sources and absorb them if required for innovation (Freel, 2000a, 2000b). Hence dependency in general, whether it is in terms of sales, technology transfer or collaborative R&D can have a negative effect on suppliers.

In contrast, for small firms in the UK, innovators are found to have higher customer and supplier dependency, i.e. depend on a small number of customers and suppliers for a large portion of their sales (Freel, 2000b). This is surprising, given that theory predicts that a wider customer/supplier base provides more stability and better access to external information and knowledge, and helps the firm avoid technological lock-in and over-specialization. At the same time, a smaller number of customers and suppliers allows closer coordination, collaboration and trust, which should contribute positively to joint innovation efforts. This result suggests the importance of familiarity and trust in vertical linkages.

McLaren (1999) provides an explanation for the greater reliance of vertical relationships in Japan (relative to the West) on cost-sharing, informal arrangements, and specific investments by suppliers. The explanation lies in differences in the level of vertical integration between Japan and the U.S.. McLaren distinguishes between two types of non-contractible actions that can be taken by suppliers to improve their production process or the quality of the input they produce. The first are *autonomous investments*, which a supplier can undertake on its own (e.g. quality control). The second are *joint investments*; these are actions undertaken by a supplier which are fruitful only if complemented by some action by the buyer (e.g. adopting a superior design). In an arm's length relationship (a fixed-price contract, for example), the supplier has incentives to undertake the optimal amount of autonomous investments, but will underinvest in joint investments. Basically, because each party gets only part of the benefits from joint investments, both will underinvest. In contrast, in an informal arrangement (e.g. no contract), the outcome will be determined by bargaining and there will be some degree of cost sharing, so the supplier will underinvest in autonomous investments, but there will be more cooperation, which will result in higher joint investments. Now, the extent of underinvestment in autonomous investments under an informal arrangement will depend on its effect on the outside opportunities of the supplier. The more there are other potential buyers, the higher is the bargaining power of the supplier, and the more its autonomous investment gives it bargaining power over the buyer (because this investment makes its input more attractive to other buyers). In a market with a high level of vertical integration, there are few other potential buyers, and the underinvestment in autonomous investment is serious; thus firms will not rely on information arrangements with their subcontractors, but will opt for formal contracts. Therefore we should observe more formal contracts between firms and their independent suppliers in markets characterized by high levels of vertical integration, and the converse in markets dominated by subcontracting.

Moreover, any factor that increases the number of potential partners will have the same effect as a lower level of vertical integration. One such factor is the decrease in the cost of international transactions, which increases the number of non-integrated firms with which a given supplier could transact. Therefore, McLaren's model also predicts an increase in the role of informal arrangements relative to formal contracts between upstream and downstream firms over time. Such a movement has been observed in the U.S. automobile industry.

However, this explanation begs the question of why the levels of vertical integration are different in the first place. That is, vertical integration arises endogenously from decisions made by upstream and downstream firms, and is itself affected by the level of trust between buyers and sellers, the type of contracts in place, and the extent of participation of suppliers in design and in the research program of buyers. Thus, the explanation, while plausible, remains incomplete.

Gereffi (1999) distinguishes between two types of supply chains: *producer-driven* and *buyer-driven*. In producer-driven supply chains, large manufacturers play a central network coordination role. This structure is dominant in capital and technology intensive industries (e.g. automobiles). In contrast, buyer-driven supply chains are found in industries where large retailers and branded marketers/manufacturers play a central role. They are more common in labour-intensive industries directed towards consumer goods (e.g. housewares). In a sense, producer-driven supply chains are "supplier dominated" in the determination of specifications and standards, whereas buyer-driven supply chains are "buyer dominated". Even as the main players in producer-driven supply chains are global oligopolies, buyer-driven supply chains are more competitive and often locally owned. In producer-driven supply chains, profits are driven by scale and technological advances, whereas buyer-driven supply chains rely on design, marketing and financial services. Success in producer-driven supply chains relies on access to key technologies and internal organization, while it relies on inter-firm relationships, strategic alliances, clustering, protectionist trade policies and brand names in buyer-driven supply chains. This classification can help understand many differences in vertical relationships between sectors.

The organization of innovation can also depend on sector characteristics. Pavitt (1984) explores the similarities and differences among sectors in terms of the sources of knowledge inputs, the nature of innovating firms and the innovations' main use, using data on about 2000 innovations in Britain from 1945 to 1979, and provides an interesting perspective on the sectoral pattern of technological change. Pavitt classifies sectors into three groups: *supplier dominated*, *production intensive*, and *science-based*. Variation of technological development among the three groups can be explained by the source of technology, the type of users and means of appropriation.

Supplier dominated firms are found mainly in traditional manufacturing such as textile, agriculture and professional financial and commercial services. They benefit more from professional skills than from technological improvement. These firms usually have weak in-house R&D capabilities and contribute minimally to own innovation. The technology is mainly transferred from suppliers' equipments and materials. The *Production intensive category* can be further divided into *scale intensive* firms and *specialized suppliers*. The former -such as metal manufacture and vehicles- are usually large firms who make significant contributions to the process technology used in their own principal sector. The latter –such as mechanical and instrument engineering firms- are relatively small firms who concentrate mostly on product innovation for use in other sectors. The users and other firms make more contribution to process innovation in the main sectors of specialized suppliers. The typical core sectors of the s*cience-based category* are the chemical and electronic/electrical sectors. The main source of their technology is in-house R&D based on the development of underlying science. They produce a high proportion of own process technology and also product innovation that are broadly used in other sectors.

Another finding of Pavitt (1984) is that there exist important linkages in terms of technology transfer among the three groups. For example, the supplier-dominated firms receive most technology transfer from production-intensive and science-based firms. Also, these linkages go beyond the traditional arm's length market transactions and involve transfer of knowledge and skills.

Giuliani et al. (2005) extend the sectoral taxonomy developed by Pavitt (1984) and apply it to Latin America. They identify four types of sectors:

1) *Traditional manufacturing*, which is labor-intensive and uses traditional technologies (example: textiles). These sectors tend to be supplier dominated, as important innovations are driven by suppliers of inputs. Technology is transferred mainly internationally, embodied in capital goods. Moreover, there are few entry barriers and appropriability is low.

2) *Natural resource-based sectors*. In these sectors, innovation results from both suppliers and applied research by public research institutes. The appropriability of knowledge tends to be low for knowledge produced by public research institutes, but high for suppliers.

3) *Complex product industries* (example: automobiles). In those sectors, firms are typically large and scale intensive, in-house R&D is critical, there are high entry barriers, and appropriability is medium.

4) *Specialized suppliers* (example: software). User-producer interactions are most important in these industries, where both entry barriers and appropriability are low.

One of Giuliani et al.'s findings is that while in all sectors large (international) buyers encourage and participate in process and product innovations, they tend to neglect or even discourage *functional upgrading* (except in the software sector, where there is no relationship). Functional upgrading is the development of new functions (example: design), and the abandoning of low value-added functions. This lack of functional upgrading keeps small firms dependent on a small number of large buyers. The latter often consider high value-added functions as their core activities, and try to prevent their transfer to local suppliers. This problem is more prevalent in quasi-hierarchical relationships, where suppliers are heavily dependent on buyers. But in supply chains where market transactions play a greater role, local firms have more latitude in engaging in functional upgrading. Hence, whether the upstream firms are in an industrialized or a developing country, multinationals may have an incentive to prevent the diffusion of certain functions and technologies to host suppliers/distributors.

Related to the issue of supplier/customer dominance is the question of the source of the innovation. Demand-pull innovation arises from the needs of downstream firms, whereas technology push innovation often arises from the technology used by upstream firms (or by firms in another industry). While the origin of the innovation may differ from where the R&D itself is performed, there is an association between the origination of an innovation and its actual development. In distinguishing between demand-pull and technology push innovation, Von Hippel (1978, 1982) has proposed the concepts of *manufacturer-active* (MAP) and *customer-active* (CAP) product idea generation. CAP arises when the customer, whose needs are unsatisfied by manufacturers, develops the specifications of the product and asks the manufacturer to provide it. MAP is more likely to be observed when the base of potential users is large, and when switching costs are small.

Foxall (1987) further refines CAP into several categories: manufacturer-initiated innovation, user-initiated process innovation, passive user-initiated product innovation (which is exactly Von Hippel's CAP), active user-initiated product innovation, and vertically-integrated user-initiated innovation. We see that there are a large number of possible combinations, depending on three factors: ownership, who initiates the innovation, and the active/passive role of the customer.

There is an association between long term contracts based on trust and upstream R&D. Lamming (1993) notes that some European automotive suppliers (the same can probably be said about North America) are not fully engaged in real collaborative partnerships. For example, Nissan UK suppliers provide lower quality than its other Japanese/UK suppliers. At the same time, Nissan's UK suppliers and potential suppliers find it reasonable to achieve cost savings and hide them from the customer (with negative implications for trust) (National Economic Development Council, 1991). Also, one of the major weaknesses of Nissan's UK suppliers is their weak R&D efforts (Lamming, 1993, p. 220). This is not surprising, given that joint innovation efforts require *co-specialized assets* (Teece, 1986), which are associated with the development of trust and long term relationships. Because members to a cooperative venture use shared assets, these assets are "complementary" in that they are used jointly to achieve the objectives of the venture. Moreover, these assets have lower value outside the venture.

Lean supply [7] favours joint innovation efforts along the supply chain. In Lamming's words, "vertical collaboration relationships, as exemplified by lean supply, can blur the demarcation between customers' and vendors' roles, emphasizing the importance of joint development of new technologies, using complementary assets in the process" (p. 245). In the lean supply model, R&D is integrated along the supply chain, component systems are developed through long-term relationships, and the expertises of the upstream and downstream firms are combined. This model calls for much more integrated R&D efforts than in the traditional arm's length (and mass production) supply model.

4. CONCENTRATION AND MARKET POWER

Concentration and market power can affect the incentives for innovation and the allocation of innovative activities along the value chain. Harhoff (1998) investigates the

[7] Lean supply involves management practices such as just in time inventories, total quality, information sharing, joint strategy formulation, synchronized capacity, global and dual sourcing, mutual agreement on quality targets, and integrated R&D. See Lamming (1993, p. 194).

relationship between vertical organization and innovation from both theoretical and empirical perspectives. He mainly focuses on the effect of the relative market power of upstream and downstream firms on downstream R&D investments. Acting strategically, upstream firms can encourage downstream entry (for example, by distributing technical information which facilitates entry) to limit downstream concentration and maintain their own market and bargaining power. Consequently, higher upstream concentration can result in high levels of R&D upstream. On the other hand, Harhoff finds that high upstream concentration depresses downstream R&D, whereas high downstream concentration encourages it (using U.S. data). These results are consistent with a Schumpeterian view of innovation, where innovation and R&D efforts are associated with market power. He also finds that technology flows from an upstream sector to a competitive downstream sector act as a substitute for downstream R&D. Moreover, he finds that equipment supplies reduce downstream R&D intensity. This is because the capital goods furnished by the upstream sector can act as a substitute for downstream R&D, and/or because those capital goods increase downstream productivity (without affecting the absolute level of downstream R&D), reducing downstream R&D intensity.

What is not clear from these results is to what extent these effects are intended by the upstream sector, or they are just a result of the structure of the industry. That is, it is not clear that upstream firms act strategically to depress downstream R&D; rather, this may be an unintended effect of their actions and of the structure of the industry. Moreover, the argument that upstream firms aim at discouraging downstream innovation is somewhat controversial, given that this could hurt the upstream sector in the long run (dissatisfaction of users, development of better substitute products elsewhere, etc.). Hence, although the results of Harhoff are clear and consistent with the finding that technology flows can sometimes act as a substitute for own-R&D (see, for example, Bernstein, 1988), the imposition by Harhoff of strategic behaviour on these effects is not well grounded in theory.

In related work, Harhoff (1996) studies R&D in vertically related industries. In his model, both upstream and downstream R&D activities improve the quality of the downstream product. The upstream firm is a monopolist, while the downstream industry is oligopolistic. Downstream firms perform two types of R&D: idiosyncratic R&D that is specific to each firm, and generic R&D which can benefit all firms. The R&D of the upstream monopolist is generic. Harhoff shows that, when the downstream market structure is fixed, it is in the interest of the supplier to invest in generic R&D and make the results available to all downstream firms. This has two effects: it increases the total level of generic R&D, and increases the productivity of idiosyncratic R&D. In other words, there is complementarity between idiosyncratic and generic R&D. When entry into the downstream industry is possible, there is an additional incentive for the supplier to invest in generic R&D: to facilitate entry. Although it may reduce the R&D performed by each downstream firm, this increased downstream competition is beneficial for the supplier (total demand for its output and as a result the supplier profits are greater). However, there is substitutability between upstream and downstream generic R&D: when the investment of the supplier in generic R&D is sufficiently high, downstream firms do not invest at all in generic R&D; they invest only in idiosyncratic R&D. This is more likely to occur, the more competitive is the downstream industry. One important result of this paper is that the substitutability/complementarity relationship between upstream and downstream R&D may depend on the type of R&D considered.

Jacquier-Roux and Bourgeois (2002) discuss how understanding upstream R&D in the energy sectors (increasing the production of knowledge in spite of reduced in-house R&D investments) requires a closer look at the innovation behaviour of the downstream operators (who benefited from the increasing outsourcing of R&D by the upstream sector). Moreover, the relationship between upstream and downstream firms has moved from purely commercial towards partnerships. Thus, the analysis of the R&D of an industry (narrowly-defined) without accounting for the vertical R&D linkages of that industry gives a distorted image of the evolution of the innovations activities of that industry.

In contrast to the traditional view that market power in one industry stifles innovation efforts in vertically related industries, Inderst and Wey (2005) argue that it can actually enhance them. In their model, buyers negotiate bilateral contracts with an upstream supplier. The contract allows for second degree price discrimination in the form of two-part tariffs. The supplier can invest in innovation activities which reduce its marginal cost. If negotiations fail, buyers will search for alternative supply options. A key feature of the model is that larger buyers have better options, i.e. they can more easily find cheap alternative sources of supply. Therefore, the larger the buyer is, the "more credible" the threat of walking away from the negotiations is. This puts pressure on the supplier and motivates it to exert greater innovation efforts when facing a large buyer (even though in this case the upstream firm makes less total profits). As a result, a positive relationship between downstream market power and upstream innovation efforts is created. Although Inderst and Wey do not consider this possibility, the same model can be used, with the roles of buyers and sellers reversed, to induce a positive relationship between upstream market power and downstream innovation efforts. However, their model has not yet been tested empirically.

Gilbert and Cvsa (2003) study the effect of contractual forms on incentives in a supply chain, focusing on innovation and demand uncertainty. They analyze the trade-off between encouraging innovation and dealing with flexibility in the context of demand uncertainty, in a bilateral monopoly framework. The buyer can invest in cost reducing or demand enhancing innovation. The investment in innovation by the buyer is observable by the supplier, but cannot be contracted upon, because it is not objectively verifiable by a third party (in a court, for example). The downstream firm determines its investment level before demand uncertainty is resolved.

They consider three cases. In the first case, pricing is determined after the buyer has innovated and demand uncertainty has been eliminated. In the second case, the supplier commits to a price before innovation takes place and before demand uncertainty has been resolved. In the third case, the supplier fixes a ceiling for the wholesale price. The main finding of the paper is that the commitment by the supplier to a wholesale price increases innovation by the buyer and results in a lower wholesale price and higher total supply chain profits. This is because with commitment, the lower wholesale price not only stimulates demand, but also increases innovation by the buyer. The important trade-off that the supplier faces is to balance its desire for flexibility in regard to demand variations, and its need to guarantee the buyer that the seller will not take it hostage after innovation has been made. The solution is for the supplier to commit in advance to a price, which gives the buyer the proper incentives for innovation. There exists a basic trade-off between price flexibility and encouraging innovation.

In sum, conventional wisdom suggests a negative relationship between concentration/bargaining power in an industry and innovation by vertically related industries. However, considerations related to strategic behaviour, entry, different types of R&D (generic/idiosyncratic), external options, and commitment can alter this relationship.

5. TYPES OF INNOVATIONS

Innovations are not homogeneous. This section examines how vertical relationships affect differentially different types of innovations. Bruce and Moger (1999) analyze vertical relationships in the UK clothing industry. They identify three types of relationships with suppliers. 1) *co-partnerships*, which are close and well-established relationships between (large) retailers and (large) suppliers, based on trust and loyalty; 2) *ad-hoc relationships*, which are adversarial, price-based relationships, with little trust or information sharing; and 3) *networks*, constituted mainly of small suppliers and retail independents. Co-partnerships perform well in terms of incremental innovations and improvements, and moderately well in terms of absorptive capacity. But this close relationship does not perform very well when it comes to radical innovations. This is due to the limited absorptive capacity resulting from the lack of exposure to other partners. Moreover, the parties in co-partnerships are in a danger of "lock-out", lacking responses to radical changes and to changing trends. Ad-hoc relationships perform even less well on incremental innovations, since absorptive capacity is limited, and there are limited resources to invest in innovation. Moreover, the arm's length nature of the relationship makes it unlikely that valuable information about possible improvements is passed on to the other party, for fear of leakages to competitors. Even the network structure does not fare that well on innovation. Large manufacturers are generally unwilling to adopt the methods or improvements of independent designers, and large retailers do not wish to leave the control of design to independent designers. Overall, the tight control over the supply chain that large firms aim at may hinder innovation and flexibility. There might even be a tradeoff between static efficiency (in terms of the static performance of the supply chain) and dynamic efficiency (in terms of absorptive capacity and responsiveness to change). This may be particularly true for mature industries. The lack of innovation of the existing major players may even open the door to entry by new and more innovative firms.

Rothwell and Dodgson (1991) note that many of the vertical technological interactions involve simultaneously SMEs and large firms. In addition to their separate functions in technological innovation, their role is also "interactive and *complementary*". The role played by each party can vary from one sector to another. In some cases, large users are a source of technology for smaller suppliers (e.g. scientific and medical instruments). In others, small suppliers are a "window" on new technological developments for large firms. Manufacturing provides many examples of technological exchanges between large downstream firms and small upstream firms. And commonly, technologically advanced downstream firms "pull" innovations for their suppliers.

Not only large and small firms play different roles in technological interaction, they also have different relative advantages and disadvantages. The strength of large firms relates to material advantage: extensive financial, human, marketing, and networking resources. Small firms, in contrast, enjoy a behavioral advantage: dynamism, flexibility, adaptability and less bureaucracy. As Rothwell and Dodgson argue, technological interaction can allow both parties to overcome their respective disadvantages and exploit their strengths. Policies aiming at encouraging vertical technological interaction need to take these characteristics into account. In particular, SMEs lack the resources, especially management resources, to fully benefit from external technological linkages. Moreover, many government policies are aimed at encouraging pre-competitive technological collaboration, which is "far from the market". However, the study of innovation relationships of UK and Italian SMEs indicates the presence of many interactions along the supply chain which are "near-to-market". It follows that "Government policies towards SMEs should be adjusted to recognise the importance of vertical linkages and to reflect the realities of SME innovation" (Rothwell and Dodgson, 1991, p. 136). Pre-competitive R&D interaction and collaboration may be best suited for horizontal cooperation between (large) competitors, but may not be sufficient to deal with the role of innovation in vertical linkages.

While in general agents in the supply chain benefit from innovation, in some cases they may lose due to innovation, and therefore resist it (Kaufman et al., 2003). It is essential to distinguish between two types of innovations. First, incremental innovations., which improve an existing product/process, and therefore allow firms to build on existing competitive advantages. Second, radical innovations, which take the product/process in a new direction, requiring firms to forego (some of) their competitive capabilities and develop new ones. Firms, who find the transition associated with radical innovation too difficult, may try to suppress it or resist it. In particular, firms along the supply chain make investments (sometimes jointly) to improve the overall efficiency of the chain. A radical innovation may devalue those investments, and firms at one or more levels of the chain may find it profitable to try to block the adoption/spread of the new technology by other firms. The greater is concentration, the easier it is for firms to coordinate and block a radical innovation (for example, by insisting that customers/suppliers continue using the old technology). An example is the disk drive industry, where suppliers did not develop a new technology due to the strong resistance of dominant customers although they themselves may benefit from this innovation. In this case, it was customers who prevented their suppliers from adopting the radically new technology (Christensen and Bower, 1996).[8]

6. VERTICAL R&D COOPERATION AND VERTICAL KNOWLEDGE SPILLOVERS

Even with legal protection such as patents, copyrights and design registration, arm's length market mechanisms alone still cannot guarantee a reasonable return on R&D efforts, and consequently are not enough to provide incentives for innovation (Cohen 1995; Harabi, 1998). Although complete vertical integration is viewed as one way of dealing with complex technology transfer and asset-specific investments, it tends to be hierarchical and slow in responding to the market (Jorde and Teece, 1990). The need to quickly respond to the changing environment and to overcome market imperfections and appropriability problems pushes for the formation of strategic alliances. Strategic alliances involve long-term reciprocal relationships. They not only facilitate transfer of technology within the alliance and keep core knowledge of members out of the market, but also reduce transaction costs by inhibiting opportunistic behaviours (Pisano, 1990;

[8] This can also be achieved through regulatory capture (firms influence regulators to their own advantage).

Hennart, 1988). A central concern of the literature is whether vertical cooperation increases innovation efforts and which mode of cooperation is more beneficial.

It is often argued that vertical cooperation facilitates knowledge exchange among vertically related firms. One firm's R&D investment not only benefits itself but also others with whom it has technological interdependencies. Cooperation provides firms with more technological opportunities, helps them overcome appropriability problems and market uncertainties, and consequently stimulate firms' innovation efforts. On the other hand, upstream (downstream) firm's R&D expenditure may be a substitute for that of the downstream (upstream) and reduce the other's R&D efforts. The theoretical and empirical evidence on this issue are mixed.

This section examines the evidence on, motives for, and consequences of vertical R&D cooperation. The first subsection shows that vertical R&D cooperation is prevalent in many industries and in many countries. The second subsection examines the motives behind R&D cooperation. These include internalizing knowledge spillovers, developing absorptive capacities, developing complex products, overcoming organizational constraints, and sharing costs and risks. Subsection 6.3 studies the effects of vertical R&D cooperation on innovation and profitability.[9]

6.1 Empirical evidence on vertical R&D cooperation

The source of innovation depends on the expected return of engaging in innovation activities of potential innovators (Von Hippel, 1988). Profit-maximizing agents devote their resources to the development of new technology only if they expect that 1) there are technological opportunities available to them; 2) the opportunities can be transformed into innovations that will be readily accepted by the market; and 3) a reasonable return can be appropriated, net of the costs incurred (Harabi, 1998). It follows that vertical cooperation can be very beneficial for the successful development and commercialization of new technology. First, the development of innovation can be viewed as a process of creating, transmitting and transforming information assets to satisfy customers (Fujimoto et. al, 1996). The tight technological interdependencies

[9] Vertical R&D cooperation is to be distinguished from another form of R&D cooperation, horizontal cooperation, which involves technological collaboration between competitors.

between upstream and downstream firms (Belderbos et al., 2004; Guillouzo et al., 1999; Revilla, 2002) make customers/suppliers a very important source of complementary knowledge. Their participation in R&D enhances a firm's innovation capability and provides more technological opportunities (Fujimoto et al. 1996; Cark, 1989; Nishiguchi, 1994; Nishiguchi and Ikeda, 1996). Second, the risky "jump" from the development of a new technology to its commercialization imposes additional challenges (Jorde and Teece, 1990). Vertical cooperation can help reduce the uncertainty of introducing an innovation to the market (Fujimoto et al. 1996; Nishiguchi, Ikeda, 1996; Robertson, 1996). Third, vertical cooperation helps to overcome appropriability problems (Von Hippel, 1988; Ishii 2004; Atallah, 2002; Belderbos et al., 2004).

Empirical evidence has clearly shown that R&D cooperation tends to take place between firms with vertical links. The mode of cooperation can range from arm's length market mechanism to complete vertical integration, from short-term to long-term arrangements, and from informal information exchange to formal cooperation. Harabi (1998, 2002) suggests that suppliers and customers are a very important source of technological opportunities. Harabi (1998) shows that about 84% of innovative firms have cooperative agreements with suppliers and users. The percentage is even higher for firms with formal R&D departments. Innovation is believed to be benefiting from coordination of agents operating at different stages of the innovative chain. Bone and Keilbach (2005) show that more than 70% of all innovating German firms have formal/informal collaborative arrangements with vertically related firms. Revilla (2002) suggests that vertical cooperation along the value chain is prevalent in metropolitan innovation networks. Freel (2000b) demonstrates the pre-eminence of vertical linkages in the R&D cooperation of UK SMEs. Sakakibara (2001) evaluates the inter-firm relatedness using the share of destination (origin) industry in the intermediate input shipments to the origin (destination) industry for 186 Japanese government-sponsored R&D consortia, and shows that vertical links are positively and highly significant in determining the probability of R&D cooperation. This is consistent with the technological linkages view because firms with vertical linkages tend to use related technologies. It is also consistent with transaction cost theory, since strong vertical linkages imply frequent transactions.

In the Dutch potato supply chain, R&D firms develop new potato varieties. The process requires many years of trial and error and a high level of craftsmanship. The financial and time costs required are substantial for small firms; consequently during the 1990s many R&D firms merged/formed alliances with larger potato firms situated upstream in the value chain (Rademakers and McKnight, 1998). Those large suppliers produce high quality products, which gives them an edge over their competitors in terms of quality, variety and prices. Hence integration/alliances benefit both the R&D firms and the potato merchants.

Kaufman et al. (2000) develop a supplier typology based on the technology used and the extent of collaboration between the supplier and the buyer. The first type of suppliers is *commodity suppliers*, who use standardized technologies and deal with downstream firms using standard contracts, and compete mainly on cost. Switching costs are low for both parties. The second type is *collaboration specialists*, who use standardized technologies but who engage in active collaboration with customers. This group of suppliers invests little in innovation. The third group of suppliers is *problem-solving suppliers*, who use advanced technologies as well as advanced collaborative methods. Innovations and product design play an important role here. These relationships result in lower monitoring costs for consumers, and a high level of trust which reduces holdup potential. Finally, there are the *technology specialists*, who use advanced technology but whose relationship with customers is weak. Customers make little specific investments, and suppliers are not dependent on a limited group of customers. The authors focus on the characteristics which distinguish problem-solvers from the three other categories. For that, they surveyed about 200 small and medium manufacturers from New Hampshire. First, the data indicate the presence of a positive correlation between the technological sophistication of suppliers and extensive collaborative relationships with customers. Problem-solvers are found to be larger in terms of employees, but not necessarily in terms of sales. They are more export oriented, pay high wages, and have high gross margins. Basically, problem-solvers develop "generic collaborative/technological know-how".

Interestingly, it is not only the level of technological advancement of the supplier that matters, but also the extent of collaboration with the buyer and trust between the parties. Although not all suppliers need to have advanced technology and advanced collaboration, the presence of these features certainly creates a greater potential for technological interaction and learning for local suppliers from FDI.

Moreover, dividing the modes of cooperation into formal and informal types can also provide some interesting perspectives. It has been shown that informal exchange of information with suppliers or customers is perceived as at least as prevalent, and perhaps even more, than formal R&D cooperation (Bonte and Keilbach, 2005; Harabi, 1998; Harabi, 2002). According to Bonte and Keilbach (2005), 70% of innovative German firms engage in vertical cooperation, but only 3% are exclusively involved in formal cooperation. Informal vertical cooperation is usually based on "reciprocity": The decision to share knowledge with another firm is contingent on the expectation of receiving valuable information in return. In addition, a firm may choose to share knowledge with customers to facilitate the diffusion of a new technology, or generate spillovers downstream to enhance the demand for intermediate outputs (Harhoff, 1996; Streb, 2003). Informal cooperation is regarded as a flexible and less expensive way of exchanging important market and technical information (Von Hippel, 1987). Harabi (1998) finds that informal exchange of information is practiced as a trust-building measure before formal cooperation between two firms can be initiated. This is supposed to address uncertainty and asset specificity. Also, since an informal relationship is not as close as a formal one, firms have less concern over the leakage of core knowledge (Harabi, 1998; Harabi, 2002). It is a trust-building step towards formal cooperation.

A firm may gain not only from cooperating with its suppliers, but also from fostering (horizontal) technological cooperation between them. Batenburg and Rutten (2003) report the experience of Océ, the Dutch manufacturer of copiers and printers, in using the supply chain to foster innovation. In 1993, Océ launched the *knowledge industry clustering* project, which focuses on enabling R&D cooperation and knowledge exchange between suppliers. The project was partially funded by the European Commission. In 1991, the firm parted with its last production facility, focusing instead on R&D and assembly. In the 1980s, Océ worked with its suppliers through an *Early* *supplier involvement*[10] scheme, whereby suppliers were not involved in engineering before a prototype was completed, and their role was limited to process engineering. In the 1990s, the firm changed its strategy, focusing instead on the development of new technologies. From that point, "for every design, a supplier was involved to work with Océ on the engineering part." (p. 264) Therefore, product engineering was outsourced to suppliers. Suppliers were selected based on their past experience with Océ, their technical competencies, and their pre-selection by a third party. But suppliers, having limited innovative capabilities themselves, strengthened their own capabilities, relied on inter-supplier collaboration, and outsourced some components to smaller suppliers. This inter-supplier collaboration, an integral part of the 'knowledge industry clustering' project, allowed novel combinations of skills which were not possible before. This required suppliers to acquire numerous inter-organizational, team, and product-engineering skills. The project was considered a success by all participants in terms of trust, innovation, speed, and quality. This project is a nice illustration of network theory, where the network allows the firm to access external (often tacit) knowledge, requiring face-to-face communication and trust.

Cooperation may also extend beyond suppliers from one country. For example, Nissan encouraged its UK suppliers to collaborate with its suppliers located in Japan (Lamming, 1993, p. 89).

6.2 Motives for vertical R&D cooperation

A segment of the literature examines the determinants and the different types of vertical R&D cooperation. The following are the factors that may influence firms' motivations to engage in vertical R&D cooperation.

Knowledge Spillovers

It is crucial to understand knowledge flows along the supply chain. Firms must often obtain external information in order to innovate (incoming spillovers). Vertical R&D spillovers capture the impact of innovation activities of an industry on vertically adjacent industries. Those spillovers can be unidirectional (from downstream to

[10] For more on this topic, see Amaral et al. (2002).

upstream, or the converse) or bidirectional, voluntary or involuntary, imbedded or disembedded.

There is strong empirical evidence for the prevalence and significance of vertical spillovers. Goto and Suzuki (1989) evaluate the impact of spillovers on productivity growth of Japanese manufacturing industries and show that supplying industries' R&D leads to higher productivity growth in user industries. Using the concept of technological distance,[11] they further demonstrate that the impact of electronics technology on other industries is mainly achieved through spillovers rather than through the transaction of intermediate goods. Suzuki (1993) investigates the manufacturer-supplier relationship in the Japanese vertical *keiretsu* groups and finds that the technology transfer from the core firm to its subcontractor is substantial: A percentage increase in technology transfer reduces the unit variable cost of the subcontractor by 0.09%. In a study of a sample 226 firms in the U.S. and Japan, Branstetter (1996) demonstrates that vertical *keiretsu* affiliations promote the productivity of R&D through combining the knowledge and expertise of upstream and downstream firms. The affiliation promotes the exchange of technological knowledge within groups: the impact of knowledge spillovers on a firm's productivity growth (measured by the revenue enhancement per R&D dollar spent within the group) is more than three times more powerful than spillovers received naturally due to technology proximity. He also points out that spillovers have a stronger influence on productivity than patenting. This is consistent with a finding common in the literature: a key factor that leads to Japanese manufacturers' edge over their U.S. and European counterparts is the close and long-term relationship between suppliers and manufacturers. This collaboration is mostly focused on incremental improvements in process technology, for which patents are not very effective.

It is useful to distinguish between incoming spillovers and outgoing spillovers. A higher level of incoming spillovers is expected to increase the probability of cooperation. In the information-processing framework, innovation is viewed as a process of integrating and transforming information into assets that are valuable to customers (Fujimoto et al., 1996). A firm's choices on innovations are constrained by its existing

[11] Defined as the similarity of technological capability. The shorter the distance is, the more quickly and efficiently that the technological knowledge developed by one firm is expected to be utilized by the other.

range of knowledge and resources (Pavitt, 1984). Incoming spillovers broaden a firm's knowledge base, enhance its capability and provide more technological opportunities.

The empirical evidence on incoming spillovers is mixed. Cassiman and Veugelers (1999) differentiate between incoming and outgoing spillovers and find that Belgian firms tend to cooperate in R&D projects when incoming spillovers are higher and outgoing spillovers are lower. Belderbos et al. (2004) study firms' decisions regarding four types of R&D cooperation (with customers, suppliers, competitors and research institutes) based on panel data on Dutch community innovations, and suggests that incoming source-specific spillovers are an important determinant of vertical R&D cooperation. However, Bonte and Wiethaus (2005) find no evidence to support the hypothesis that incoming spillovers between vertically related firms contribute to either formal or informal vertical cooperation, based on survey data on a sample of 730 innovating German firms. Kaiser (2002) also finds no evidence supporting the argument that vertical spillovers increase the probability of firms' cooperation in the German service sector.

On the other hand, outgoing spillovers mean that the benefits of a firm's R&D efforts go to another agent who does not bear any R&D expenditure. Although this concern over vertical spillovers is not as important as horizontal spillovers, there is still the possibility that important information will leak out to competitors through common suppliers or customers (Bonte and Wiethaus, 2005). The concern over unwanted information leakage may jeopardize the cooperation agreement. It may also induce firms to form strategic alliances to internalize the externalities or acquire complementary assets.

In some cases the potential losses from uncontrolled information leakages are so important that the main concern of firms is how to limit and control outgoing information flows. [12] Involuntary information leakages reduce the benefits of the innovator. Asymmetric information makes it almost impossible to sell an innovation without disclosing important information. Despite the legal protection mechanisms such as patenting and copyrights, a reasonable level of return for a firm's R&D efforts still cannot be guaranteed (Cohen 1995). Bonte and Wiethaus (2005) argue that the firm

[12] Such a concern has arisen, for instance, in the Semiconductor Manufacturing Technology Consortium (SEMATECH), where semiconductor suppliers who share information with SEMATECH members were worried about leakages to their competitors (Grindley et al., 1994).

considers its appropriability conditions before entering formal cooperation to prevent unwanted leakage of its core knowledge. They measure appropriability conditions using two groups of indexes: firms' own strategic protection mechanisms such as secrecy, complexity and lead-time; and legal protection mechanisms such as patents, copyrights and brand names. They find that the strategic protection mechanism has a positive effect on vertical cooperation but does not affect the probability of informal cooperation. This suggests that instead of dealing with the appropriability problem proactively, firms tend to react passively. Only if a firm has better capability of capturing and protecting its R&D results, will it then engage in formal cooperation. This also suggests that firms have less concern over informal exchange of information and may think of it as a "trust-building" step towards formal cooperation, which usually implies a closer relationship involving a higher risk of losing core knowledge.

On the other hand, the legal protection mechanism generally does not affect a firm's decision to cooperate formally or informally. This is consistent with Harabi (1998), who investigates survey data on 370 manufacturers in Mannheim and shows that self-protecting actions, measured by secrecy, complexity design, lead time and the long-term employment of qualified personnel, is very important for innovative efforts, while legal protection mechanisms such as patent protection and design registration are much less important. The legal system and arm's length relationships are not enough to guarantee a desirable rate of return on the innovator's R&D efforts, and consequently have only a minimal impact on firms' decisions about innovation.[13] Cassiman and Veugelers (2002) also find similar results in Belgian manufacturing industry: Better appropriability conditions through strategic protection mechanisms increase the probability of cooperation.

Patents are one way of limiting knowledge flows which can be used directly by other firms, including competitors. Regarding the role of patents in the allocation of R&D resources to upstream versus downstream industries, the theoretical work of Goh and

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[13] Patents are commonly used to protect innovations, but their effectiveness is often limited by the ability of competitors to invent around them. For example, Arundel and Kabla (1998) report that in the early 1990s, the majority of innovations in Europe and the U.S. were not patented. Firms are concerned with the disclosure requirements of patenting. Pharmaceuticals and chemicals are some of the sectors where patents are highly effective and heavily used.

Olivier (2002) suggests that greater patent protection should be provided to upstream sectors than to downstream sectors. Patent protection in the downstream sector increases market power downstream and reduces its final output and consequently its demand for the intermediate input from the upstream industry. This discourages the innovation efforts of upstream firms. Whereas the profits of downstream firms are independent of the costs of intermediate inputs, hence stronger upstream patent protection does not exert a negative externality on the downstream sector.

Compared with the view that firms tend to passively avoid outgoing spillovers and take their appropriability conditions as given before entering cooperative agreements, a segment of the literature regards formal R&D cooperation as an efficient way to internalize the externality (Nelson, 1959; Arrow, 1962). The theoretical work of Ishii (2004) and Atallah (2002) demonstrate that internalization of vertical spillovers increases the level of R&D investment and social welfare. Assuming incoming and outgoing spillovers exogenous and/or symmetric, Ishii (2004) analyzes the effects of cooperative R&D (incorporating knowledge sharing) in two vertically related duopolies with both horizontal and vertical spillovers. In his model, there are two upstream firms selling homogeneous inputs to two downstream firms, which produce homogeneous final goods. Firms act in three stages: In the first stage, they decide on their R&D expenditure levels. In the second stage, upstream firms choose their outputs and following that, the downstream firms choose their outputs (compete in quantities). Each firm's R&D expenditures have two effects on its rival: a negative effect whereby the firm's R&D investment enhances own output and discourages its rival's output; and a positive effect where an increase in R&D expenditure increases the rival's output through horizontal and vertical spillovers. The results show that a vertical research joint venture (two firms sharing knowledge no matter whether the R&D decisions are coordinated or not) accelerates technological improvement and increases social welfare. The positive direct impact of knowledge sharing with a vertically related firm dominates the negative impact of outgoing spillovers (due to which its rival has a higher output). This paper is very closely related to Atallah (2002), who studies how changes in vertical and horizontal spillovers affect R&D investments and social welfare. The results also show that vertical spillovers always increase R&D efforts and welfare. Atallah also studies the interaction between vertical and horizontal R&D cooperation, and shows that each type of cooperation reinforces the other and increases its benefits.

Von Hippel (1988) shows that user-dominated innovations account for more than two-thirds of all innovations in electronic, semiconductor and printed circuit board assembly industry. He explains that the functional source of innovation can be predicted by the expected rent of innovation for the potential innovators. The reason why the expectation differs among the actors within the value chain lies in their ability to appropriate the rewards. Users are in a favorable position because they are more capable of protecting the secrecy of innovations by "hiding the innovation behind their factory walls as a trade secret" (Von Hippel, 1988, p. 5). They also face less risk in developing new products because they derive rents from using the innovation themselves. They are unlike other agents such as suppliers, who have to sell the innovation in order to benefit, and who therefore face greater risks of information leakages. Cooperation with users helps manufactures internalize unwanted information leakages and reduces market uncertainty.

Also, according to Jorde and Teece (1990), R&D cooperation helps firms to collect necessary complementary assets to make the innovation commercially successful. When a new technology has to be embedded in output in order to be valuable to end-users, "any artificially created shortage in the critical complementary assets" can effectively act as an entry barrier and enable the innovator to achieve monopoly profits (Harabi, 1998, p. 160). Consequently, firms cooperating within the value chain are more likely to innovate than any single firm within this chain (Harabi, 1998). If the above is true, we expect to see more cooperation arrangements in industries that have unfavorable appropriability conditions. However, Sakakibara (2001), using data on Japanese government sponsored R&D projects over a 30 years period, finds no evidence suggesting that cooperative R&D projects tend to occur in industries with appropriability problems.

Although the empirical evidence is mixed, vertical knowledge flows seem to play a role in vertical R&D cooperation.

Absorptive capacity

Technology does not flow costlessly (Jorde and Teece, 1990). A technology may need to be modified before it can be used within another organization (Robertson, 1996). Firms need to develop an absorptive capacity in order to assimilate the external information and transform it into useful knowledge. Empirical studies such as Cohen and Levinthal (1989) and Levin (1988) have shown that this absorptive capacity is a result of internal R&D efforts. Consequently, a higher level of firms' own R&D activities is expected to enhance vertical cooperation. However, empirical evidence on this issue isn't conclusive. Bonte and Keilbach (2005) find that continuous R&D investment has a positive effect on the vertical cooperation decision. Tether (2002) demonstrates that R&D intensity tends to increase the likelihood of cooperation, and that customers are more likely to be involved when developing novel and complex new products. Belderbos et al. (2004) show that incoming spillovers from research institutes stimulate vertical cooperation, suggesting that this type of spillovers has a generic nature and enhances firms' own technological capabilities, and in turn the effectiveness of cooperation with other firms. They also find that R&D intensity and firm size have a positive impact on vertical cooperation. Revilla (2002) compares the metropolitan innovation systems among Barcelona, Stockholm, and Vienna and find that higher quality of human resources (measured in higher proportion of R&D personnel and personnel with academic qualification) enhances Stockholm firms' absorptive capability and stimulates networking with suppliers and customers. This same pattern is also observed for SMEs: those with better in-house technical capabilities tend to have more external links, including with suppliers and customers (Macpherson, 1997). However, although Cassiman and Veugelers (2002) do find that cooperation with research institutes increases the absorptive ability of Belgian manufacturing firms, their results do not support the claim that there is a positive relationship between firms' own R&D activities and the probability of vertical cooperation. This is consistent with the results from Miotti and Sachwald (2003), who finds no evidence for such correlation for French firms.

Product complexity

Firms are more likely to cooperate when their innovation activities are concentrated on the development of complex products or process. Suppliers may want to include customers in order to broaden their knowledge base and have a better understanding of the user's needs; they may also cooperate with customers in order to reduce the uncertainty they face when introducing the innovation into the market. Customers who develop complex products may want to engage in R&D cooperation to train their suppliers to ensure that the intermediate goods meet their requirements.

Tether (2002) examines the response of 2342 manufacturing and services firms to the UK version of the second European community innovation survey (CIS-2). He estimates not only a general multivariate model for cooperation with any type of partner, but also multivariate models for cooperation with each type of coordinator (consumers, suppliers, competitors, universities, consultants and others). Five categories of variables are included: 1) Difficulties with the innovation process such as responsiveness of customers, financial risk and organizational inadequacies; 2) The level of R&D engagement; 3) Type of innovation (for example, innovations new only to the firm versus innovations new to the market); 4) Investment in externally developed technologies; and 5) Firm characteristics such as firm size, ownership and sector. The results show that firms attempting to introduce high levels of innovations, indicated as innovations new to the market rather than new to the firm itself, are more likely to engage in cooperative arrangements, especially those with customers and suppliers. He also shows that the conduct of R&D, the intensity of R&D, the resistance of customers (which is usually related to radical innovation) also increase the likelihood of cooperation. Considering that these factors are closely related to the complexity of innovation, this also suggests that there is a positive relationship between cooperation and innovation complexity.

Belderbos et al. (2004) use the ratio of the number of firms reporting bringing new products to the industry to the number of those which did not, weighted by firm size to proxy for the speed of technological change. They demonstrate that R&D cooperation with customers is more likely when there is a greater speed of technological change in terms of new product development.

Organizational constraints

Firm-specific constraints such as lack of qualified personnel or shortage of resources can hamper the innovation process. It is expected that these constraints will provide incentives for firms to cooperate. Belderbos et al. (2004) show that capability constraints (such as shortages of personnel or knowledge) have a positive impact on cooperation with suppliers. Freel (2000a) finds that one of the important reasons for small manufacturers to cooperate with suppliers is for joint marketing/exporting. This is consistent with the view that insufficient marketing expertise hinders the ambition for innovation (Okey, 1991). In contrast, collaborating with either suppliers or customers on training or raising finance is negatively associated with innovation. This is consistent with Freel (2000b), who shows that innovators are less likely to use external finance to fund their innovation activities. Although innovative SMEs tend to apply for external finance, especially long-term debt and public grants (reflecting greater need for financial resources in order to innovate), they generally are less successful in getting access to it compared with their non-innovative counterparts. It could be that such collaboration is indicative of a lack in employee skills, or financial difficulty, which can be expected to limit innovation potential. When a firm resorts to external sources to overcome own constraints, a successful delegation requires that this external agent has to have the right incentive to collaborate and is able to give good advice (Nooteboom 1994). An established long-term relationship helps firms ensure the competence of the source and build up trust. Freel (2000a) shows that established relationships and frequency of contact are the most important factors for successful cooperation, while lack of trust is a crucial barrier for building up external networks for small firms.

Costs and risks

The costs and risks of innovation are also important considerations for firms' decisions on cooperation. From the point of view of diversification, firms with diversified R&D investments have a higher expected return (Sakakibara, 2001). Also, when there are economies of scale (the minimum efficient scale of R&D is large), firms are motivated to share the fixed costs with external agents.

6.3 Effects of vertical R&D cooperation

Theoretical studies predict a positive effect of vertical R&D cooperation on innovation and profitability. Assuming that firms' ability of utilizing spillovers is exogenous, Ishii (2004) shows that vertical research joint ventures accelerate technological improvement and increase social welfare no matter whether the R&D decisions are coordinated or not. Similarly, Atallah (2002) finds that although vertical cooperation has a smaller effect compared to horizontal cooperation, it always increases R&D efforts and welfare.

Empirical findings are consistent with these predictions. Suppliers and/or customers are shown to be a very important determinant in driving innovation in the U.S. auto industry (Jorde and Teece, 1990), the Japanese auto industry (Clark et al., 1987), the semiconductor and electronic subassembly industry (Von Hippel, 1988), the Spanish ceramic industry (Albors and Molina-Morales, 2001), the steel industry in its early phases (Knoedler, 1993), agriculture (Moschini and Lapan, 1997), and the textile industry (Pavitt, 1984), to name only a few examples.

The involvement of suppliers in product development reduces lead-time and engineering hours (Clark, 1989; Fujimoto et al., 1996; Bonaccorsi and Lipparini, 1994; Shenas and Derakhshan, 1994). It enhances firms' flexibility to accommodate variety and speed (Nishiguchi and Ikeda, 1996; Nishiguchi, 1994) and innovative ability through the long-term learning effect (Branstetter, 1996; Sobrero and Roberts, 2002). It follows that cooperation stimulates firms' R&D efforts (Branstetter, 1996; Freel, 2000a; Freel, 2000b), enhances innovation performance (Chung and Kim, 2003; MacPherson, 1997; Streb, 2003) and eventually increases total factor productivity (Branstetter, 1996; Nishiguchi, 1996; Ikeda, 1996) and improves product quality (Bonaccorsi and Lipparini, 1994; Fujimoto et al., 1996). It also reduces costs (Suzuki, 1993; Sobrero and Roberts, 2002; Dyer, 1997; Shenas and Derakhshan, 1994) and improves firms' financial performance (Chung and Kim, 2003). The importance of customers in providing updated market and technological information and reducing uncertainty about market demand has long been recognized (Von Hippel, 1988; Harabi, 2002; Knoedler 1993). Evidence from Freel (2000a) suggests that innovation is positively associated with the participation of customers in design, development, and product improvement.

Branstetter (2000) finds that firms with vertical keiretsu affiliation spend 32% more on R&D than non-affiliated firms, and generate more patent applications. Kaiser (2002) shows that cooperating firms have a higher R&D expenditure in the German service industry. Clark et al. (1987) show that a key component of Japanese automakers' advantage over their U.S. and European competitors in introducing new models is the *early supplier involvement* in product design: Japanese firms are able to develop a vehicle of competitive quality using much less time and less engineering hours.[14] Using evidence from the automobile and electronics industries in Korea, Chung and Kim (2003) show that the involvement in the manufacturer's product development enhances the supplier's financial and innovation performance (measured in patenting rates). Their results also suggest that suppliers involved in the earlier stages of development learn more about new technology and market opportunities. Revilla (2002) demonstrates that the most important cooperation partners for manufacturers in the metropolitan systems of Barcelona, Stockholm, and Vienna are customers and suppliers. Von Hippel (1988) claims that "it was typically the product user, not the product manufacturer, who recognizes the need, solves the problem through an invention, builds a prototype and evaluates the prototypes' value in use" (p. 25). He finds that user-dominated innovations account for 77% of innovations in scientific instruments and more than 60% of improvements to the machinery in the semiconductor and printed circuit board assembly process. Knoedler (1993) points out the important role that customers play in promoting both increased innovation in basic steel productions and the innovative efforts of the steel producers between 1880 and 1910 in the U.S..

The issue of external linkages is particularly important for small firms. For instance, Britton (1993) notes that the poor innovation performance of small manufacturing firms in Canada is partly due to poor connections of those firms with external sources of technical and management support, mostly due to limited financial and human capital resources. This finding is consistent with that of MacPherson (1997a). Using data from a postal survey of 472 New York State SMEs in four industry groups including scientific and professional instruments, electrical industrial equipment,

[14] The timing at which suppliers are brought into the design of a new product matters. The rewards are higher when suppliers are involved earlier in the process (Manufacturing & Technology News, 1998).

fabricated metal products, and office/household furniture, MacPherson shows that there is a positive relationship between successful SME innovation and the recourse to external sources of expertise. What is more, he demonstrates that advice coming from suppliers and customers, despite its lower costs, plays an innovation-supporting role that matches the impact of more expensive external support such as contract R&D. In related work, using the same data, MacPherson (1997b) shows that external technical services support the innovative activities of firms. 40% of outsourcing activities are driven by quality/cost considerations (defined by a condition where a firm obtains superior or low-cost inputs from suppliers which cannot be produced in-house) and 36% by necessity (defined as an urgent need which cannot be satisfied using in-house resources). Also, he finds that among all modes of outsourcing (including informal/non-market services, private services and public services), suppliers, customers and informal business networks cost relatively low (or even nothing), but were constantly ranked very high in terms of their impact.

Freel (2000a), based on a sample of 228 small West Midland's manufactures, shows that innovating firms are more likely to be involved in collaborative arrangements with suppliers than their non-innovating counterparts, and that new product development/ improvement is the most common reason for cooperation. The other interesting finding of his is that "established long-term relationship" and "frequency of contact" are ranked as the top two factors contributing to successful cooperation, while operating in the same supply chain is much less important. This underscores the importance of trust and familiarity in small firms' interactions with external agents. The conceptualization of Nooteboom (1994) may provide the explanation: when internal resource constraints are significant, the firm usually recourses to external sources to share the responsibilities. Successful cooperation requires that the other party 1) has the incentive to give advice and 2) is able to give good advice. The two factors are likely to lead small firms to resort to customers and suppliers, with whom they have frequent contacts and who know their business.

However, there may be some difficulties related to institutionalizing cooperation (Helper, 1996). On one hand, knowledge from participating parties has to be integrated and turned into assets valuable to users. Firms need to develop absorptive capability in order to optimally utilize external information. Cooperating partners have to be able to figure out a way to pool complementary knowledge and assets together. On the other hand, proper incentives have to be given to motivate persistent efforts. Helper (1987, 1991) develops a scheme for relations based on two types of responses: *voice* and *exit*. When a problem arises, the participating party chooses either exit or staying with its partner to figure out a solution (voice). The key to the *voice* strategy is 1) a mechanism facilitating the flow of information (higher flows of information facilitate problem-solving and increase switching costs); and 2) adequate commitment. Whereas insufficient commitment may lead to failure of cooperation, excessive commitment reduces the incentives to improve, since the other party is "locked" into the relationship. Helper backs the argument using evidence from her survey of 312 U.S. and 32 Japanese automotive suppliers, and shows that the best incentive system should involve both rewards and risks and have a long-term horizon.

The work of Helper is closely related to Streb (2003), who concentrates on the channels through which knowledge is transferred between suppliers and customers. He models knowledge exchange as a two-stage game: the upstream firm decides whether to transfer, and the downstream firm decides whether to reward the upstream firm or free ride. In a one-shot Nash equilibrium, the result is that the downstream firm chooses to cheat and the upstream firm chooses not to transfer. However, if this game is turned into a repeated game and the upstream firm manages to credibly punish the downstream firm for cheating by excluding it from further transfer, the sub-game perfect equilibrium turns out to be a Pareto efficient solution which ensures persistent knowledge exchange along the supply chain. Streb illustrates his results using the German plastics industry (including chemical firms, plastic fabricators and machine makers). The formation of a vertically integrated firm (I.G. Farben) improved the flow of information and induced more R&D investments. After the break-up of I.G. Farben, firms made use of both contractual and non-contractual solutions to facilitate information exchange, which is the main factor behind Germany plastic industry's exceptional international competitiveness.

These results are also consistent with other empirical evidence. Shenas and Derakhshan (1994) show that repetitive and long-term manufacturer-supplier interaction encourages knowledge transfer and inhibits opportunistic behavior. It facilitates the implementation of simultaneous engineering. Chung and Kim (2003) find that long-term commitment of suppliers in product development not only enhances learning, but also motivates their innovative efforts in order to be continuously involved in cooperation. Clark (1987) finds that the extensive involvement of suppliers allows Japanese automakers to introduce a new model with less engineering hours and in shorter lead time than their U.S. and European counterparts. Nishiguchi (1994) claims that the problem-solving oriented mechanism is the main reason why Japanese producers gained advantage over British firms. Dyer (1994) demonstrates that Japanese companies managed to simultaneously achieve high asset specificity and low transaction costs. Higher commitment of manufacturers to suppliers (repeated transactions) and better information flows all contribute to effective collaboration.

Sobrero and Roberts (2002) also look into the institutionalization of a vertical relationship related to new product development and show that there can be a trade-off between short-term efficiency and long-term learning. The outcome of coordination depends on the manufacturers' relation strategies (the mechanism of information transfer, the level of involvement of external agents and the incentive system). More articulated coordination mechanisms with a higher level of supplier involvement (earlier involvement and more responsibility) generates higher costs, but creates conditions for effective information exchange. This (long-term) learning effect helps to broaden the manufacturer's internal resource set and its benefits will spread to future projects. However, if the supplier is used merely as subcontractor and if the relationship is just bargaining-oriented, this may reduce costs in the short-term but at the expense of long-term learning. In vertical relationships, firms try to reach an optimal mix of the two mechanisms and the mix may change depending on the nature of the task and the environment.

Whereas Helper (1996) concentrates on the issues of incentives and investigates what is necessary to motivate suppliers involved in product development, Fujimoto et al. (1996) investigate what kind of organizational structure enhances integration. They look at innovation as a process of interpreting and transmitting market and technical information to satisfy customers. The latter consume the experience that the product delivers and their evaluation of the product is incorporated by producers for subsequent innovation efforts. This perspective sits very comfortably with the concept of innofusion (Fleck et al., 1990) and appropriation (Von Hippel, 1982). In order to improve product quality efficiently, two dimensions of organization are crucial: 1) *Specialization*: high product quality requires expertise and a certain degree of specialization is necessary; and 2) *Organizational integration*: internal integration is important for product coherence and external integration for product fit. Fujimoto et al. emphasize the role of leadership and the process that product managers use to achieve integration and show that a *heavyweight system* significantly contributes to product development. Compared to a *lightweight manager* who concentrates on coordinating engineering activities to achieve internal integration, a *heavyweight manager* cultivates continuous interaction with customers, efficiently interprets market information and has a strong influence over generating a concept and infusing it into product design and development. This is consistent with the empirical findings from Clark et al. (1987), who show that when the heavyweight manager leads a multifunctional team and problem-solving tasks are linked through intensive dialogue, this significantly contributes to the competitive advantages of Japanese automakers over their U.S. and European counterparts.

7. MULTINATIONALS AND CROSS-COUNTRY ISSUES

Several of the issues discussed in the previous sections arise in a domestic context as well as in an international context. Many of the R&D intensive firms are large multinationals which locate production and R&D activities in several countries. The organization of the innovation activities of MNCs is more and more based on globally integrated networks (Dunning, 1996). Understanding the relationships between multinationals and their suppliers/customers in host countries, as well as their internal vertical organization, is key to understanding the relationship between vertical organization and international R&D location.

The organization of global value chains is partly dependent on how multinationals organize their operations horizontally and vertically. There exists a large literature on the determinants of the location of various business activities across countries. There is a distinction between *horizontal* and *vertical* multinationals. Horizontal multinationals produce the same products in several countries, and those countries are typically of similar size and are at the same stage of economic development (see, for example, Brainard, 1993). Whereas vertical multinationals go abroad mainly to integrate different stages of production across national borders (see, for example, Helpman, 1984). Much of this literature is concerned with the relationship between country characteristics and aggregate sales of affiliates.

This section looks at how the vertical organization of multinationals affects the location of their innovation activities. First, a distinction is made between *home-base exploiting* R&D, which aims at exploiting an existing advantage abroad, and *home-base augmenting* R&D, which aims at augmenting the technological capabilities of the firm. Second, we look at the vertical organization of the MNC, and how it relates to knowledge flows. Third, we study how the presence of MNCs affects competition, and how this can change the impact of their R&D investments. Fourth, we examine backward and forward linkages, and study under what circumstances the benefits from FDI to the local economy are maximized. Finally, we study the role of MNCs in some specific global industries.

7.1 Home-base augmenting/exploiting FDI

What is the motive behind FDI, and in particular behind performing R&D abroad? Is it to take advantage of existing strengths and extend them overseas, or to benefit from knowledge and competencies existing in the host economy? Or a combination of both? A large literature deals with this issue. In the international business literature, the dominant view is that firms locate those activities abroad mainly to exploit their home-base advantages. From this perspective, subsidiaries play at best a supportive role, and are not expected to make important technological contributions. The alternative view, that firms also need access to external knowledge and complementary assets, is supported, for example, by the capabilities theory of the firm.

The level of development of an economy can affect vertical relationships. In a theoretical property rights framework, Acemoglu et al. (2003) argue that the optimal vertical structure may depend on the level of technological development. They assume that vertical integration forces owners/managers to allocate their time to production and innovation, which creates a managerial overload. Therefore, when a firm is far from the technology frontier, so that imitation is more important relative to innovation, vertical integration is preferred. Whereas, for firms close to the frontier, innovation is crucial, and outsourcing is preferred. This can affect how multinationals choose to operate in different countries. When operating in a technologically advanced country, the firm would rely more on outsourcing. Even as the same firm, operating in a less technologically advanced country, would rely more on vertical integration. Similarly, the multinational whose home country is technologically advanced would rely more on outsourcing, whereas the multinational whose home country is a technological follower would rely more on vertical integration. In the same fashion, differences in the degree of technological advancement of multinationals from the same country will affect the way they approach vertical relationships: those operating in more advanced sectors would have a higher level of outsourcing. Moreover, using outsourcing in a technologically advanced country gives the multinational greater access to the local technological knowledge. Whereas, in the less advanced country, local technological knowledge is more limited, and the benefits from greater contacts with local firms are less important.

Belderbos et al. (2001) argue that the R&D intensity of a firm affects the local content of its foreign affiliates. Because a high R&D intensity is associated with greater use of in-house know-how and intangible assets, and because the home country is typically abundant in technology-intensive inputs and in the human capital needed to produce such inputs, multinationals are less likely to use subcontracting, and less likely to produce those inputs abroad. Only when the technological capabilities of the host country are high, will such subcontracting occur. This creates a negative relationship between R&D intensity and local content, and this relationship is mitigated by absorptive capacity and the level of technological sophistication of the host country. They find support for this hypothesis for Japanese parent firms. The negative relationship disappears when the host country is highly developed, such as Canada.

Kuemmerle (1999) distinguishes between two types of foreign R&D: *home-base exploiting*, which aims at adapting the product to a new local market, and *home-base augmenting*, which aims at benefiting from the quality of the local knowledge base. Home-base exploiting R&D aims at "exploiting firm-specific capabilities in foreign environments" (p. 3), while home-base augmenting R&D aims at benefiting from spillovers from local R&D organizations (universities, competitors, supporting industries, etc.). He predicts that the former type of R&D is associated with market size, whereas the latter type is associated with the quality of the local knowledge base. The quality of local knowledge is measured by the relative R&D intensity of the host country, the relative competitiveness of the host country in exporting in the industry under study, and the presence of recent Nobel laureates in relevant fields in the host country (and also by the population with tertiary education). The size of the local market is measured by the difference in GNP between the home and host countries. The data, from a survey of laboratory investments made by 32 large pharmaceutical and electronics firms, support these hypotheses.

Le Bas and Sierra (2002) investigate whether firms locate technological activities abroad to exploit their initial technological advantage, or to benefit from the technological advantage of the host country. They identify four foreign FDI strategies. First, a *technology-seeking* strategy, whereby the multinational invests in R&D in a country and in an area where it is weak in the home country (and overall) (e.g. European and Korean firms investing in the U.S. in the semiconductor industry). This can be done through setting local R&D units, or through equity investments into local firms. The second strategy is *home-base exploiting*, where the host country is weaker technologically than the home country. The goal of this strategy includes technology transfer to the subsidiary, adaptation of the product to local conditions, and providing technical support to foreign customers. The third strategy is *home-base augmenting FDI*, where both the home and host countries are technologically strong. Here, the firm aims at acquiring capabilities which are complementary to its own. Finally, *market-seeking FDI* corresponds to a situation in which both the home and host countries are technologically far from the frontier. In this case, technology is not the main driver behind the investment, rather it is part of a growth-by-acquisition and mergers oriented strategy.

Their analysis is based on European patents over the periods 1988-90 and 1994-96. The dominant strategy overall -for both countries and fields- is home-base augmenting FDI, with only a few exceptions. The second dominant strategy is the home-base exploiting FDI. Interestingly, Canada is one of those exceptions when the analysis is based on the number of cases rather than on patent counts. The other two strategies are somewhat marginal. Differences between fields may explain why Canada is one of the exceptions: strategy 2 is dominant in telecommunications and materials-metals, two fields in which Canadian firms are prominent. Moreover, over time, strategy 3, which is associated with "dynamic learning" becomes even more dominant over strategy 2, which is a more myopic approach.

Yamawaki (2004) extends this literature by focusing on the geographic organization of different value-chain activities. He uses data on foreign MNCs who invested in Japan during the period 1973-1994. He finds that foreign-owned subsidiaries operating in Japan tend to locate labour intensive activities outside Japan and import those intermediate goods into Japan. This is expected, given that Japan is a capital-abundant country. Moreover, intra-firm trade is more likely in R&D intensive industries. This is consistent with the transaction cost hypothesis, since R&D is a specialized asset. Intra-firm trade is less likely in advertising-intensive industries, since local customization is more important in such industries. Moreover, foreign MNCs are more likely to locate R&D intensive activities in Japan, and production activities outside Japan. This is consistent with the high technological capabilities in Japan that attract high-tech activities. Distribution activities are more likely to be located in Japan (vertically integrated distribution channels) when the industry is advertising-intensive, again due to the need for local customization. These results suggest that different value chain activities have different determinants, and hence that the study of the distribution of aggregate operations of MNCs masks important differences in the distribution of specific activities.

One of the policy implications of these results is that a country must determine, based on its characteristics, which type of foreign R&D (home-base exploiting or home-base augmenting) it can attract, and in which industries. A developing or newly developed country might find it easier to attract home-base exploiting R&D, while a technologically advanced country could focus on home-base augmenting R&D.

In light of this analysis, one possible reason why automakers invest little in R&D in Canada is the similarity between the U.S. and Canadian markets (in addition to the small size of the Canadian market), and hence there is little need to invest in home-base exploiting R&D. In addition, the Canadian context does not offer any particular technological advantage, thus the motive for home-base augmenting R&D is also absent:

the size of the knowledge base in Canada is small relative to the U.S., and the quality is not very different.

7.2 Vertical internal organization

In recent years, subsidiaries of MNCs have been expanding their activities in many areas, including R&D (Mudambi and Navarra, 2004). This results in greater autonomy for subsidiaries, but may also induce greater tensions within the MNC. Mudambi and Navarra explore knowledge flows and autonomy within dispersed MNC networks. They attribute to managers two objectives: profit-maximization, and rent extraction. The bargaining power of the subsidiary determines the ability of its managers to extract rents; but rent-seeking behaviour can also be found at the headquarters. This greater independence of subsidiary managers is a potential source of wealth-creation for shareholders, but also a potential source of managerial rent seeking. The MNC can take different measures to limit the discretion of subsidiaries (monitoring, control), which will affect the allocation of resources to R&D between the headquarters and the subsidiaries. The headquarters may try to control the behaviour of subsidiaries through tight control and monitoring, but this control can reduce the efficiency of the subsidiary and the gain from its strategic independence.

Mudambi and Navarra argue that knowledge flows and control of knowledge assets (R&D intangibles) determine the bargaining power and rent appropriation of a subsidiary within the MNC. They test their predictions using data on high technology UK subsidiaries of MNCs. They measure knowledge flows by patent citation data, and measure rents (which should be associated with bargaining power) using net (financial) flows within the MNC, which are due to dividends, royalties, etc.

They identify four types of knowledge flows: from the subsidiary to parent (*knowledge transfer*), from location (*host country*) to subsidiary (local competence exploitation), from subsidiary to location (*spillovers*, both intended and unintended), and from the parent to the subsidiary (*exploitation of a home-base advantage*). Note that knowledge flows between the home and host countries (in both directions) represent another layer of vertical relationships, since buyers and suppliers are among the agents operating in the host country. They hypothesize that the bargaining power of a subsidiary is enhanced by its knowledge output to other units of the MNC, its age, the extent of its external orientation (example: exporting in multiple markets), and the control it has over its production process, and is weakened by its knowledge inputs. Most of the hypotheses are supported by the estimation results, except for the effect of knowledge inputs into the subsidiary and the effect of external orientation.

The work of Mudambi and Navarra draws our attention that opportunism and rent seeking are not the exclusivity of the market, and that vertical relationships within the firm are not only about efficiency. Rather, bargaining power, rent seeking, and opportunism play a role in determining, and are also determined by, the distribution of critical functions -including R&D and knowledge creation- within the MNC. In consequence, the location of R&D activities within the MNC (for example, upstream or downstream, in the home country or in the host country) needs to be explained using both efficiency and agency considerations. Moreover, intangible assets are much more important in determining the bargaining power of a subsidiary, since property rights over those assets are hard to define; whereas it is easier for the headquarters to retake control of physical assets.

7.3 Competition effects

A MNC can affect the competitive structure of the local industry, both upstream and downstream. This can affect the extent to which the host country benefits from FDI, and the incentives of the multinational to transfer technology to the host country.

Markusen and Venables (1999) develop a theoretical model to study how entry by a multinational affects a domestic industry in which there are local upstream and downstream firms. The number of domestic firms is determined by a zero profit condition, while entrants into the country decide whether to operate as foreign importers or as multinationals, producing domestically. They identify two effects. The first is a *competition effect*, by which there is substitution of the multinational for domestic downstream producers, and possibly even for imports. The second effect is a *linkage effect*, between the multinational and upstream producers, by which the multinational then encourages the development of the local industry. Eventually, the second effect may become so important, that the development of local producers drives the multinational out of the host country. Although theoretically possible, this displacement result is unlikely to occur in many markets, as even when local suppliers develop, they are often dependent on the multinational, which is also more technologically advanced than them.

Technology diffusion and the ease of imitation are also factors that affect the incentives of a multinational to transfer technology to a supplier/distributor in a host country. The theoretical and empirical evidence on this issue is mixed: some studies have concluded for a negative effect of diffusion on technology transfer (for example, Ethier and Markusen, 1996 on the theoretical side, and Lee and Mansfield, 1996 on the empirical side), whereas other studies have found a positive relationship (for example, Glass and Saggi, 1998 on the theoretical side, and Blomstrom et al., 1994 on the empirical side).

Those studies consider technology transfer in general. One advantage of the theoretical work of Pack and Saggi (2001) and Goh (2005) is that they focus specifically on technology transfer via buyer-supplier relationships. Pack and Saggi (2001) model a situation where a (downstream) firm in a developed country (DC) outsources production to a (upstream) firm in a less developed country (LDC) and engages in vertical technology transfer. The technology transferred to the LDC firm may leak to a competitor in the LDC. One would expect that this potential leakage has a negative effect on the incentives for vertical technology transfer. But Pack and Saggi show that it can have the opposite effect, by increasing competition among the LDC suppliers. And even when technology transfer induces entry into the downstream DC market (hence increasing competition for the DC firm), the transfer may still be beneficial to the two original firms involved in the technology transfer. This is because diffusion upstream increases competition in the upstream market, which benefits the DC firm; and entry downstream increases competition in the downstream market, benefiting the LDC supplier. The original firms gain when this increase in competition is not too severe. This suggests that the incentives for vertical technology transfer may be greater under international outsourcing than under vertical integration, since a vertically integrated firm would not achieve this gain from increased upstream competition in the LDC.

An interesting feature of the Pack and Saggi (2001) model is that "actions of one firm can alter the market structure in both upstream and downstream markets." (p. 393)

More specifically, the technology transfer decision of one firm can affect downstream and upstream market structure through feedback effects between the two markets. These results can help us understand the policies of Japan and Korea that encouraged the dissemination of knowledge. While Pack and Saggi develop their model for vertical technology transfer between industrialized and developing countries, the same reasoning can apply to technology transfer between industrialized countries.

There exists a theoretical counterpart to this result. It has been shown theoretically that information sharing between upstream and downstream firms enhances the innovation efforts and the benefits from technological cooperation between them (Ishii, 2004). However, the risk that the information leaks indirectly to one's own competitors limits the incentives for vertical knowledge disclosure (Bonte and Wiethaus, 2005). This applies to domestic as well as international vertical relationships.[15]

Goh (2005) extends the work of Pack and Saggi (2001) by endogenizing the level of effort chosen by the LDC firm. This is done by requiring the supplier to invest in process R&D which reduces production costs. This reflects the fact that technology is not absorbed passively, but requires active efforts on the part of the recipient. He shows that the cost of this process R&D is important for the relationship between diffusion and technology transfer. The degree of technology transfer is represented by the quality of the input required by the DC firm. Namely, when improving efficiency is costly (cheap), diffusion to competitors of the LDC firm increases (decreases) technology transfer. This result comes from two effects. First, diffusion intensifies upstream competition, reducing the input price and increasing the input of the incumbent firms. This is the *supply effect*, which favours technology transfer. Second, the increased competition reduces the technological effort of the incumbent LDC firm; this is the *effort effect*, which discourages technology transfer. When technological effort is costly, the supply effect dominates the effort effect, resulting in a positive relationship between diffusion and technological transfer. When, however, technological effort is cheap, the converse is true, and the relationship between diffusion and technology transfer becomes negative.

In general, the competition effect may have positive or negative effects on local firms. On the one hand, increased competition due to the presence of multinationals may

[15] See section 6.2 for a more detailed discussion of this topic.

induce local firms to streamline their operations, eliminate inefficiencies, and upgrade their technologies. On the other hand, if this increased competition reduces the market share of local firms, it may increase their average costs, and in some cases may lead to the disappearance of local firms. The net effect is ambiguous.

7.4 Positive or negative backward linkages?

In general we think of FDI as benefiting the host economy. However, there are instances where FDI has limited or even negative effects, and many of those negative effects (can) take place through the vertical value chain.

Suppliers of a multinational may be unable to attract general R&D functions locally, which the MNC may prefer to perform at home or in another location (endowed with a large market, for example). However, it may be possible, even for small countries, to attract innovation and R&D activities in some specialized areas. For example, Farshchi and Janne (2003) study the role of MNCs in the automotive industry in the West Midlands region in the UK. They selected five global vehicle manufacturers and 20 first-tier component suppliers. In spite of the general decline of the automotive industry in the UK and in the West Midlands, and in spite of the fact that most global vehicle manufacturers maintain their R&D (and design) operations outside the UK, this region (and the UK more generally) has been able to develop a strong expertise in engine design and manufacturing, and is seeing an increase in FDI and in R&D collaborative agreements in that area.

Crone and Roper (2001) study knowledge transfer from MNCs to local suppliers in Northern Ireland. Their results rely mainly on the opinions of senior managers from the MNE plants located in that country. They find that a large proportion of MNCs are engaged in knowledge transfer activities with local suppliers. This transfer is limited, however, by the “low level of local sourcing” (p. 545). Moreover, strategic autonomy, formal supplier development policies, and the presence of an engineering component, increase the likelihood of knowledge transfer.

Javorcik (2004) notes that benefits from FDI are more likely to materialize through vertical than horizontal relationships. Multinationals try to limit the benefits accruing to local competitors, while they would work with local suppliers to improve product quality and transfer technology. Using data on Lithuania, he finds that the benefits from FDI occur mainly through backward linkages (contacts between local suppliers and multinational clients). He finds little evidence for horizontal spillovers (benefits to competitors of multinationals) or forward linkages (benefits to downstream firms from the presence of multinationals upstream). Similar findings for horizontal spillovers are made, for instance, by Aitken and Harrison (1999) for Venezuela. Moreover, the benefits come from firms which are jointly owned by domestic and foreign interests. This is because foreign-owned firms rely on imported inputs to a larger extent. Several channels exist through which suppliers can benefit: copying technology, hiring labour trained by the multinational, higher quality requirements, and increased demand for inputs (which allows local suppliers to take advantage of economies of scale).

The vertical impacts of international transactions are not limited to multinationals. Domestic firms who export can also benefit the local economy through spillovers and backward linkages. Alvarez and Lopez (2005) argue and find, using data on Chilean manufacturing establishments, that vertical spillovers emanate from multinationals as well as from domestic exporters. Thus, not only are exporters more efficient than non-exporters (Bernard and Jensen, 1999), but they also provide indirect benefits to them. This efficiency effect can be due to either technology transfer, a competition effect, or both. For example, exporters may provide technical help to their domestic suppliers in order to improve quality. The novelty of the paper of Alvarez and Lopez is to argue that this effect comes not only from multinationals, but also from local exporters. Similarly, exporters (as well as multinationals), by increasing demand, can induce upstream firms to take greater advantages of economies of scale. The improved performance of upstream firms can also benefit their customers, creating forward spillovers from exporters to downstream firms. At the same time, the desire of firms to limit information flows to their competitors limits horizontal spillovers from exporters, while upward pressure on input prices can reduce the benefits of vertical spillovers.

The empirical results of Alvarez and Lopez suggest that exporting firms impose negative backward effects on upstream firms (i.e. increase their costs). This is because exporting firms rely less on domestic inputs, forcing upstream firms to reduce their production and move up on their average cost curves. More specifically, domestically owned exporters exert a negative backward externality, whereas foreign owned exporters exert a positive one. At the same time, forward spillovers are positive. Moreover, those results hold whether the exports are shipped mainly to a developing or developed country.

A similar result is obtained by Thangavelu and Pattnayak (2005), who find that foreign firms create positive horizontal spillovers in the Indian pharmaceutical industry, but induce negative backward linkages. Again, full (foreign) ownership of foreign firms is associated with negative spillovers to local upstream firms. This can be due to a wide gap in efficiency and technology between local upstream firms and multinationals. Moreover, because of weak intellectual property protection, the limited interaction with local suppliers can be a preemptive strategy on the part of multinationals to protect their know-how. The authors suggest several strategies to transform those negative vertical linkages into positive ones: improving the reliability and quality of local suppliers, investments in training of the local workforce, and stronger IPRs, particularly for product innovations.

Javorcik et al. (2004) find that multinationals from different countries generate vertical spillovers of different magnitudes. First, a greater distance between the host country and the home country of the multinational induces the latter to rely more on local intermediate inputs, which increases the benefits to the host country. Second, tariffs are typically lower within regions than between regions, again encouraging multinationals from distant countries to rely more on local suppliers. Third, rules of origin often give preferential treatment when the product uses inputs from within a certain region. Multinationals from the same region as the host country can import inputs from their home country and still benefit from this preferential treatment, whereas multinationals from distant countries will find it more advantageous to source locally. Consistent with these predictions, and using Romanian data, Javorcik et al. find that American and Asian multinationals generate more vertical spillovers in that country than European multinationals. Namely, the presence of American and Asian multinationals downstream has a positive effect on the productivity of Romanian suppliers upstream. Whereas European multinationals have a negative effect. This negative effect comes from the fact that entry by multinationals downstream can drive out local firms, reducing the demand for inputs from upstream firms, increasing their average cost. This effect is particularly strong when the multinational relies mainly on imports rather than local sourcing.

Moreover, one would expect that the negative effects on the local economy would be more negative the more backward it is relative to the home country of the multinational. It is in those instances that multinationals are most likely to use imports or in-house production rather than local sourcing. However, the existence of negative backward linkages by itself does not imply that the net effect on of FDI on the local economy is negative, as there are horizontal and other effects which can more than compensate for those effects.

7.5 Examples from the global automobile, semiconductor, and consumer electronics industries

Many of the studies of vertical relationships of multinationals are cross-industry studies. Some studies adopt an in-depth approach, focusing on particular industries. Three industries which illustrate the workings of vertical relationships in relation to innovation in the context of multinationals are the automobile industry, the semiconductor industry, and the consumer electronics industry.

The global automobile industry

Miller (1992) analyzes the factors affecting the location of R&D (and also engineering) activities in the global automotive industry. His study relies on interviews with 41 R&D senior managers in 21 firms from the Northern Hemisphere, as well as formal questionnaires. One of the important roles of regional technical centers is to adapt upper-bodies to local preferences, regulations and climate. In addition, assembly plants in local markets and relationships with local suppliers (the improvement of their qualifications, strategic control over them and R&D cooperation with them) require FDI in R&D. Although firms prefer to do most of their R&D in-house (either at home or abroad), some R&D activities benefit to a greater extent from research contracting, in particular “structure design, generic research and styling” (p. 31). Moreover, firm status and experience affect their external technological relationships. New entrants are highly dependent on external contracts and alliances with other car manufacturers and (Tier 1) suppliers, high-volume generalists rely on Tier 1 suppliers for new technologies, whereas technological leaders rely mostly on internal technology development and to a lesser extent on Tier 1 suppliers.

Moreover, structured R&D activities can be performed externally, but there is a need for an experimental plant not too far from headquarters, which explains why most R&D is done near home. The exception is when the regional market is large, which would justify the establishment of a local R&D centre. Linkages with corporate strategy, the standardization of under-bodies, and economies of scale and scope are major factors in keeping R&D at home. The scale effect is quite large in the automobile sector. For instance, it is estimated that annual sales of 950 000 units are required to justify the establishment of a full scale R&D centre. The need for regional R&D to adapt the product to the local market (e.g. upper-body design), competitors' surveillance, international expansion, the desire for autonomy by local managers, and local governments' pressures all favor locating R&D abroad. Many of those factors apply to other industries as well.

Miller identifies four strategies with respect to R&D in the global automotive industry: an *export-oriented* strategy with concentration of R&D at home (BMW), a *regional* strategy with also concentration of sales in one major region and concentration of R&D at home (Peugeot), a *global* strategy but with only "listening post and engineering centers" in the host country (Toyota), and a *multi-regional* strategy with autonomous R&D facilities abroad (Ford).[16]

An open question is how the current restructuring of the North-American automotive industry will affect R&D relationships within that industry and with other industries. The American auto companies have reduced their overall level of vertical integration, but R&D has remained largely integrated. Whether the new smaller firms that will emerge from the restructuring will maintain that internal R&D model, or whether independent R&D suppliers[17] will play a greater role (possibly with long term contracts) remains to be seen.

[16] The Argentine automotive industry is also illustrative of the complexity of innovative activities in a network (Albornoz and Yoguel, 2004).
[17] As has happened in Chemicals and, to a lesser extent, Pharmaceuticals.

Successful vertical relations cannot simply be copied from one jurisdiction to another. For example, the organization of the Japanese motor industry is characterized by a high degree of inter-organizational dependencies and trust, which limits the applicability of this type of vertical relations to other industries, like for instance the UK car industry. The latter is characterized by competitive relationships, short term contracts, high levels of stocks, and limited collaboration (Turnbull et al., 1992). Therefore vertical technological relationships cannot be separated from the overall vertical relationship in the industry.

The semiconductor industry

One important dimension of vertical relationships is the degree of vertical specialization, whereby activities such as design, marketing, and production are performed by independent firms. The Internet and e-business can affect the degree of vertical specialization in an industry, including the organization of R&D and process design. The semiconductor industry is one instance where vertical specialization has increased recently, and this trend has been facilitated by Internet based e-Business applications (Macher et al., 2002). The separation of design and manufacturing is particularly pronounced in this industry: design is concentrated in the Triad, even as manufacturing is more dispersed, with Southeast Asia playing a central role in packing and testing. Initially, the increase in vertical specialization has been driven by the increase in the size of the market and the increase of fixed costs (both factors increased the importance of economies of scale), the standardization of the technology used, and the standardization of interfaces between the different components. In spite of these advantages, some integrated firms remain active, especially in the high-tech area, where the coordination of the different stages is particularly crucial (Macher et al., 2002).

The Internet is used by firms in this industry to exchange information about timing and content of design and manufacturing, design rules, and order status. However, as Macher et al. (2002) note, this constitutes a continuation of existing trends, rather than "qualitative advances" in the coordination of complex transactions. Also, the qualitative shift seems more important in design than in manufacturing (for example, the internet-based markets for blocks of Intellectual Property on semiconductor designs, and the outsourcing of design, including collaboration between geographically dispersed teams). The semiconductor equipment and materials industry is also affected (for example, remote monitoring and repair of equipment). Finally, we note that semiconductor firms formed a consortium (*RosettaNet*) in 1998 to define e-Business protocols. Moreover, e-Business applications can also be adopted by integrated firms, with even less coordination efforts, although they may result in selective disintegration by large firms. Hence e-Business can benefit both integrated and disintegrated structures.

The semiconductor industry illustrates many characteristics of vertical supply chains. First, technology often accelerates existing trends toward increased specialization, rather than creates them. Second, in some niches of a sector some firms choose to remain integrated, in parallel to the majority of disintegrated firms. Third, clustering benefits can be greater in some parts of the vertical chain, leading to the dispersion of some activities while other activities (e.g. design, in the case of semiconductors) remain concentrated geographically. Fourth, different stages of the vertical chain can be affected to different degrees by the increased coordination made possible by technology. Finally, a standard-setting body can facilitate the widespread adoption of e-Business applications along the value chain.

Consumer electronics

Capannelli (1999) studies technology transfer from Japan to Malaysia through buyer-supplier transactions in the consumer electronics industry. His study is based on visits/interviews with firms and empirical estimates of the determinants of technology transfer. He finds that local suppliers benefit considerably from technology transfer from their customers, and the gain is particularly large for low-tech suppliers. Assistance from the large Japanese buyers to the local Malaysian suppliers took several forms, including the specification of product design, advice on the use of equipment, the introduction of new technologies, and the solution of technical problems. Moreover, learning was more intense from those buyers who sourced more inputs locally from Malaysia, and from buyers who had a higher R&D intensity in Japan, for sellers who made large sales to specific buyers, and for technologies which are more standardized. Thus, it is not only high-tech suppliers who get to gain technologically from selling to and getting support from large buyers located in industrialized countries, but the gains exist for low-end suppliers, too.

In addition, specific investments by both upstream and downstream firms increase the technology transfer and the absorptive capacities of the recipients. This finding shows the limitations inherent in the traditional transaction cost perspective, which argues that specific investments make market transactions unlikely. In this framework, asset specificity is exogenous. Whereas, as the results of Capannelli illustrate, specificity is endogenous, and can help the (independent) parties achieve greater efficiency.

Capannelli also notes that technology transfer imposes a cost on both the transmitter (here, the buyer of the input) and the receiver (here, the supplier of the input) of the technology. But both parties still gain from the transfer, which reduces production costs and/or increases the quality of the input being sold.

8. CONCLUSIONS

No single theory can explain all the features of the complex relationship between vertical organization and innovation. Transaction cost theory, the capabilities approach, externalities, network theory, international business theory, and agency considerations, shed light on different aspects of this relationship, and complement each other in identifying its main features.

Policy

Understanding the level and distribution of innovation activities along the global vertical supply chain can help governments attract R&D-related FDI in areas most suitable to the local economy, and from firms and countries most likely to find this investment profitable. Several policy issues have been discussed throughout the paper, but it is useful to summarize some of the policy lessons here.

One important policy question is whether the same approach should be applied to vertical and horizontal R&D cooperation. Rothwell and Dodgson note that innovation policy is open towards precompetitive R&D collaboration between firms, which is "far from the market". Such a policy was designed mainly with horizontal R&D collaboration in mind. However, vertical R&D collaboration often requires firms to collaborate on development activities, "near the market". Whether the full exploitation of vertical linkages requires a more lenient approach towards vertical R&D collaboration is an important policy issue which requires further examination.

Crone and Roper (2001) note that the level of knowledge transfer from MNCs to local suppliers is likely to be suboptimal, hence there is a market failure which might be addressed through government intervention. MNCs may be reticent to share knowledge, and may prefer limited local sourcing. Supply chain measures aimed at strengthening local linkages and encouraging knowledge transfer might be called for. Supporting the R&D activities of local suppliers makes them more attractive to foreign firms, increases their absorptive capacities, and can encourage the MNC to engage in joint research with them. This may also foster the R&D activities of the MNC in the host country. An interesting policy initiative in Northern Ireland is the *National Linkages Programme* which aims at developing the capabilities of local suppliers, encouraging long term relationships with MNCs, and increasing learning.

Not only multinationals, but also exporting firms, can exert positive vertical linkages on the local economy. Moreover, partial domestic ownership increases the benefits from vertical linkages, whereas complete foreign ownership reduces those benefits. Stronger (horizontal) IPRs can favour vertical knowledge sharing and vertical linkages, because of reduced fears of leakages to competitors. Competing with the home country of the MNC in terms of location of R&D facilities can be difficult (but not impossible), but it should be easier to compete with other foreign locations. A firm that has already located significant R&D facilities away from its home country has already internationalized its R&D function, and is more likely to continue doing so in the future. Whereas a firm that concentrates its core R&D functions at home will not change this strategy easily, even when offered significant incentives. There is some sort of *discontinuity* at the point where R&D activities have already been located away from home, and it may be easier to focus on attracting the future R&D expansions (or transfer of current activities from third countries) of those firms. U.S. car companies have already located significant research facilities in Europe, and conversely, European car manufacturers have also located research facilities in the U.S.

Some R&D-related functions are located away from the home country more easily, and some of those functions are a better fit for specific countries. It is important for a country to identify the areas in which it can offer an innovation-related comparative (or absolute) advantage to MNCs. The question is not only how advanced the local firms are, or whether they can provide the inputs needed by the MNC, but also *where* they fit (if they do) in the global integrated innovation network of the MNC. Ideally, the local firms would be technologically advanced, and offer the MNC something (a technology, a skill, a cost advantage) it cannot easily find elsewhere (or, at least, not at home). Moreover, a country that already has a home multinational in an industry may find it easier to attract the R&D activities of a foreign multinational (it already possesses the supplier network, the skills, etc.).

Farshchi and Janne (2003) list some of the features which make it easier to attract foreign manufacturing and more particularly foreign R&D: a good support infrastructure, a good environment for specialist research, engineering skills, strong local innovative firms, and awareness of the importance of collaboration. Moreover, Farshchi and Janne suggest that, in aiming to attract automotive firms and R&D while avoiding being too dependent on one sector, policies should promote technologies which are important to that industry and to other industries as well (i.e. with generic characteristics). Examples are fuel cells, software, and green technologies.

The different forms of vertical organization and extents of technological vertical collaboration (the global automotive industry is one illustrative example, but there are many other examples) are also related to the *Varieties of Capitalism* approach of Hall and Soskice (2001). In their seminal book, Hall and Soskice divide the industrialized economies into two types. First, *Liberal Market Economies*, characterized by deregulated labour markets, arm's length relationships between firms, strong competition policy, high income inequality, and short-run firm horizon. This group of countries comprises essentially the Anglo-Saxon countries, including Canada. The second group of countries, the *Coordinated Market Economies*, is characterized by regulated labour markets, long-term employment, strong inter-firm networks, long-run firm horizon, and lower income inequality. This group comprises many Continental European countries, as well as Japan. As Coordinated Market Economies rely more on explicit coordination and on consensus decision-making, it is easier for those economies to develop informal cooperative relationships between firms. In particular, this makes it easier for them to foster formal and informal cooperation along the supply chain. To use the authors' words: "firms also derive competitive advantages from the institutions in their home country that support specific types of inter- and intra-firm relationships." (Hall and Soskice, p. 56) These institutional differences have to be taken into account in the identification of the comparative (technological, organizational, and institutional) advantages of each country.

Canada – U.S. comparisons

The global automotive industry is of particular interest to Canada, and it has been already discussed. Remember that the greater the difference between the home and host countries (climate, regulations, taste, distance), the greater the need to locate R&D abroad. The similarity and proximity between the U.S. and Canadian markets, regulations, and climates, which favors Canada in so many ways, plays against U.S. multinationals doing R&D in Canada. For example, from a consumption point of view, the North-American car market is a homogeneous market (tastes, weather, regulations), therefore little or no R&D is needed to adapt the U.S. product to the Canadian market. In a sense, Canada is penalized by the small size of its market, the small size of its high skills pool (in spite of its high quality), the lack of distinctiveness relative to the U.S. market, and the proximity to the U.S. market. At the same time, it is not easy for Canada to attract R&D from European or Asian multinationals, because of the small size of its market, and the ability of these markets to adapt their products to the Canadian markets by relying on the R&D they perform at home and in the U.S.. Therefore, proximity with the U.S. plays also against the R&D of multinationals from outside North-America coming to Canada.

A relevant question is what are the specific areas into which Canada can attract foreign R&D (home-base exploiting, home-base augmenting, etc.)? For example, the UK car industry, in spite of some weaknesses, has been able to exploit a niche in car design. Synergies with other sectors (e.g. telecommunications, aerospace) in which Canada is recognized as an international leader should be taken into account in answering this question.

The fact that there is a large number of U.S. subsidiaries in Canada serving the Canadian market, in itself, goes a long way in explaining why those firms invest more in R&D at home than in Canada. Moreover, in assessing the level of R&D investment and productivity of foreign relative to domestic firms, the relevant comparison should be between firms of similar types from the two countries. For example, Bagchi-Sen and MacPherson (1999) note that Canadian small and medium-sized manufacturing firms are more innovative than their U.S. counterparts (at the Niagara Frontier).

Canada is a technologically advanced country. From that perspective, Canadian firms will not automatically benefit from international supply chains, given that innovation in the domestic environment is quite strong. Only partners who are equally or more technologically advanced will benefit Canadian firms. Paradoxically, proximity to the U.S. can contribute to both higher R&D spillovers from the U.S. and lower R&D investments, even by Canadian firms. For instance, Bernstein (2000) finds that spillovers from the U.S., even though they increase capital intensity and reduce production costs in Canadian manufacturing, induce Canadian firms to reduce their own R&D.

Contributors to higher levels of innovation

This paper helps us understand how the vertical organization of an industry may affect the measured innovation performance of an industry, and explain inter-industry differences in R&D intensities. Some factors relating to vertical organization contribute to increasing the innovative activities and the R&D intensity of an industry.

A good "match" between the ownership structure of an industry and its technological characteristics fosters innovation. An industry where coordination between R&D and other functions is crucial, asset specificity is high, economies of scale and specialization are not important, contracts are highly incomplete, and a typical firm possesses all the skills necessary to innovate may be better served by vertical integration of R&D. In contrast, an industry where coordination between the R&D function and other activities is not key, asset specificity is low, economies of scale and specialization are crucial, contracts are sufficiently complete (most contingencies are foreseeable), and technology is so complex that no firm can undertake all the innovation activities on its own, is better served by vertical disintegration of R&D or by a hybrid structure.

A variety of hierarchical relationships are compatible with successful innovation along the supply chain. What matters for the performance of a supply chain is not only the innovative performance of each firm, but also the overall performance of the chain. In some sectors, especially traditional resource-based sectors, suppliers tend to have a dominant status, and develop most innovations. In contrast, large manufacturers (often using complex technologies), small specialized suppliers and science-based firms rely mainly on their own technological efforts.

Nonetheless, whether a firm is dependent on a small number of suppliers/ customers, or whether its supply and consumer bases are large, the firm has an interest in investing in R&D itself, rather than relying passively on technology transfer. Firms who perform their own R&D have better absorptive capacities, are less dependent on the technology of their suppliers/customers, are more attractive partners (both commercially and technologically) for current and potential suppliers/customers, and less vulnerable to changes in the business cycle. This does not mean that every firm should invest in R&D (especially for small firms), but rather points to the advantages of doing so when the firm meets a minimal critical size threshold. In particular, innovation encompasses several informal activities and is not limited to a formal R&D department.

Vertical R&D cooperation (formal as well as informal) has been shown to be a major driver of innovation along the value chain. Cooperation increases technological opportunities, helps firms overcome appropriability problems, and induces the sharing of costs and risks of innovation. Thus, industries where such cooperation is allowed and encouraged by governments, where vertical information sharing and knowledge flows are prevalent, will have a better innovation performance. Trust is important for the success of a vertical relationship, and in particular for fostering joint innovative activities. We should expect sectors which foster trust and where lean supply plays a more important role, to perform better on innovation.

From an international perspective, some characteristics of a country, an industry, or a firm can make firms capture a larger share of innovation efforts and benefits along the value chain. A high level of local absorptive capacity (which requires a certain level of own R&D) allows suppliers to benefit more from the presence of multinationals and the diffusion of their technologies. A country will have higher R&D investments by foreign firms whenever there is a good match between the technological, skills, and market characteristics of that country and the needs of a multinational (see the discussion on home-base augmenting vs. home-base exploiting R&D in section 7.1) in terms of benefiting from home advantages, using/learning local technology and skills, and adapting its products to local markets. Stronger subsidiaries have more bargaining power in dealing with their mother firm, are more independent in terms of investments and innovation, and are more likely to perform R&D themselves rather than rely on home R&D. Not only multinationals, but also domestic firms who export, generate larger vertical R&D spillovers. There is also the possibility that multinationals (and to a lesser extent exporting firms) produce negative backward linkages through their lesser reliance on local suppliers, and the (potentially) negative effect they may have on the degree of competition in local markets (upstream or downstream).

Future research

The large literature on the topic of vertical linkages and innovation has answered many questions but has also opened up many paths of investigation. Regarding how different types of R&D are affected differently by the internationalization of R&D, it is possible that process R&D is more concentrated at home, whereas product R&D is (relatively) more decentralized, as it is aimed at customizing the product to different markets. Consequently, different types of innovation activities may be performed at different locations, with different levels of centralization and corporate control.

It would be useful to develop a typology of supplier relationships in Canada, taking into account regional and sectoral differences. This would help identify the role of vertical relationships in fostering innovation by both Canadian and foreign firms, and identify important underexploited linkages.

Moreover, most studies have focused on the distribution of innovative inputs (R&D investments) along the supply chain. It would also be useful to examine the distribution of innovation outputs. What is the patent output and quality of different parts of the supply chain, and what is the share of sales of new products in their total sales?

Much of the literature has focused on the relationship between vertical organization in the host country and the R&D strategy of the multinational. However, it would also be useful to examine vertical relationships in the home country, and how they affect the multinational's R&D strategy. Close and long term vertical relationships at home, with supplier collaboration on design and research, will make the multinational reluctant to relocate its R&D abroad, even when the host country offers some advantages. Whereas weak vertical links at home, and little supplier involvement, make it easier for the multinational to locate some significant R&D operations abroad when it wishes to do so. Therefore, what matters is a comparative study of vertical relationships between the home country and the host country, and how they interact with global R&D strategy. It is not only the relative levels of technological advancement, but also vertical organization (or, more generally, using the words of Hall and Soskice, 2001: comparative institutional advantages) that matters. This is especially true given that firms often try to replicate their vertical relationships at home in the host country.

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