

Small firm-large firm relationships and the implications for small firm innovation: what do we know?

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ABSTRACT

This paper provides a review of existing research on small firm-large firm (SF-LF) interactions for innovation structured around a new typology of linkages. Such linkages are important in local and global supply chains and in terms of public policy initiatives in areas such as procurement. The typology distinguishes between Supply-chain or vertical relationships which originate with the flow of material goods but which also create opportunities for innovation; and, knowledge creation and exchange or horizontal relationships that are created specifically to co-produce or access the knowledge necessary for innovation. Significant case-study and supply-chain analysis does exist but broader econometric or statistical analysis of SF-LF interactions is limited, in part due to limitations in most innovation surveys such as the Community Innovation Surveys. The review leads to an agenda for future research.

Key words: Innovation; linkages; small firm; SME; typology

JEL Codes: O31, O33, O34

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1. INTRODUCTION

There has been a long-standing debate on the relative innovativeness of large and small firms.¹ The aim of this White Paper is not to examine this question but instead to examine an important yet less well researched topic, namely the impact of relationships between large firms and small firms on innovation in smaller firms. Such relationships may be important in a number of contexts – supply chains, sub-contracting or sub-supply relationships, procurement and/or more developmental relationships where small firms have otherwise unavailable capabilities or technologies. Surprisingly perhaps given the extensive literature on SME innovation (and increasingly on open innovation in SMEs) there have been relatively few studies of this topic. The seminal work of Roy Rothwell, despite having been published some 25 years ago, provides the starting point for much of what follows.²

The idea for this paper developed from a discussion between the authors in a seminar hosted at the Manchester Institute of Innovation Research (MIOIR). As part of a broader conversation about the determinants of innovation in smaller firms it became clear that while good econometric evidence exists on the role of inter-firm linkages on SME innovation, we know relatively little about the specific impact of relationships between smaller and larger firms. Good quality and insightful sectoral and individual case studies do exist but to date there has been little synthesis or integration of this evidence. The aim of this White Paper is therefore to review the academic literature on the nature of relationships between large and small firms (during the innovation process) and the implications of these relationships for small firm innovation. This helps to clarify what we do and do not know, to identify gaps in our knowledge, and suggest areas for future research.

Ideally, our review might also have led to policy recommendations where a robust evidence base does exist. However, while it is clear that external knowledge and relationships can play an important role in motivating,

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enabling and commercialising SME innovation, the specific role of larger firms in this process remains under-researched. Rather than developing policy recommendations or insights therefore our emphasis here is on defining a future research agenda around SF-LF linkages in innovation.

This matters as the innovation success and growth of small firms will, in part, be linked to the effectiveness of their strategies for engagement with large firms. Effective networking with large firms may be one means of overcoming ‘barriers to growth’: accessing demanding customers and the complementary assets that are needed to commercialise the innovative technologies that they develop. Equally, the open innovation strategies of large firms are placing increasing emphasis on the effective engagement of external sources of innovative capabilities, including those within SMEs. The interactions between small and large firms for innovation, and the impact that these interactions have on small firm innovation is therefore of increasing management interest.

A deeper understanding of small firm-large firm interaction for innovation will also benefit policy makers and business support organisations. Closer collaboration between SMEs and large firms for innovation is central to developing policy agendas: the Technology Strategy Board (TSB) is seeking to encourage such linkages through its Catapult Centres and Knowledge Networks; Cabinet Office efforts at increasing SME engagement in public procurement have increasingly come to recognise that much of that SME engagement is through the supply chain of large prime contractors and that the decisions of these focal firms influence the opportunities for SME innovation; regional efforts to create clusters of small firms around large firms have a long history both in the UK and elsewhere.

1.1 Small firm-large firm relationships in innovation – a typology

Our point of departure is the recognition that the innovation process is becoming increasingly distributed across organisations with related changes in the patterns of relationships between firms participating in the innovative process. There has been a shift from traditional relationships

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such as sub-contracting, research associations and government R&D programmes to more integrated forms of collaboration, reflecting increasingly 'open' innovation.³ Networks of collaborative relationships, especially in fast growing technology industries provide a mechanism for co-ordinating the activities and assets of individual firms. Even the largest companies engage with a complex network of relationships for the creation of new knowledge, its development into new products and services and the marketing and distribution of those products and services. Accordingly, we start from Rothwell's observation that:

'... small and large firms do not exist in separate worlds but, on the contrary, are part of a 'web' of industrial production and industrial technological change characterised by complex flows of technological know-how and finished innovations. As part of this web there is a variety of inter-firm relationships of varying intensity and duration involving large firm-large firm, large firm-small firm and small firm-small firm interchanges'.⁴

Table 1 provides a typology of these small firm-large firm (SF-LF) interactions for innovation developed from that originally proposed by Rothwell.⁵ The SF-LF interactions represented in Table 1 are primarily formal relationships and we can usefully distinguish between:

- 1) **Supply chain or vertical relationships** which originate with the flow of material goods but which also create opportunities for innovation; and,
- 2) **Knowledge creation and exchange or horizontal relationships** that are created specifically to co-produce or access the knowledge necessary for innovation. Here, we might also distinguish between those SF-LF relationships that are created to internalise knowledge (e.g. collaborations, licensing and acquisitions) and those which aim to establish or formalise a division of innovation activities (e.g. contract research, corporate venturing, open innovation eco-systems).

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The implications for small firm innovation vary across these modes of interaction, yet much of the quantitative evidence on the role of inter-firm relationships in shaping innovation outputs does not distinguish between them. In the various waves of the UK Innovation Survey, for example, firms are asked to indicate simply whether they have innovation co-operation with other firms (or other organisations) but do not provide any information on the nature, governance or content of those relationships.

The particular interest of SF-LF interactions is that they are partnerships of un-equals. In particular, writers have contrasted the material advantages of large firms with the behavioural advantages of small firms.⁶ Large firms have relatively greater financial and technological resources for innovation and their resources and capabilities mean that they are better placed for innovation that require large teams, specialised equipment, large scale investment in production facilities, extensive distribution networks or relatively long-time-to-value investments. In contrast, small firms' advantages are those of entrepreneurial dynamism, internal flexibility and responsiveness to changing circumstances. The inter-play of the resources and capabilities of large and small firms gives rise to the possibility for innovation. Indeed, Rothwell himself observed how certain small firm-large firm (SF-LF) relationships can most effectively combine the advantages of large and small firms in technological innovation.⁷ These 'dynamic complementarities' mean that small firms can play a crucial role in the distributed innovation processes of large firms, especially in an environment in which large firms are increasingly engaged in a variety of 'open innovation' practices.

At the same time, large firms can play an important role as a route to commercialisation for technological innovations from small firms.⁸ A substantial body of research also demonstrates how networks can contribute to the innovative capabilities of small firms by exposing them to novel sources of ideas, improving access to inputs and enhancing the transfer of knowledge.⁹ In order to thrive, small businesses are often advised to develop relationships with external organisations that have the potential to assist business development and growth. A focus on the

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external relationships of the small business underlines the vital importance of external resources in moving a small business toward increased success and profitability.¹⁰ However, as we suggested previously we know rather little about the specifics of SF-LF relationships and their implications for small firm innovation.

1.2 Structure of the White Paper

The objective of this White Paper is to provide an overview of the evidence on the effects of large-small firm interactions on small firm innovation. Building on the typology presented in Table 1 we deal separately with vertical (supply chain) and horizontal (activity structuring and knowledge acquisition/exchange) relationships. Our focus here is on the implications for innovation of different forms of SF-LF relationship with an emphasis on the nature of the dyadic relationship. We pay less attention to the influence of the wider context on either the nature or effectiveness of that dyadic relationship while recognising that significant sectoral and contextual influences may also be important.¹¹ The final section of the White Paper defines a future research agenda.

2. VERTICAL SF-LF RELATIONSHIPS AND INNOVATION

Supply chain relationships are vertical relationships which originate with the flow of material goods, and where opportunities for learning and innovation can arise because of the existing commitment of the two parties to the trading relationship. Vertical relationships may include downstream links with customers and users as well as upstream links with suppliers. Two main modes exist in this category:

- **Producer-customer relationships** - whether B2B, or with end-users, can have a significant impact on small firm innovation. The evidence that supply-chain linkages have a greater impact on innovation among small firms than large firms is presented in Section 2.1. Some of the reasons for this, including proximity to end-users and firm responsiveness are discussed in Section 2.3.

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- **Manufacturing sub-contracting relationships** are often arm's length and the opportunities for learning by either party in this mode are relatively low. However, some sub-contracting relationships are close and stable (e.g. the Japanese Keiretsu model). When this is the case there is some evidence that there are more opportunities for learning by both the smaller sub-contractor and the larger client.

2.1 The role of demand networks and value chains in SME innovation

The first naturally occurring knowledge linkages typically form with SMEs' clients and suppliers with whom there tends to be regular contact. For these reasons, we can expect the most frequent and beneficial innovation linkages for small firms to be with customers and suppliers. In addition, one would expect that supply-chain linkages will have a greater impact on innovation among small firms than among larger firms.

There is substantial empirical support for both of these contentions. For example, a recent study of circa 1500 European SMEs suggests that customers are the most attractive source of innovation inputs. Similarly, in an analysis of the innovation value chain for UK-based hi-tech SMEs¹², supply-chain linkages were most likely to be associated with (product) innovation performance, a finding replicated for Irish SMEs.¹³ The latter study also finds that supply chain linkages have a much stronger effect on innovation outputs for establishments in the 10-49 employee range than for larger establishments, suggesting that customers and suppliers have an especially important role for SME innovation. A study of technological collaboration as an input to the innovation process, using a large longitudinal sample of Spanish manufacturing firms, also found that vertical collaborations with suppliers and clients had the greatest impact on firm innovativeness, though this effect is clearer for medium-sized enterprises than for the smallest firms.¹⁴ Another study shows that SMEs who are proactive in strengthening vertical relationships with innovative suppliers, users and customers have higher innovation performance than other SMEs.¹⁵

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A survey of 436 firms on the impact of co-operative ties on product and process innovation across five UK industrial sectors¹⁶ provides further evidence that vertical co-operative ties are more significant than horizontal co-operative ties in explaining firm levels of innovative performance. From a small firm perspective, technological collaboration is a critical mechanism for small firms to improve innovativeness¹⁷ and vertical (as opposed to horizontal) collaboration with suppliers and clients has the greatest impact (though this effect is clearer for medium sized enterprises).

In combination, the evidence suggests that small firms benefit from wider inter-organisational linkages, and that customers are the most important source of new innovation. However, this quantitative research does not distinguish between individual consumers and large organisational clients. Typically, quantitative studies also do not distinguish between end-users and intermediate products despite the potential that the relative importance of such relationships differs according to the position of the SME in the value chain.

2.2 Governance of value chains and the opportunities for SME innovation

Large firms often act as lead firms in demand networks, performing an intermediation role as the primary channel to market. The decisions made by lead firms can have important implications for innovation at small supplier firms. Yet, there is surprisingly little evidence about the position, opportunities and constraints of SMEs to develop and sell innovation in those networks, or the impact lead firms have on downstream innovation.

Some potential insight is provided by research on Global Value Chains (GVC) which examines the location of value-adding activities across firms and geographic regions. The GVC approach prioritises the links between powerful lead firms and their suppliers, considering how the governance of those relationships can lead to opportunities for upgrading through innovation (producing better products, making existing products more efficiently or moving into higher skilled activities).¹⁸ Different vertical

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relationships and governance structures affect opportunities for small firm suppliers to upgrade their activities.

It has been suggested that three factors determine how relationships are governed:¹⁹

- i) the knowledge that exists in the supply base and hence a measure of the capabilities of suppliers;
- ii) the codifiability of the knowledge required by suppliers to perform the required work; and,
- iii) the complexity of the information that needs to be exchanged between the lead-firm and their supplier in performing the required work.

From these three variables five governance ‘types’ emerge in which firms co-ordinate the linkages between value chain activities. These five types and how they provide different innovation opportunities for small firms are briefly discussed below:

1. **Market linkages** – are value chains characterised by arm’s length or short-term contractual relationships between large buyers and small suppliers, generally governed by price alone. Low complexity of products enables relatively easy communication, less coordination effort and risk for lead-firms.²⁰ Barriers are low for SMEs to upgrade, yet complementary assets may be required (e.g. technical knowledge exchange, financial support, market information, market access etc.). Returns to product or service innovation here may be uncertain due to the risk of imitation by competitors; cost related process innovation may be more rewarding as it offers direct value to customers.
2. **Modular linkages** - Where products are more complex but sufficiently modular that technical standards and information can be specified and communicated to a third-party. In this type of value chain, lead firms may outsource manufacturing, with product and quality guidelines.

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Smaller firms undertake production autonomously, possible sub-contracting. The case study of Apple externalising in-house personal computing manufacturing facility to an SME in the 1990's is one example.²¹ This arrangement enabled Apple to concentrate on product design. Here, SMEs are able to learn from the lead-firm and develop their product/service offerings. However, the opportunities for upgrading within the value chain to higher functions remain limited as the lead-firm sets the parameters of production through design.

3. **Relational linkages** – here interactions between the lead-firm and supplier are complex, iterative and long term. Tacit knowledge and learning are important. Examples of such linkages are found in high-tech industries including biotech²², motor sport²³ and electronics²⁴ where the capabilities of suppliers are high. Geographic co-location is important, though not always critical.²⁵ Here collaboration may be regarded as critical for innovation both to enable firms to share risk and combine complementary resources.
4. **Captive linkages** – here the lead firm provides detailed specifications to low capability suppliers. A high degree of coordination, monitoring and control is observed. The small supplier may become 'locked-in' to the lead firm's supply chain with a potential for the hollowing out of higher level functions and innovation capabilities in SME suppliers in response to cost pressures. This can have negative implications for SME innovation, and revenue can be extracted disproportionately by the large firm. However, lead firms can assist suppliers in upgrading without any associated conflict of interest.
5. **Hierarchy**: Vertically integrated organisations are preferred when products are complex, not standardised and smaller suppliers have limited capabilities. The innovative activities of SMEs, often recognised through collaborative arrangements, can lead to acquisition opportunities for lead-firms of their smaller partners.

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There are clear advantages to small suppliers operating within global value chains that stem from the access to knowledge and resources that larger firms can provide. Gereffi (1994) describes how apparel manufacturers in Hong Kong developed strategies in order to enhance their positions within the regional market using the knowledge they had gained from supplying large retailers based in the US to develop brands of their own.²⁶ In the coffee industry, research has shown that lead-firms assist suppliers in maintaining quality, price and delivery targets through standards and production compliance measures.²⁷ For more complex products, working with lead-firms can foster upgrading through technology and skills transfer²⁸ and lead-firms can also provide smaller firms with access to industry best practices, along with hands-on advice such as how to upgrade production capabilities and improve production flows.²⁹ Entrepreneurial risks and costs can be reduced through participation in a value chain relationship where the lead-firm provides support in terms of the resources needed for new product development³⁰ as is seen increasingly within multiple sectors such as biotech.^{31 32}

Despite such advantages, research also suggests that lead firms do not always have a positive effect on their suppliers' opportunities for upgrading. One study examined the modular value chains found in the automotive component production industry in Turkey whose suppliers serve the industry at a global level. Despite the success of Turkish suppliers in taking on certain design and product development tasks, their buyers are found to restrict the types of upgrading strategies pursued in order to prevent encroachment on their core competences.³³ A similar result was found in separate a study of the globalisation of R&D, focussed on the Czech automotive industry³⁴, where suppliers' activities aligned to the strategic direction of the core transnational corporations.

Work on the interface between local clusters and global value chains has brought new insights into how smaller firms are affected, and can respond to, the realities of globalisation. A study of how local instrument producers in the Tuttlingen cluster in Germany have responded to new innovation

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opportunities that external linkages have presented highlights the need for a supplier's adaptability to change, suggesting that new external linkages may upset the status quo and that small firms which do not expand their knowledge base within a cluster may struggle to keep up with new developments. The case also highlights the potential benefits of joint action amongst private actors in order to adapt to new challenges collectively.³⁵

Another study of a traditional export oriented footwear cluster in Brenta, Italy, illustrates the impact on local competitiveness of external global design houses. Here, many of the local suppliers have relinquished some of the higher value added activities such as retail and design in a process termed "functional downgrading", where smaller firms focus on production in order to increase their competitive advantage within the cluster.³⁶

The GVC approach provides an insightful way to understand the power relations between small and large firms in supply chains, suggesting the type of structural factors which may influence small firm innovation. Learning and knowledge exchange between buyer and supplier certainly provides the small firm with opportunities for upgrading. However, within a GVC context, upgrading refers to a firm innovating in some way to increase their value-added within the chain, not necessarily introducing a product or process that is new to the world, more often the introduction of a new product or process that is new to the firm.³⁷ Research focussed on electronic components manufacture in the automotive sector suggests that there is a positive relationship between the process of industrial upgrading and the innovation performance of supplier firms³⁸ but more work needs to be done to understand how the different relationships and modes of governance that develop within GVCs foster or inhibit the capabilities of suppliers to innovate.

2.3 Responsiveness of lead firms to innovation from SME suppliers

Although there is broad recognition of the inter-dependencies between large and small firms in the innovative process, limited attention has been paid to the factors that may support or hinder the engagement of small

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firms in the supply chains of large firms or to the responsiveness of lead firms to innovation from SMEs.

A renewal of the (large) firms purchasing function has been informed by 'lean' supply chain management (SCM) practices. Lean supply chain management emphasises the engagement of a smaller number of highly competent suppliers.³⁹ Large firms have pursued a strategy of vertical disintegration in which they increasingly act as a system integrator⁴⁰ (or lead firm⁴¹), orchestrating the integration of sub-systems and components that are the product of intellectual property generated and owned by suppliers.⁴² A key element of this type of corporate strategy has been the rationalisation of supply chains and the outsourcing of risk and capability to suppliers. Outsourcing by prime contractors and their dependence on suppliers has increased dramatically as lead firms establish partnerships with key suppliers and create increasingly global supply chains. Such developments have reduced the number of SMEs that play a role in their supply chains.⁴³ However, in some sectors (such as defence and pharmaceuticals), this is accompanied by considerable emphasis on the importance of supplier involvement in new product development.⁴⁴

There has been a great deal of debate as to whether the rhetoric of supply chain management reflects the reality of inter-firm relationships in global value chains. The influence of the structure of supply chains on the scope for and nature of technological innovations produced by smaller firms along the supply chain is examined.⁴⁵ Whilst the lean supply chain mode is associated with incremental innovation⁴⁶, it has also been argued that where a large firm has a monopoly or oligopoly, this downstream relational power may act to suppress radical upstream innovation⁴⁷. One study of the automotive industry supply chain in North America notes the critical role of large transnational firms in organising and coordinating the global value chain: restructuring of the supply chain has led to a consolidation of the supply base including a decline in the number of suppliers, where large firms control intellectual property and value price reduction.

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There is also some evidence that the extraction of value by large firms in some supply chains has an overall negative effect on innovation. In food retailing, the shift in power within food marketing channels towards the multiple retailer has generated considerable academic, industry and policy debate globally about the governance of the food retail supply chain and its implications for suppliers and customers.⁴⁸ A recent study for BIS noted ‘Concerns about the market power of large businesses in a monopolistic or oligopoly relationship with small businesses, and the negative impacts of this relationship on SMEs’ and quoted a Competition Commission investigation into the food retailing sector that found evidence that large firm practices ‘adversely affect the competitiveness of some of their suppliers with the result that the suppliers are likely to invest less and spend less on new product development and innovation, leading to lower quality and less consumer choice’.⁴⁹

Similar questions have emerged regarding public procurement, not least the role of prime contractors, their power within the defence procurement supply system and the influence of their behaviours and commercial decisions on opportunities for SMEs. In discussions about the engagement of SMEs in public procurement, the policy narrative about the prime contractor-SME relationship has been almost entirely negative in tone. The Glover Report commented that:

‘when operating within supply chains, SMEs often find their ability to input curtailed, their margins squeezed and the flexible and innovative approaches that they can offer rarely exploited. They often suffer unfavourable terms and conditions, and can face disproportionate delays in payment’.⁵⁰

Asymmetry and power imbalances face SMEs that collaborate with large firms.⁵¹ The relative bargaining power of participants affects the division of profits along the supply chain⁵² and the bargaining power of lead firms is higher when there are only a few large buyers. Despite this, there are many advantages for small firms entering into supply chains dominated by large

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firms. Aside from access to mass markets, many supply chains generate enough profits to support investment and innovation by participants, and once suppliers are positioned, high switching costs can give a smaller supplier greater bargaining power.⁵³

Research drawing on 18 case studies attempted to identify the dynamic capabilities⁵⁴ that enable small firms enter mainstream markets by operating as suppliers to large purchasing organisations.⁵⁵ This study confirms the importance of dynamic capabilities in helping an SME to “sustain its ability in strategically positioning itself within the new marketplace” but again provides further evidence of the difficulty (from the perspective of small firms) of establishing collaborative, knowledge-sharing and reciprocal relationships with large purchasing organisations. Key issues reported by the smaller firms included unequal relationships with senior managers and the complexity of contractual procedures. Interestingly, the survey on co-operative ties⁵⁶ finds that it is not just the existence of co-operative relationships between buyers and suppliers but the quality, or strength, of these relationships has a significant impact upon levels of innovation. Trust⁵⁷ and appropriate relational contracting, specifically long term contracts, a high volume of exchange and frequency of interaction between firms likely to be important for innovation.⁵⁸

The journal *Supply Chain Management* published a Special Topic Forum on Innovation in Business Networks from a Supply Chain Perspective (2013), focusing on Innovations within the supply chain network (ISCN).⁵⁹ The editors note that innovation is supported when supply chain partners are collaborative and characterised by cooperation, trust, communication and knowledge exchange (to support learning), whilst recognising that not all supply chains are cooperative in nature.⁶⁰ A survey of 207 Australian manufacturing firms shows that key supply chain partner innovativeness has a positive effect on product innovation strategy and that building strategic relationships with supply chain partners enhances the exchange of knowledge, learning and therefore innovation.⁶¹ Papers in the special issue focus on how firms should leverage knowledge in their supply

network and integrate it with their own knowledge assets to increase innovative performance

Overall, there is an emphasis on the importance of absorptive capacity to leverage the supply network for innovation.⁶² The authors argue that the responsiveness of lead firms depends on successful management of 'closed' or internal innovation, requiring ambidexterity on behalf of the lead organisation. This research resonates with findings in the innovation literature that internal and external sourcing strategies of innovation inputs are complementary or synergistic.⁶³

3. HORIZONTAL RELATIONSHIPS

There is a growing recognition that innovation depends on a firms' ability to absorb external knowledge, combine it with their own proprietary knowledge and develop new market offerings.⁶⁴ Open innovation has captured the attention of academics and practitioners but it has long been recognised that firms' external linkages or networks may play a potentially important role in the innovation process.⁶⁵ Horizontal relationships for innovation are typically created to co-produce or access the knowledge necessary for innovation: they can therefore be characterised as knowledge exchange and creation relationships. Here, we can distinguish between (a) horizontal 'activity structuring' relationships that are created to establish or formalise a division of innovative activity, e.g. contract research, corporate venturing, open innovation ecosystems; and (b) those horizontal relationships intended to internalise knowledge, e.g. collaborations, licensing and acquisitions.

3.1 Activity structuring relationships

The large firm is the primary focus of most research in this area, however, internal knowledge resources and lower ability to invest in in-house knowledge creation make outside-firm sourcing of knowledge especially important and attractive for small firms. As small firms typically start with a lower overall level of knowledge resources than large ones, adding more or new types of external knowledge linkages is likely to have larger effect on

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small firms: in other words, starting from a lower level means higher marginal benefits from adding each new knowledge linkage.⁶⁶ For small firms the search for knowledge created elsewhere is also a viable alternative source of new knowledge and technologies relative to in-house generation. This is the case as some linkages, such as customers and suppliers, are likely to involve lower 'entry' costs than R&D. Knowledge creation through in-house R&D involves substantially larger fixed costs than sourcing knowledge from customers or suppliers. Smaller firms are on average, less capable of covering these fixed costs, simply because of their lower scale and sometimes also because of their lower productivity.

SMEs might also benefit more from external linkages because of their flexibility and speed of decision making. Typically, they can adapt their activities significantly faster based on the new knowledge sourced from outside the firm. Quick decision-making benefits also from fewer organisational rigidities and bureaucracy than in large firms.⁶⁷ Due to this and their ability to specialize to narrow market segments that are unattractive to larger firms, SMEs may be better at quickly adopting the ideas and suggestions by the lead users into the product development phase.⁶⁸

One study of circa 3000 Irish manufacturing plants finds that the effect of 'breadth' of openness (i.e. the variety of innovation linkages) on innovation performance is indeed much stronger for small plants than for larger ones. For small establishments (10-49 employees) external linkages account for around 40 per cent of innovative sales compared to around 25 per cent in larger firms. They also find that small plants reach the limits to benefitting from openness at lower levels of 'breadth' of openness than larger firms.⁶⁹ Similarly, a study of Australian SMEs suggested that SMEs may rely more heavily on external knowledge networks as an input to innovation than do large firms.⁷⁰ An analysis of the performance of start-up companies in the Canadian biotechnology sector suggests that variation in the alliance networks of start-ups produces significant differences in their early performance, and especially their innovative performance.⁷¹

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In this respect, the literature on innovation stresses the role of horizontal relationships focussed on cooperative R&D in overcoming the lack of internal resources and in improving innovativeness and competitiveness, particularly for SMEs.⁷² Indeed, SMEs engaged in technological innovation have used cooperative R&D for information exchange, resource acquisition, technology transfer, and risk management. The collaborations, though, are not homogeneous across sectors and their impact is not uniformly positive.⁷³

Small firms may be attractive partners if they possess distinctive technological capabilities but it is a commonplace observation that they are often hampered by limited management experience and suffer a power imbalance when collaborating with large firms. Relationships between large firms and SMEs are asymmetric not only because of their respective sizes, but also because their power, management, capabilities and organizational cultures differ substantially. Starting from this observation, Blomqvist and colleagues argue that; ‘the evolution of inter-firm trust is critical in enabling the creation of common ground and compatible cultures between the partners’. They argue that the process of successful contract negotiation can – if handled appropriately – lead to the development of that trust.⁷⁴ Another study emphasises the importance of personal contact between key actors as pivotal in creating a successful large firm-SME relationship. Such relationships, the study argues, may face ‘cultural and institutional rigidities’ of ‘traditional’ large firm business practices. Champions of the relationship may need to overcome large firm scepticism and the ‘Not Invented Here syndrome’. Informal personal networks between scientific and engineering personnel on both sides was argued to be key to success.⁷⁵ Another study notes that vulnerability due to smaller size means that SMEs have to be wary of alliances, not least because of the high risks and costs of managing an alliance, along with an understandable wariness about choosing a partner when there may be few opportunities to rectify a bad choice.⁷⁶

3.1.1 Contract Research

Contractual relationships between smaller and larger firms may arise in a number of ways: as a result of a broadening of a supply chain relationship; as an alternative to acquisition or merger; or, as a new collaborative alliance. A key issue with any contractual approach to organising joint innovation or R&D activity, however, is the implicit uncertainty and the risk of cheating or moral hazard. This situation is exacerbated where technical, legal and market resources are unevenly distributed between the parties as they might be in the context of SF-LF relationships. In supply chains the incentives to cheat can be reduced by 'braiding' explicit contractual requirements and more implicit or informal agreements.⁷⁷ This reflects evidence of the importance of trust and continuity of personnel in the broader success of the management of SF-LF relationships within the supply chain.⁷⁸ Outside the supply chain, evidence suggests that at least some of these difficulties can be overcome where appropriation rights (patents) are granted to the R&D supplier⁷⁹ and appropriate KPIs are adopted to measure R&D progress.⁸⁰

Contractual R&D may act as a substitute for internal R&D activity, and there is some evidence for this in small firms in biopharmaceuticals and software.⁸¹ More broadly, little research exists on the implications of contractual or collaborative innovation links between larger and smaller firms. There is however, some related evidence on the impact of contractual and collaborative innovation between firms and universities. Among German firms, for example, there is evidence of a complementary relationship between contractual and collaborative (informal) linkages suggesting 'the management of the firm should therefore strive to maintain close informal relationships with universities to realize the full potential'.⁸² A Spanish study also considered the key success factors in SME research contracts with universities. Based on an analysis of 81 such contracts with the University of Navarre, success depended primarily on the characteristics of partners with the specificities of the research contract being less important.⁸³

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Contracting for R&D and innovation can be difficult in dyadic relationships and may pose even greater challenges where networks of partners are involved.⁸⁴ An interesting national initiative to promote contractual network relations among small firms or between small and larger firms is the Italian Business Network Contract Law introduced in 2009.⁸⁵ This allows the legal establishment of network relationships between companies based on a common innovation programme, a common project fund and exit and closure rules. Commentary on the Italian Law, however, suggests that ambiguities in the legislation may be undermining its effectiveness, and some research suggests that contracts are being used simply to formalise existing informal relationships. Use of the statute also seems to be stronger among larger firms perhaps due to the lack of legal resources or expertise in smaller firms.⁸⁶

3.1.2 Corporate Venturing

Corporate venture capital investments – equity investments in small entrepreneurial firms by large firms - are one means for corporations to seek to leverage inter-organizational relationships to acquire, transfer, exploit, and explore external knowledge from young technology-based firms.⁸⁷ There is a substantial literature on corporate venture capital investment that examines such issues as who makes corporate venture capital investments and their motivations^{88,89}, and the conditions under which corporate venture capital investments generate value for the investing company.^{90,91}

The focus of this research has primarily been on the outcomes for the large firm investor rather than the consequences for the innovative performance of the small firm. For instance, one study found that corporate venture capital programmes “may be instrumental in harvesting innovations from entrepreneurial ventures and thus an important part of a firm’s overall innovation strategy”. The study argued that they were especially effective where the intellectual property regime was weak and where the firm has sufficient absorptive capacity. The study’s analysis of a large panel of firms

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over a 20-year period found that increases in corporate venture capital investments by large firms were associated with subsequent increases in firm patenting.⁹²

3.1.3 Open innovation ecosystems

Large firms that pursue an open innovation strategy require the effective engagement of external firms and organisations as a source of complementary knowledge and capabilities.⁹³ Open innovation researchers have observed that this may require the creation and management of networks of external organisations and SMEs play a role in these business ecosystems as sources of technological innovation.⁹⁴ Engagement in open innovation ecosystems raises particular challenges for SMEs, however. Typically small firms are less likely to generate the internal knowledge on which innovation may be based through R&D, and are therefore potentially more dependent on outside sources of knowledge for innovation, whether university spin-outs or small specialised firms in mature sectors. In addition to lacking existing in-house knowledge resources, small firms often lack the ability and resources to efficiently protect their intellectual property.⁹⁵

In addition, the lower absorptive capacity of smaller firms, as proxied by their own R&D expenditure or share of skilled workforce, may hinder not only the capacity to build external linkages, but also to benefit from such linkages. Open innovation therefore poses challenges for SMEs partly because of their shortage of the abilities that are needed both to build organisational structures for the identification of useful external knowledge as well as to absorb externally developed ideas and technologies. In addition, the low level of knowledge resources in SMEs means that they may be unattractive collaborative partners for others, further reducing the chances of building 'openness'.⁹⁶

Absorptive capacity is defined as 'the ability of a firm to recognise the value of new, external information, assimilate it, and apply it to commercial ends'⁹⁷. Absorptive capacity can be generated through R&D, as a by-product of a firm's manufacturing operations or by sending staff for

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advanced technical training. Relatively little research has been conducted on absorptive capacity in SMEs, however. Firm newness may be an issue in scale and scope of absorptive capacity meaning that new firms are likely to have less absorptive capacity.⁹⁸

Amongst the disadvantages for small firms in innovation is that they may lack the time and resources to forge suitable external S&T networks.⁹⁹ In a survey of innovative SMEs in the Netherlands, it was found that the most significant challenges for small firms relate to organizational and cultural issues as a consequence of dealing with increased external contacts.¹⁰⁰ There has been some attention paid to the role of intermediaries in trying to help SMEs overcome such challenges. The role of intermediaries in facilitating open innovation amongst Korean SMEs suggests that a network model emphasising the role of intermediaries in linking SMEs may be an effective strategy for enabling collaboration and specialisation.¹⁰¹ A study of 'traditional industries' in Belgium observes that small firms have little or no absorptive capacity and emphasises the role of technology intermediaries in helping small firms take advantage of distributed knowledge through scanning the market for emerging technologies, helping SMEs develop the ability to absorb acquired technologies and performing complementary R&D activities.¹⁰²

3.2 Knowledge Internalisation Relationships

Other forms of horizontal relationships are also characterised by their knowledge creation and exchange objectives: but here the key objective is the internalisation of knowledge, with three main modes being identified.

3.2.1 Purposive SF-LF collaborations

Collaboration for innovation is a strategy for exploiting external sources of innovation and internalising knowledge. Collaboration usually requires a level of absorptive capacity at both the small and large firm. Small firms often have limited managerial resources, may struggle to identify opportunities for collaboration with larger firms, and often have more to

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lose within the relationship. There is some evidence that small innovative firms are willing to form strategic alliances if the relationship reduces their customers' perceptions of risk in the adoption of their innovation, and that the small firm is confident that the collaboration does not diminish control or autonomy. Beyond combining distinct sets of knowledge and skills to create new knowledge, or applying existing knowledge to products or processes, small and large firms collaborate to assess the complementary assets necessary to innovate, for example, large firms are more likely to have greater experience of regulatory systems, access to finance and well developed distribution channels. Most research has been undertaken from the perspective of the large firm, often in periods of technological discontinuity.

A number of studies provide evidence on the innovation returns from SMEs' purposive links, generally differentiating between links on the basis of partner types. Horizontal relationships with partners outside the supply chain are often differentiated from either forwards or backwards linkages, although the evidence suggests both can be positive for innovation. One recent study of Swedish IT firms, for example, examines the impact of horizontal and vertical technology collaboration alongside the benefits of technology sourcing. Each of these activities is found to have a positive link to either incremental or radical innovation.¹⁰³ Other studies have suggested that the benefits to different types of innovation from different types of purposive links may vary.¹⁰⁴ While the evidence suggests such linkages are potentially important for SMEs there is less direct evidence on the contribution of LF-SF linkages. Clear evidence does exist, however, on differences in the open innovation practices of small and larger firms and their IP protection strategies which might create tensions in such linkages.¹⁰⁵

These tensions are illustrated by a recent study of Swedish SMEs and larger firms engaged in multi-partner alliances. This argued that relative positions of power within such alliances might mean that small firms were more acquiescent to multi-partner agreements than larger firms with

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potential implications for innovation. The evidence suggests some support for both propositions, i.e. that smaller firms are more inclined to adopt acquiescent strategies and that such strategies can be effective in maximising the impact on innovation of SMEs' alliance membership.¹⁰⁶ Extended to the SF-LF context this suggests that while smaller firms undoubtedly face particular issues in such relationships (e.g. resources, influence etc.) even acquiescent relationships may provide significant innovation benefits.

3.2.2 Licensing agreements

Licensing is one of the most widely used methods for acquiring a technology.¹⁰⁷ In contrast to collaboration, licensing is a relatively arms-length and discrete form of exchange between agents and enables firms to rapidly establish positions in new technical areas. Technological knowledge can 'flow' either from the large firm to the smaller firm, or from the smaller firm to the larger firm. Licensing can be a key element of the business model of an innovative small firm, or a necessity to operate in a particular market area (e.g. in the case of defensive licensing). The implications for small firm innovation vary according to the sector, maturity of the technological field and strategy of both the large and small firm.

General evidence on licensing in technology suggests that it allows SMEs to avoid technological uncertainties and potentially to accelerate the growth process. Technology licences may, however, also be restrictive in nature limiting the way in which any technology can be used. In terms of inward technology licensing for technology acquisition the evidence for SMEs is positive, albeit relatively limited. A recent Korean study, for example, which compared various modes of internal R&D and external collaboration in services SMEs found that both collaborative R&D and licensing made a positive contribution to SMEs' technological development and that 'technology acquisition may be one of the most efficient collaborative activities when this activity can be simply conducted to complement insufficient resources'.¹⁰⁸ An essentially similar study which focussed on

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Swedish IT firms also found that technology licensing made a significant contribution to both radical and incremental innovation activity alongside firms' purposive linkages.¹⁰⁹ For small firms, outwards licensing can also be particularly challenging due to internal resource constraints. It has been suggested however that out-licensing can be an important strategy for SMEs to increase their economic benefits from proprietary knowledge without having to develop downstream commercialisation activities.¹¹⁰ Research into out-licensing has largely focussed on larger firms and where research has been conducted it suggests the returns to technology licensing are greater for larger firms.¹¹¹ One recent paper makes a useful practical contribution, however, by outlining a toolkit for out-licensing in SMEs.¹¹²

Both the evidence on inwards and outwards licensing in SMEs has little to say about the specific issues involved in either inward or outward licensing in the context of SF-LF relationships. By implication, however, it is reasonable to suggest that such relationships may pose more significant issues than perhaps SME-to-SME relationships due to the contrasting resource capabilities of small and larger firms, differences in IP management strategies¹¹³ and broader approaches to boundary spanning activities in innovation.¹¹⁴

3.2.3 Knowledge-informed acquisitions

Merger and acquisition (M&A) is used by companies to increase their market power, enter new markets or enhance their capabilities,¹¹⁵ and is growing in importance as part of a firm's knowledge acquisition process.¹¹⁶ From an innovation perspective, M&A can be used to absorb the complementary external technology capabilities needed to compete successfully in radically changing areas¹¹⁷ and often the motivation behind an acquisition is to establish a position quickly in a particular technical area.¹¹⁸ Such activity may be related to corporate venturing which was discussed earlier.

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For large firms, the acquisition of small firms is one means to access new technological capabilities. There is considerable evidence on how large multi-technology firms, build up and exploit their technological capabilities by acquiring small technology-based firms. Indeed, a survey of 38 UK and Japanese firms in a variety of sectors, found that roughly half of them had purchased stakes in other firms as a means of accessing a new technology. The targets for these minority stakes or full acquisitions were mainly small entrepreneurial firms.¹¹⁹ The acquisition of small firms has also been used by large firms as a “catch-up” strategy in some emerging technology fields.¹²⁰

From the perspective of smaller firms, the sale of the business to a larger firm may be used by small firms as a means to overcome their barriers to growth. Acquisition may be a means to access to the superior financial resources, production capabilities or marketing and distribution channels available within a large company. Equally, acquisition can be a means for the owners of the small firm to realise value from their innovative activity. Indeed, the business models of many new technology based firms – especially those who receive venture capital funding – include an exit strategy based on the eventual sale of the business.

The expectation of such transactions is typically that the acquisition of small high technology firms by large firms will generate synergies between the technological capabilities of the SME and the established marketing infrastructure, distribution networks and corporate brands of the larger firm. However, there is a substantial body of empirical evidence that highlights the challenges presented by the acquisition of a small firm by a large firm and the negative consequences that can have for the innovative capability of the small acquired firm. A number of studies have found that where the acquirer is large relative to the acquirer this can lead to a decline post-acquisition innovation output.¹²¹ This body of research emphasises that the acquisition of high technology small firms presents distinctive managerial challenges, related to the organisational characteristics of such firms and their technology.¹²² The success of R&D integration has been found to be

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related to the relative size of the acquirer and the acquired business with large firm acquisitions of small firms proving less successful.¹²³

High-tech firms may prefer collaborative relationships to acquisition (due to associated costs and potential negative outcomes) however increased control through integrative modes may be necessary to protect interests in external relationships affecting their core business.¹²⁴ However, this research does not distinguish between small and large firms. Additionally, small firms may have less explicit and codified knowledge than large firms so knowledge embodied within skilled people, teams or the firm as a whole may only be transferable by a complete take-over.¹²⁵ When this is the motivation, new-technology-based firms (NTBFs) may be acquired by larger firms (as demonstrated by the acquisition of biotech firms by large pharmaceutical firms, see Box 1).

Box 1: The bio-pharmaceutical experience: technological discontinuity & complementary assets

In the biotechnology industry, as in many other sectors, radical innovation was first pursued by newly formed small firms, not large incumbents. Biotechnology originally emerged from US research universities in the 1970s and universities continued to play an important inventive role in this area. The university spin-out phenomenon played a unique role commercialising fundamental knowledge created in the university and 'transferring' it into the wider economy. This pattern is seen in other sectors, including ICT.

The majority of socio-economic research on small biotech-large pharma relationships has focused on the development of bio-pharmaceuticals. As the bio-pharmaceutical sector has evolved, most small biotechs formed collaborative relationships with large pharmaceutical firms, created licensing agreements, or were acquired when pharmaceutical firms internalised biotechnology knowledge. The relationship between large pharmaceutical firms and smaller biotechnology firms tends to be understood in relation to upstream (biotech) versus downstream (pharma) competencies and explained by the concept of 'complementary assets'. Complementary assets are assets, infrastructure or capabilities needed to support the successful commercialization and marketing of a technological innovation, other than those assets fundamentally associated with that innovation.¹²⁶ Collaboration served to link resources and competencies that

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were fragmented among different agents.¹²⁷ Small biotechs possessed the knowledge, research capabilities and linkages with the scientific community necessary for the commercial development of emerging technologies (upstream competencies), but lacked the complementary assets held by the pharmaceutical companies necessary to develop therapeutics (downstream competencies). Although initially predicted that biotechnology firms would displace the large pharmaceutical firms, their lack of the financial, regulatory and marketing assets necessary to move biotechnology-based drugs to market impeded the continual growth of small biotechs. Large pharma were able to adapt to radical technological change through collaborative relationships with small biotechs when they had the complementary assets necessary to commercialise the new technology. These relationships led to an improvement in large firm performance, avoiding creative destruction in the pharmaceutical industry, as small biotechs were assimilated into the sector or settled into technological niches.

There is some evidence that active M&A markets may induce innovation in small firms and that although innovation activity increases with demand, competition and industry in all firms, this effect is stronger for small firms.¹²⁸ This research is concerned with innovative activity at the small firm prior to, and to encourage, acquisition by a larger firm. Once acquired the evidence on innovative outcomes is mixed, and not specific to the new subsidiary.

4. TOWARDS A RESEARCH AGENDA ON SF-LF LINKAGES IN INNOVATION

Significant progress has been made in recent years in our understanding of the profile and contribution of external relationships to small firm innovation. First, perhaps because of managerial constraints, while SMEs do engage in innovation partnerships they tend to have fewer linkages with less diverse organisations than larger firms. Second, these linkages add significantly to SMEs' ability to innovate. Thirdly, supply chain linkages, particularly to customers, seem to contribute most to SMEs' product innovation. Finally, the nature of SMEs' innovation linkages differs significantly by sector, location and the strategic orientation of the SME.

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The vast majority of this research relies, however, on national variants of the Community Innovation Survey (CIS) and some non-EU counterparts. This provides useful if rather specific information on the innovation partnerships of different companies. The three main data items available are:

- First, an indication of whether a firm collaborated with suppliers, customers etc. as part of its innovation activity and whether these partners are local, national or international. No information is available on the duration of these linkages, their intensity in terms of say frequency of contact, the nature of the contact between firms and/or the nature of the knowledge or information exchanged or acquired.
- Second, a subjective indication of the importance of each of these types of linkage for firms' innovation activity. This provides information at firm level and little indication of the importance of linkages for any specific innovation project or type of innovation project. No indication is provided whether these links are contractual or collaborative.
- Third, an indication of other sources of information for innovation such as trade shows, patents, standards, journals etc. This is potentially useful data but again provides only a very broad summary of the breadth of firms' non-interactive linkages.

Business-to-business linkages are reflected most fully in the first and second indicators, with the differentiation being by the relationship to the focal firm (i.e. customer, supplier etc.) rather than size or sector. No information is therefore available from the CIS on whether small firms' innovation linkages are with other small firms or larger companies. As a result, research based on CIS data provides little information on the specific impact of larger customers or suppliers on the innovation activities of smaller firms. Evidence on the impact of particular purchasing or supply chain strategies by lead contractors on supplier innovation is also largely limited to case study or qualitative investigations. As a result we know surprisingly little about the role, position, opportunities and constraints

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facing many SMEs as they seek to develop and sell innovation in demand networks.

Addressing these issues is likely to require new data collection beyond the existing CIS. Studies in the GVC and supply chain literatures suggest a number of factors which may also be important to consider, factors which may not be so important in horizontal relationships.^{129, 130} These are linked primarily to the governance of supply chain relationships and the positional advantages of larger customers and suppliers within the supply-chain. In particular, the factors which shape governance relationships in GVCs and the technological characteristics of particular supply-chains may be influential in shaping SF-LF influences on innovation. The supply-chain related incentives for SME innovation may also be related to the regulatory environment within the sector and the receptiveness of larger customers to SME innovation. In a sector characterised by open innovation, for example, the incentives for SME innovation may be much greater than those where supply chains are hierarchic with innovation concentrated in primes.

Evidence on the horizontal linkages of SMEs also remains limited due to the structure of the CIS data. Commenting on their own analysis one study notes:¹³¹

‘... the current survey does not study how large and small firms interact in open innovation... large, established companies and small start-ups manage open innovation differently, reflecting their differential position within the innovation system. Hence, future research should focus on the requirements of open innovation on differences in culture, structure and decision making between partners of different sizes and from different industries’.

Existing research also provides little insight into the objectives of particular SF-LF innovation relationships – activity structuring or knowledge acquisition/exchange – or about their benefits. In terms of activity structuring relationships, for example, we have limited evidence on the

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relative benefits of contractual and collaborative frameworks for SF-LF innovation relationships; the impact of corporate venturing on the innovation activities of small firms or the impacts of participation in open innovation eco-systems. In terms of knowledge acquisition and exchange relationships we know more about purposive links but less about the barriers and enablers of technology licensing (inwards and outwards) in small firms. The impacts of acquisition on SME innovation are also unclear.

The typology outlined in Table 1 provides a starting point for any future study of SF-LF interaction and its impacts on SME innovation. To address gaps in our understanding the other key issues which will need to be addressed are:

- The innovation strategy or objectives of the SME and its larger partner and their willingness and ability to collaborate with suppliers and customers. Absorptive capacity may also be important here;
- The nature, context and content of SF-LF relationships as well as their contractual and/or collaborative frameworks;
- The governance structures involved in SF-LF relationships within the supply chain and how these either reinforce or mitigate power differentials within supply relationships;
- The regulatory and competitive environment within the sector, the availability of alternative suppliers or customers and the appropriability regime. Each may influence SMEs' incentive to innovate.

Synergies between linkages may also be important reflecting the potential for complementarities or managerial learning in working with boundary-spanning linkages.

Table 1: Typology of modes of small firm-large firm interactions for innovation

<i>Supply Chain Relationships: Orientated around the flow of material goods</i>		
<p>Manufacturing sub-contracting relationships</p> <p>Small firms supply components and sub-assemblies to large companies. As part of this process, large companies frequently transfer technological, manufacturing and quality control know-how to their small suppliers. Stable relationships can develop which are mutually advantageous</p>	<p>Producer- customer relationships</p> <p>Small firms supply finished products to large companies. Large companies can transfer technological know-how and supply suggestions for improvements to small suppliers based on user experience. This mode can involve collaborative development of new products for the large firm: e.g. small software or design houses collaborating respectively with large computer and automobile manufacturers.</p>	
<i>Knowledge Creation & Exchange Relationships: Internalising knowledge</i>		
<p>Large-small firm collaborations</p> <p>Large and small firms collaborate for the development of an innovative new product or process. This involves the production of knowledge. e.g. large firm provides financial, manufacturing and marketing resources; the small firm provides specialist technological know-how and entrepreneurial dynamism (complementary assets). e.g. small-large firms combine knowledge resources to create new knowledge.</p>	<p>Licensing agreements</p> <p>Large firms licensing to small firms: e.g. involving knowledge that the large company does not wish to exploit in-house but which may be utilised to gain a financial return on/or subsequently purchase the commercialised product.</p> <p>Small firms licensing to large firms: e.g. small firms in periods of technological discontinuity or for niche technologies when new knowledge primarily resides with small firms.</p>	<p>Knowledge-informed acquisitions</p> <p>An alternative to collaboration, used by large firms to directly internalise knowledge, skills and capabilities held by small firms. e.g., large firms acquire New Technology Based Firms (NTBFs) to maintain competitive advantage, e.g. bio-pharmaceutical sector, ICT sector.</p>
<i>Knowledge Creation & Exchange Relationships: Activity structuring</i>		
<p>Contract Research</p> <p>Large firms fund targeted R&D in small specialist consultancy companies (contract research organisations, or CROs): e.g. automobile companies funding R&D in specialist engine developers; pharmaceutical companies funding R&D in small biotechnology companies.</p>	<p>Corporate Venturing</p> <p>Large firms offer financial backing for small firms, with the aim of generating income, cost savings or accessing external innovation. May not involve financial investment, can involve payments in-kind. May involve access to managerial, marketing and manufacturing expertise and to channels of distribution. Includes supporting corporate spin-outs to exploit technology developed within the parent company, but which is deemed unsuitable for in-house exploitation.</p>	<p>Open innovation ecosystems</p> <p>Large firms are increasingly outsourcing their research and innovation activities to (often) smaller firms. Research corridors, science parks and regional areas are mechanisms through which large firms are accessing cutting edge research. Research on clusters relates to this mode.</p>

(adapted by the authors from Rothwell 1989)

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