Distributed and Distributing Innovation: Competing through Services and Networks – Changes to Skills and the Organisation of Innovation

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Preamble

This is very much work in progress. It is certainly not a completed paper, but rather a set of ideas that I am trying to pull together. Essentially, there are three points of departure. The first and most elaborated here is the role of skills in innovation. A couple of years ago I undertook a study with colleagues for the then Department of Trade and Industry (DTI) of the UK Government into the relationship between skills and innovation. What was striking then was the dearth of literature from innovation scholars on the inter-relationship between skills and innovation – i.e., how skills shape innovation and how innovation changes the demand for skills. As a community we have debated extensively the role of knowledge and capabilities, but it is surprising how little we have paid explicit attention to the interplay between skills and innovation. The second point of departure is work on innovation in services, and services innovation, which I have been working on for some time. Following Pavitt (1984), services are generally perceived to be supplier dominated recipients of technologies, rather than innovators in their own right. But this perspective is increasingly being called into question. New research shows that innovation in services (and service innovation) tends to be more distributed than archetypal innovation in manufacturing. In other words, whereas innovation in manufacturing is still perceived to revolve around R&D activities (and process innovation through technology adoption), innovation in services seems to typically involve a much wider set of actors – i.e., it is more devolved, both within and between organisations. This brings me to my third point of departure, the growing literature on distributed or networked forms of innovation, particularly where this innovation is not undertaken through R&D based strategic alliances. My aim is to pull these strands together for a project I am starting on how manufacturers are shifting into providing services and engaging in more distributed forms of innovation. Essentially, the question to be asked it whether moves into providing complementary services or into more collaborative approaches to innovation require changes in the skills of the employees within the organisation, or have knock on effects on the skills of the employees. Alternatively, firms that lack access to the required skills may be unable to effectively move in these directions. Unfortunately I did not get as far as I would have liked in pulling these strands together over the summer. I hope the discussant and discussion will find something of interest and be able to advise on further development.

Introduction

The view that innovation is largely the product of R&D activities is inherent in the Lisbon Strategy of the European Union. In essence, this reflects the old linear model: the key to innovation is investing in the front end – i.e., R&D. Yet the origins of innovation are appear to be becoming more widespread, in part because of our broadening perspectives, such that increasing attention is being paid to organisation and other non-technological forms of innovation, and the hegemony of the internal R&D unit as the primary driver of innovation is in decline. Indeed, in their recent survey of Chief Executive Officers, IBM found that internal R&D was regarded as a most significant source of innovative ideas by less than one in five (17%) CEOs, well behind employees, business partners and customers (IBM, 2006, p. 15). Innovation also appears to be increasingly based on collaborations. Three-quarters of the CEOs that participated in IBM's study considered collaborations and partnerships were very important for innovation. And companies like Proctor and Gamble have embraced 'open' approaches to innovation to such an extent that extent that a third of its innovations now originate from outside the company. Its ambition is that half should originate from outside the company (Sakkab, 2002; Dodgson et al., 2006; Huston and Sakkab, 2006). In moving to a more open approach to innovation, P&G recognised that for each of its own researchers there were 200 scientists and engineers elsewhere in the world who were just as good – "a total of perhaps 1.5 million people whose talents we could potentially use" (Huston and Sakkab, 2006, p. 60) – the issue is how to tap into this expertise.

Our concern in this paper is with developing the foundations for a study of innovation in manufacturing firms, and in particular we are interested in two forms or directions of innovation which are aimed at enhancing value added and avoiding becoming embroiled in cost based competition: the establishment of alliances, and engaging in the provision of services (alongside the firm's traditional production of goods). We consider that both of these can be quite radical forms of innovation, as they are likely to require the firm to adapt, at least in terms of its organisation but possibly also in terms of its skills and technologies.

At a basic level, a firm can be considered an organised combination of people (with skills) and capital (i.e., technologies) which produces outputs the value of which should exceed the cost of the inputs. Innovation involves substantial changes to one or more of these, and arguably more radical innovation involves interdependent changes to more than one skills, technologies and organisation. We begin by reviewing some existing studies on the interdependencies between skills, technology, organisation and innovation.

Interdependencies between Skills, Technology and Organisation and their Implications for Innovation[1]

The effects of innovation on the type and quality of employment has generated growing interest among labour economists. Ideally, firms not only have to choose an allocation of resources between capital and labour but also decide what kind of labour to use in combination with given capital endowments. Theoretically, their choices will depend on the relative scarcity, and hence the relative cost, of different kinds of skills, but also the productivity of these different kinds of labour in relation to the kind of capital that is utilised in the firm's production process. If the technological or organisational innovations adopted

[1] This section of the paper draws heavily on the report to the DTI written by myself, Andrea Mina, Davide Consoli and Dimitri Gagliardi. I thank and acknowledge my colleagues' contributions.

by firms require higher proportions of skilled workers over unskilled workers, the change is said to be (positively) *'skill-biased'*[2] (Machin, 2001).

Over the last two or three decades in the labour markets of several advanced economies, demand for skilled workers has increased *faster* than the demand for unskilled workers, and *faster* than the supply of skilled workers. The phenomenon of skill-biased technical (and organisational) change has proven especially strong in the US, and to a lesser extent in the UK, where the number of jobs requiring skilled workers has been increasing rapidly, and faster than the supply of such workers, resulting in increasing wage inequalities between groups of workers with different skill endowments. Piva *et al*. (2005) provide an overview of the recent literature on the topic and a discussion of international comparisons.

How Technical Change Affects the Demand for Skills

The nature and direction of technology-related biases vary over time and technical change is *not* inevitably positively skill-biased. At the beginning of the Industrial Revolution technical progress favoured the employment of unskilled workers and caused the demand for the skills of artisans to fall sharply during the 19th century (Goldin and Katz, 1998; Manning, 2004).[3] Nevertheless, over the last two to three decades advanced capitalist systems have faced a *strong skill bias* associated with growing investment in capital and the increasing automation of production tasks; new machines have increasingly *substituted* for the labour of unskilled workers, whilst new technologies have been introduced *in combination* with more highly skilled labour so that both can fully realise their productive potential (Hoskins, 2000; 2002).

Car production is a mature industry, but illustrates long-term processes of change in archetypal, scale intensive manufacturing. The industry was born in the late 19th century as a craft-based business that required highly skilled and adaptable workers, but in the early 1900s, it was radically transformed by the diffusion of Taylorist and Fordist methods of mass production, where complex tasks were simplified into a highly refined division of labour, with the production of standardised components, in such a way that unskilled workers could be made to perform them after very little training. The non-manual component of virtually all tasks was separated from the shop floor and concentrated in layers of specialised management (Kaplinski, 1988). Meanwhile, the growth in aggregate demand fuelled employment and absorbed increasing shares of unskilled labour.[4]

If the introduction of the assembly line caused a relative shift from skilled to unskilled labour, the emergence in the late 1970s of Japanese 'lean production' techniques, coupled with heavy capital investment in automated production, started to turn car production back into a fairly skill-intensive industry (Wells and Rawlinson, 1994).[5] Consequently, jobs that used to be performed by the unskilled became increasingly automated and tasks that were routine became complicated by the adoption of robotics and therefore started to require a higher

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[2] Acemoglu (2002) provides a clear and technically rich survey of the modern micro-economics of skill-biased technical change.

[3] Moreover, not only is technical change uneven over time but also across sectors of the economy (Malerba, 2005). For example, there may be niches of the service sector (such as domestic cleaning and waiting tables) where technology favours unskilled labour due to 1) difficulties in mechanising complex hand-eye co-ordination tasks; 2) the impossibility of trade and 3) the growing demand of increasingly wealthy customers at the other end of the earnings spectrum for personal and customer services.

[4] Note also that the cost of failing to educate the labour force to its full potential was not fully apparent, as during this Fordist era of mass-production there was a high demand for people without qualifications who could be persuaded to undertake highly repetitive forms of work (Prais, 1995).

[5] See Womack *et al*. (1990) for the thorough analysis of the evolution of the sector and Utterback (1996) for a discussion of it from an innovation perspective.

percentage of higher skilled staff. In the Japanese model, the introduction of multi-skill and multi-task jobs in mass-market industries reversed the global trend, led by US firms, towards excessive labour specialisation and favoured a distribution of skills across organisational levels. In what became known as high involvement, high commitment, or high performance work practices, workers were encouraged to contribute to technical improvements through their involvement in teamwork and similar practices. This not only accelerated the reaction time to changes in demand, but also improved the innovative potential of firms by valuing workers' creative efforts and by multiplying the opportunities for learning and the incremental acquisition of complementary skills (Kaplinski, 1988). Recruitment and training practices changed accordingly. From the quick, task-specific and on-the-job methods of the Fordist period, a shift took place towards formal training and lengthy 'before-the-job' search and selection processes aimed at testing thinking (cognitive) and diagnostic skills of prospective employees (Gilles, 1978, and Rutherford, 1994; cited in Duranton, 2003).

Further evidence of complementarities between changes to technology, skills and organisation has emerged through studies of the adoption of information technologies. Indeed, the majority of studies on the skill-bias hypothesis discussed above focus on the adoption of IT equipment at different levels of aggregation: at the individual level (for example, Krueger; 1993), at the firm level (Doms *et al*., 1997; Mairesse *et al*., 2001) and at the industry level (Berman *et al*. 1994; Autor *et al*. 1998; Falk, 1999). The vast majority of contributions in this area talk about complementarities between capital investment and skills to explain the effects of the diffusion of IT on wage differentials and employment patterns within and across sectors. These effects are especially clear for the 1980s, when the greatest skill-upgrading was recorded in those manufacturing industries where the introduction and diffusion of IT was the more rapid (Berman, Bound and Machin, 1998).[6] The core of the argument connecting investment in IT and skills (or human capital) is that better-educated workers are able to extract better performances from the use of computers than less educated ones. This was especially true in the early phase of the diffusion of computers, before the introduction of graphical inter-faces and 'point-and-click' technologies, which made computers a lot more accessible to those without specialist skills.

Bresnahan (1999) suggests that IT has raised the demand for skilled workers but has done so primarily by changing the organisation of the firm rather than by improving the productivity of individual workers. Bresnahan speaks of *limited substitutability* and *organisational complementarity* between IT and skills. The first point concerns the imperfect capacity of computers to substitute non-routine 'cognitive' and 'interactive' features of labour (human decision-making above all); the second concerns the way in which the application in workplaces of computers - and especially networked computers - changes production processes and often the *form* of production processes (as in many service industries).[7] This implies that understanding trends in the demand for skills requires consideration of the links between *organisational change* and the changing nature of work.

Bresnahan *et al*. (2002) also report a strong correlation between (positive) skill-biased technical change and organisational change with the introduction of IT equipment in a sample of US firms. They argue that "…firms do not simply plug in computers or telecommunications equipment and achieve service quality or efficiency gains. Instead they

[6] However, greater uncertainty exists for studies relating to the 1990s, which perhaps indicates that IT investments have moved to a more mature stage, and thus have a lower requirement for skills.

[7] As a consequence, estimation of individual wage equations with a regressor for computer use is not an accurate tool to measure the impact of computers on the labour market.

go through a process of organizational redesign and make substantial changes to their product and service mix. […] … IT is embedded in a cluster of related innovations, notably organizational changes and product innovations. These three complementary innovations – 1) increased use of IT, 2) changes in organization practices, and 3) changes in products and services – *taken together* [emphasis in the original] are the skill-biased technical change that calls for a higher-skilled labour mix." (Bresnahan *et al*., 2002, pp. 340-341). Piva *et al*. (2005) have recently reached the same conclusion on a sample of Italian firms where up-skilling went hand in hand with both technical and organisational change.

These complementarities are likely to be especially relevant for service innovations, which are still relatively understudied (Miles, 2005). It can be argued that where the boundaries between process and product innovation are rather ill defined – as is often the case with services – complementarities between technical and organisational change acquire paramount importance in shaping the distribution of skills within and across firms. Overall, it is quite clear that processes of *substitution* of unskilled labour with machinery are only part of the story of skill-biased technical and organisational change. The simple observation that modern production practices are associated with increasing employability and increasing wages amongst the high skilled suggests that capital investments and investments in skills are complementary, especially with respect to cognitive and relational tasks. This has been perceived since the 1960s, when Nelson and Phelps (1966) and Griliches (1969) suggested that adaptable skills are themselves essential in the process of adoption of new technologies and that the diffusion of innovations will tend to favour economies, firms and individuals with higher human capital.

Adaptable Skills, Innovation, Value Added and Product Strategies

The connection between adaptable skills and firms' ability to innovate and move into higher value added markets has been demonstrated by the comparative studies of Britain and German by Prais (1995) and colleagues at the National Institute of Economic and Social Research. Prais found that the capacity of a firm to adapt is related to the skills of its workforce and management. The narrow and rigid job-specific skills sets traditionally imparted to production workers in Britain meant that these workers tend to be assigned to fixed tasks, as change is difficult and costly. By contrast, the more flexible and dynamic skills sets of German production workers meant they are better able to adapt to change and, thereby, engage with and uphold innovation. These limitations in skills then restricted the competitive strategies available to British companies. For example, in relation to textile industry, Prais observed that: "The frequent changes in German textile design relied on operators being able to read directly from sketches. This allowed the German firms to engage in small batch production and rapidly switch production in response to changes in demand, thus achieving high value added; the British operators more often relied on physical demonstration by supervisors. The limited abilities of British operators were thereby implicated in the 'strategy' of long production runs. This meant the British firms were unable to switch rapidly in response to changes in demand, and consequently they tended to compete on volume, and price, the part of the market most easily entered by producers based in lower cost places of production, such as East Asia" (Prais, 1995, p. 69).

Prais also found that British firms tended to defer the implementation of new equipment and sought to purchase simpler models to reduce the complexity of implementation. This was due to several factors, including the low level of shop-floor skills, but also reflects an inability of British managers to manage the implementation of new technologies: "British management sought to accommodate their acknowledged weaknesses in operations. For

example, British firms recognised their weak in-house ability to manage sophisticated machine tools such as CNC machines. They accommodated this weakness by tending to buy simpler machine models and delaying purchase until they were sure suppliers had dealt with all the 'bugs' associated with advanced models" (Prais, 1995, p. ???). The use of simple machines conferred limited advantage on British firms, which ended up competing on price with foreign producers in countries like China rather than competing on quality.

In terms of productivity, it emerged that the major differences concerned not the amount of work done, but its quality. This was particularly evident for biscuit manufacture, where according to the productivity measure of 'biscuit-tons per employee hour' the German workers produced 20% less than the British (Prais, 1995, p. 55), but the 'average German biscuit' commanded 2-3 times the retail price of the average British biscuit. The German biscuit manufacturers had moved their products so far up the quality scale that per biscuit productivity was no longer a significant indicator of true difference (Howells, 2005, p. 202). Prais' researchers observed that these differences in productivity were all related to a distinct and superior ability of German firms to manage and incrementally improve operations. This ability was in turn directly underwritten by the superior quality and quantity of technical skills available to them (Howells, 2005, p. 202). At the heart of this were some relatively simple things – like the regular maintenance of plant to avoid emergency breakdowns.

More recent work has explored further the relationships between a change in product strategy and innovation in terms of the nature and quality of products offered, the processes of production or provision, and the skills requirements and organisational arrangements of the firm. Several studies have investigated the hypothesis that workforce skill levels are positively related to more innovative and productive, high-value-added product strategies (e.g. Wensley, 1999; Wilson and Hogarth, 2003; Mason, 2004). Accordingly, a high value added strategy is theoretically associated with more innovation and high skill levels, whilst a low value added strategy is theoretically associated with little innovation and low skill levels. It follows that if the stock of skills improves, this might stimulate firms into upgrading their strategies and move up the value chain.

Mason (2004) suggests that employers' demand for skills in Britain is lower than that of several other economies because a large proportion of British enterprises have adopted low value-added product (or service) strategies, with production concentrated on the less innovative (i.e. more-standardised / less-complicated) end of the quality spectrum for which skill requirements are relatively low. This implies that in the absence of strong incentives such as foreign competition, there is no reason to expect that such firms will change their strategy. In the face of foreign competition, the firms may well have to adapt (and shift towards more innovative and skill-intensive high-quality product strategies) or die.

Mason used the 2001 Employers Skill Survey to investigate two basic propositions: 1) All else being equal workforce skill levels are positively correlated with value added product strategies (i.e. high-high; low-low); 2) All else being equal value added product strategies are positively correlated with the degree of exposure to foreign competition (i.e. high-high; low-low). Broadly, high value added product strategies involve more innovation than low value added product strategies. He found strong support for both hypotheses at the aggregate level. In addition, more innovative, high-end product strategies were positively associated with recent growth in sales but also with high levels of capacity utilisation, whilst low-end product strategies were associated with declining sales and low levels of capacity utilisation. Mason therefore infers that a significant proportion of British firms that are pursuing low value added product strategies and could potentially enhance their competitiveness by innovating

and moving to higher specification, more skill-intensive products and services. Unfortunately, the results also suggest that changing the product strategy requires different skills and firms are likely to experience skill shortages when they try to move 'up-market'. This is most apparent in sectors where there is already a high proportion of firms using more innovative, high value added product strategies. Conversely, in sectors where low-end product strategies prevail, the impact on the demand for skills by firms that want to upgrade their product strategies appears to be relatively modest.

Interestingly, this positive relationship between product quality and the skill levels of the workforce is also reflected in cross-country comparisons. Several studies have explored Anglo-German differences in the predominant mix of product strategies and show these to be systematically related to the of workforce skills in a number of industries, including clothing, food processing, and automotive components (see Steedman and Wagner, 1989; Mason, van Ark and Wagner, 1994; Prais, 1995; Mason and Wagner, 2002). For example, higher levels of skills in the workforce of German automotive component plants is believed to mean the workforce is also more flexible, which increases the rate of incremental innovations and reduces downtime. Higher workforce skills also complement other investments in physical capital and R&D to enhance productivity (Mason and Wagner, 2002).

In another recent study, Mason (2005) compared two samples of British companies – those achieving High Value Added (HVA) and those achieving Medium Value Added (MVA) within plastics processing, printing, and logistics, industries selected on the basis of their observed variation in key dimensions such as product strategy choices, level of workforce skills, productivity performance and competitive market conditions.[8] The aim was to assess the relationship between skill levels and performance. Mason finds that firms operating in the *plastics processing* and *printing* sectors are experiencing increasing pressure from low-cost foreign competitors. The gap between HVA and MVA firms in terms of innovative strategies (i.e. product innovation versus cost minimisation) and ability to deal with skill problems are remarkable. In addition to that, because of skill and physical capital deficiencies, the MVA firms struggle to innovate and change their product standards towards HVA levels, thus displaying a rigid set of capabilities. In both these industries, more innovative HVA firms seem better placed to compete effectively, and whilst the MVA firms are currently profitable they are likely to struggle to remain so as they come under increased competition. The *logistics* sector is however a bit different. First, most HVA firms are foreign-owned (and have therefore imported many of their technologies and work practices) while the MVA ones are large domestically-owned. Second, in this sector MVA emerge as more dynamic, as they are actively engaged in product diversification and high-value activities. Third, HVA and MVA firms deliver broadly the same level of on- and off-the-job training. Fourth, since MVA firms are actively involved in diversification, skill gaps are being induced by their venturing in new territories, rather than existing in established lines of business.

The studies by Wilson and Hogarth (2003) which focused on food processing and business hotels found similar results. "In general terms, the case studies confirm that in both of the sectors studied there was evidence that some of the organisations concerned were firmly embedded in a 'low skills equilibrium' [Finegold and Soskice, 1988][9] or on a low skill

[8] The study also covers the insurance industry, but at the time of writing the report did not include the results for the insurance industry.

[9] Finegold and Soskice introduced the idea that the UK may be trapped in a 'low skills equilibrium', "in which the majority of enterprises staffed by poorly trained managers and workers produce low quality goods and

trajectory. This was the result of the internal market and other environmental constraints that they faced in their day-to-day operations. Despite the effort of some of organisations to innovate and extract themselves from this situation, the most common reaction of respondents was acceptance of their position and of the fact that there was little that they could do to change it" (Wilson and Hogarth, 2003, p. xii). Wilson and Hogarth however emphasise that especially for business hotels the availability of workforce skills, internally or though recruitment, was often not the key difficulty (although sometimes it was). The key difficulty was often managerial abilities to co-ordinate the innovation process.

In essence, businesses develop satisfying behaviours and strategies (Simon, 1957; Cyert and March, 1963). They become accustomed to the local conditions in terms of the supply of labour, the nature of customers' demands and the abilities of their management to co-ordinate production. As Wilson and Hogarth found: "As with the business hotel sector, there was little evidence that the case study food processing organisations were looking to innovate and break into higher value-added market segments. Rather they were concerned to increase the efficiency with which they produced the existing range of goods and services. Admittedly there was also improvement to the range of goods and services but these were improvements very much within their existing market segment' (Wilson and Hogarth, 2003, p. xv). In other words, firms focused on highly incremental innovations within their existing markets, rather than using innovation to radically reposition the firm into higher value added markets. From a capabilities or resource based view of the firm, these firms may be highly fit that is they are very closely aligned with the markets in which they operate. The danger is that if there is a shift in the selection environment, for example by the arrival of new competitors, they may fail to adapt quickly enough to the new circumstances. In other words, their core competences may become core rigidities (Leonard-Barton, 1992).

Taking Stock

The literature reviewed above has emphasised three things:

- Firstly, that recent technological and organisation changes, and indeed the interactions between these, tend to be biased in favour of workers with higher skills. This is particularly the case with information technologies and the use of high involvement (or high commitment) work practices.

- Second, that a firm's skills endowments are particularly important in shaping, and limiting their room for manoeuvre in terms of adopting different product or service strategies. Two types of skill sets are particularly important: managerial skills (the weakness of which tends to make firms undynamic) and workforce skills, which when weak can lead to important rigidities in the strategies adopted.

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services" (Finegold and Soskice, 1988, p. 22). They saw the situation as one of 'systems failure' where UK individuals and employers react rationally to the incentives they face, for example many enterprises remain profitable by engaging in risk averse low specification strategies involving little innovation on the basis of low skills, whereas it might be costly for them to seek to move to high specification strategies based on greater innovation and higher skills because the limited availability of these skills makes them expensive to obtain. More recent work such as that by Mason, and Wilson and Hogarth, stresses high and low value added rather than high and low product specifications, as it is possible to have high quality low specification products (whether they be goods or services). Low-specification products tend to be characterised by long production runs, economies of scale, standardisation and low value added. They tend to require low levels of skill to produce.

- Third, that change in an industry often comes from outsiders moving in, rather than from internal reform within companies. When there is no external competition, groups of firms can become locked into a low-skills equilibrium.

We are interested in applying these ideas to two forms of innovation amongst manufacturing firms – moving to the provision of services alongside goods, and moving to a more collaborative approach to production. We conjecture that both of these innovation strategies will typically involve a change in the way the firm is organised, possibly a change in the technologies utilised, and a change in the skills required to undertake these types of innovation effectively. The arguments outlined above suggest that many firms will have difficulty in embracing these strategies, should they wish to do so.

Innovation in Services

The fundamental question is whether the development and introduction of new services is similar to the development and introduction of new goods and processes. If this is the case, firms that innovate goods and processes should be able to adapt these to innovate services; if it is not, then more substantial changes are likely to be required.

Services have been extensively studied by management scholars, especially those in operations management and marketing,[10] but despite constituting the bulk of economic activities in advanced economies, they have received relatively little attention from scholars of innovation (Miles, 2006). In the past, innovation scholars have dismissed services as being 'supplier dominated' users of technologies (Pavitt, 1984), rather than true innovators – the implication being that technology adoption is the 'easy bit' of innovation. In recent years services have however received increasing attention from scholars of innovation (e.g., Gallouj and Weinstein, 1997; Gallouj, 2002; Sundbo, 1997, 1998; Evangelista, 2000; Sunbo and Gallouj, 2001; Djellal and Gallouj, 2001; van der Aa and Elfring, 2002; Drejer, 2004; Hipp and Grupp, 2005; Djellal and Gallouj, 2005; de Vries, 2006). Although a growing consensus recognises that there is no clear divide between how manufacturers and service firms innovate (Evangelista, 2000; Hollenstein, 2003), most of these studies argue that innovation in services tends to differ from archetypal R&D based technological innovation, for in general innovation in services does not originate in R&D or innovation departments, but is more distributed. Sundbo (1997) argues that innovation in services (and other non 'high-tech' activities) tends to be strategically determined and market driven, in contrast to the 'technological model' of R&D based innovation which is prevalent in high technology manufacturing.

In a recent study, Tether and Tajar (2007) have empirically identified three modes of innovation: a product research mode, which is oriented to technological advances and product innovation, and which involves R&D and/or R&D based strategic alliances; a process technologies mode, which is oriented to process innovation and increasing the organisations efficiency and/or flexibility, and involves adopting advanced technologies; and an organisational co-operation mode, which is oriented to organisational changes and involves cooperative practices within the supply chain and which emphasises the skills of the workforce in carrying this through. Although all of these modes are found in all sectors of the economy, the distribution of each varies significantly. In line with expectations, the product-research mode is particularly prominent in high technology sectors, the process-technologies mode is particularly prominent

[10] There are well established textbooks on service operations management and service marketing. For example, Normann's "Service Management", first published in 1984 is now in its 3rd edition, whilst Fitzsimmons and Fitzsimmons textbook on the same topic is now in its fourth edition, and Lovelock and Wirtz's "Service Marketing" is now in its sixth edition. There are also specialist journals, such as the Journal of Service Research and the Service Industries Journal.

in low technology manufacturing, and the organisational-cooperation mode is particularly prominent in services, as Figure 3 (from Tether and Tajar, 2007) shows in detail.

Distributed Innovation

Commentators have long argued that firms do not operate or innovate in isolation, but through enduring inter-relations with other firms and institutions (e.g., Hakansson, 1987; Freeman, 1991; Harland, 1996; Gulati et al., 2000; Coombs et al., 2003). And competition is often recognised as being between supply-chains or networks rather than between individual firms (MacBeth and Ferguson, 1994; Oliver, 1990). Dyer and Singh (1998) have argued for the relational view of competitive advantage (as a parallel to resource or capabilities-based view which tends to take the firm as the unit of analysis). They argue that combinations of firms (in supply-chains or networks) can outperform others when they invest in idiosyncratic and synergistic assets and capabilities, and employ effective governance mechanisms that the lower transaction costs between them (see also Powell, 1990).

Despite the strong interest in distributed or open innovation, we still know relatively little about the extent of these forms of innovation, and in particular, relatively little is known about the implications for skills of engaging in this type of innovation (and whether inadequate skills hinders moves towards more distributed or open innovation). The following examples, hint at the skill requirements involved:

Inter-Organisational Cooperation and Capacity Optimisation at Frankfurt Airport, Germany[11]

Like many of the world's busiest airports, including London's Heathrow, New York's JFK and Tokyo's Narita, Frankfurt airport has grown well beyond its planned capacity, but has been unable to expand through building new runways and other infrastructure for political reasons. Essentially the airport has been forced to search for efficiencies in order to make the best of its available infrastructure, a situation which has given rise to some interesting initiatives and innovative practices (Tether and Metcalfe, 2003). In order to efficiently accommodate as many flights as possible, the three principal actors at Frankfurt airport - the airport owner (Fraport), the air traffic control provider (DFS), and Lufthansa, the largest airline based at the airport - established in 2000 the Future for FRA (or FFF) program for collaborative working. As Volker Zintel, executive vice-president for traffic and terminal management at Fraport explains:

> All three organisations have a vital interest in optimizing capacity at Frankfurt Airport. We recognized that it is difficult for any one of the partners to achieve significant improvement without the involvement of the others. We all depend on each other. That is why we created the Future for FRA in 2000 as a trilateral platform for cooperation measures, joint projects and mutual communications. Within this structure we can agree on activities, implement them with the appropriate participants and avoid parallel work. In short, FFF is a 'win-win-win' partnership for all three organizations (Volker Zintel in anonymous, 2004, p. 5).

This program has led to significant improvements in co-operative practice at Frankfurt airport, and innovations which have increased capacity and allowed a more effective utilisation of the existing capacity. For example, by working together, Lufthansa, Fraport and DFS developed an arrival prioritisation system, which allows Lufthansa to re-sequence the order of its arriving flights up to 30 minutes prior to their arrival. This allows the airline to prioritise flights that have a high number of connecting passengers, and thus helps to minimise the number of missed connections. Whilst this development clearly complicates the work of air traffic control, it provides significant benefits to the airline and its passengers. Another innovation is the

[11] Sources for this case study include anonymous (2004), Walther (2002) and Tether and Metcalfe (2003)

development of a novel 'high-approach landing system / dual threshold operation' [HALS/DTOP] that allows the spacing between arriving aircraft to be reduced, and has consequently increased capacity in terms of the number of flights that can be handled.

What is notable is that these innovations were not developed by R&D departments in any of the parties concerned. Instead, they are the result of growing inter-relations between and empowerment of operations managers in the three organisations. These inter-relations have been encouraged by a system of devolved authority and staff exchanges, which: "improves employees' understanding of the processes and challenges faced within the other organisations, improves communications at a personal level, and creates the conditions for even better cooperation in the future" (Volker Zintel in anonymous, 2004, p. 6). The three organisations have also established joint platforms or teams with responsibility for areas of mutual interest. For example, a trilateral punctuality management system has been introduced, with a joint punctuality management team to initiate and co-ordinate improvement measures,[12] and the three partners now attend twice daily common shift briefings together with the German national meteorological service on the expected traffic situation, weather conditions and other factors. In this way all three organisations take everyday operational decisions with the same basic information. This enables them to seek to operate at maximum efficiency only when that is really necessary, rather than impose this (and the stress of this) unnecessarily on staff at other, slacker times.

Further Illustrations of Innovation through Inter-Organisational Cooperation

Other examples of innovation through organisational-cooperation include changes in organisational inter-relations in the construction industry, an industry which is typified by competitive tendering, short-term financial considerations, and uncooperative, suspicious attitudes whereby each party in a consortium looks to maximise its reward and offset risk rather than to the success of the project as a whole (Huemer, 2004).[13] In recent years some firms have sought to change this situation. For example, Huemer investigates the 'Project Alliance' formed by South-African Breweries (SAB), Brown and Root and three main contractors. This introduced a new form of collaborative contract and working practices, with risk and reward sharing, which had "profound effects on the division of labour as well as on the roles of the actors" (Huemer, 2004, p. 195). Also notable is the T5 agreement, implemented by BAA for the construction of Terminal 5 at London Heathrow, under which BAA has taken all of the financial risk associated with the project so that its contractors can concentrate on building the terminal safely, on time, to budget and to the right quality. Huemer concludes: "By organising and regarding one another differently, it becomes possible in the construction business to jointly participate and shape project developments, to brain-storm with one's partner and maybe come up with solutions neither party would have discovered on their own" (Huemer, 2004, p. 196).

[12] These improvement measures have involved developing a common software programme i.e., this is a case of organisational change leading to technological change

[13] According to Huemer (2004, p. 191) "Most standard forms of contracts actively encourage non-collaborative behaviour, whereby actors develop their own objectives, goals, and value system without considering the impact on others or on project performance. Standard contracts [in the construction industry] are tools to seek strict liabilities and attach blame, and under traditional circumstances the parties are easily led away from trust towards self-interest".

Research Issues to be Explored

We conclude the paper by outlining the issues to be addressed in the forthcoming research.

Firstly, we have seen that changes to technologies, organisation and skills tend to be inter-related, and that limitations in skills can restrict a firm's movement into new activities, such as service innovation or collaborative production.

From the empirical survey evidence and the anecdotal evidence it would appear that service and collaborative innovation (within the supply chain) typically requires different skills than archetypal innovation for products and processes in manufacturing. In particular, these activities require much more devolved authority and initiative, which runs counter to very centralised modes of organisation. The issues, therefore are what types of firms engage in these types of innovation? Do they tend to be those with stronger management and ex ante stronger workforce skills? Beyond this, what changes do the firms have to engage in, in terms of their skills and organisation, in order to effectively participate in these types of innovation?

After further refinement, we will explore these and related issues in a study of innovation in UK manufacturing firms over the next couple of years.

References

To follow

Figure 3
Allocation of Firms to Modes of Innovation by Size and Sector