Innovation and Business Performance: A Literature Review

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INNOVATION AND BUSINESS PERFORMANCE: A LITERATURE REVIEW

Commissioned by GO-ER

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EXECUTIVE SUMMARY

Innovation has been cited as one of the key factors that affects competitiveness. Yet despite widespread agreement about its benefits, innovation is still poorly understood. Definitions are confused and the link between innovation and business performance remains to be proven.

This literature review reports the first stage of an extensive study into the relationships between innovativeness, business performance and innovative capacity of firms. The aim of this review is to set out the context for a research project into these topics, by summarising the studies that have been completed to date.

The report consists of four main sections. In the first the question "why innovate" is tackled, as the generic benefits of and barriers to innovation are identified. In the second section the question "what is innovation" is answered, as the constructs: (i) innovation, (ii) innovativeness and (iii) capacity to innovate are explored and the five models of innovation process are presented. In the third section the question "what is the link between innovation and performance" is addressed, as studies of innovation at the firm, regional and national levels are reviewed. The fourth section concludes the report by identifying areas requiring further research and proposes a forward programme designed to support the formation of an innovation policy for the Eastern Region.

The main findings of this review are:

Section 1 INNOVATION:

- *In the emerging knowledge economy, the ability to innovate at the firm, regional and national level dictates the wealth generation capacity of an economy.*
- *Within UK, there is a growing concern that firms are lagging behind the best-in-class in terms of innovation.*
- *There remains limited understanding as to what actions can be taken at the regional level to facilitate innovation, although some barriers such as costs of innovation, lack of information and shortage of support/infrastructure have been identified.*

Section 2 INNOVATION MANAGEMENT:

- *The three dimensions of innovation are product, process and organisational.*
- *Innovative capacity is the potential of a firm, region or nation to generate innovative output.*
- *Studies suggest that at firm-level, innovative capacity is influenced by three dimensions: firm culture; internal processes; and external environment.*
- *The concept of innovativeness relates to the propensity of an individual or a firm to innovate.*
- *Firm innovativeness is influenced by three sets of factors: organisational characteristics; managerial characteristics and environmental characteristics.*
- *The models used to depict innovation process can be classified into five generations. They are: technology-push model, market-pull model, coupling model, integrated model and networking model.*
- *Networking is a key element in enhancing the innovative potential of firms.*

Section 3 INNOVATION AND PERFORMANCE:

- *Numerous empirical studies suggest that innovation enhances firm performance.*

- *Innovation enhances business performance because the product of innovation increases firm competitiveness and the process of innovation transforms a firm's internal capabilities making it more adaptive to change.*
- *Innovation is hard to measure because of its multi-dimensional character.*
- *The most commonly used measures of innovative activities include: R&D expenditures, patent counts and innovation counts.*
- *Two of the most commonly used methods of collecting information about innovative activities are the patent analysis and innovation survey.*

Section 4 CONCLUSIONS: (Suggested research areas)

1. Regional-level:

a. *How does regional innovative capacity affects the performance of firms within region?.*
b. *What form of regional innovation infrastructure is most conducive to innovation?*
c. *What is the role of networks in innovation?*

2. Firm-level:

a. *What are the linkages between innovative capacity, innovativeness and business performance?*
b. *What are the means in enhancing firms' capacity to innovate?*

1 INTRODUCTION

In April and May 1996, representatives of 75 manufacturing businesses in the Eastern Region were interviewed by members of Cambridge University. During each interview, questions were asked about five main areas: (i) business strategy; (ii) market place; (iii) innovation; (iv) human resources; and (v) investment. The data collected were analysed in several different ways, one of which involved using value added per employee to distinguish between high and low performing companies. The results of this analysis suggested that high performing companies in the Eastern Region, within the mechanical engineering and electrical engineering sectors, tended to:

1. Have a unique product or technology.
2. Have an in-house design capability.
3. Serve demanding customers.
4. Charge premium prices.

The theme that unifies these findings is *innovation*. Businesses retain in-house design capabilities to ensure they have the capacity to innovate. If used correctly this capacity to innovate enables them to develop unique products or technologies which satisfy the performance expectations of demanding customers and which can be premium priced.

Given these findings the Government Office for the Eastern Region decided to commission a follow-up study which will seek to explore in more detail, the relationship between innovation and business performance. Anecdotal evidence suggests that a virtuous circle exists between capacity to innovate, innovativeness and business performance. Scientific evidence to confirm or refute this association appears rare and inconclusive.

The first phase of this study involves reviewing the academic literature on these topics. The report that follows summarises this review. More specifically it seeks to answer the following questions:

- What evidence is there of a correlation between the innovativeness[1] of firms and business performance[2]?
- What evidence is there of a correlation between the capacity to innovate of firms and their innovativeness?
- What factors at firm, national and regional levels appear to impact on the capacity of firms to innovate?

The report that follows consists of four main sections. In the first the question "why innovate" is tackled, as the generic benefits of and barriers to innovation are identified. In the second section the question "what is innovation" is answered, as the constructs: (i) innovation, (ii) innovativeness and (iii) capacity to innovate are explored and the five models of innovation process are presented. In the third section the question "what is the link between innovation and performance" is addressed, as studies of innovation at the firm, regional and national levels are reviewed. The fourth section concludes the report by identifying areas requiring further research and proposes a forward programme designed to support the formation of an innovation policy for the Eastern Region.

[1] Innovativeness defined in terms of product, process and organisation.
[2] Business performance defined in terms of both financial and non-financial factors.

2 INNOVATION

2.1 Why innovate?

The 1990s is an era characterised by rapid social, political and technological change. Phrases such as globalisation, global warming, the borderless world, personal computer and the Internet have all entered the vocabulary. These words reflect the issues that individuals, societies and nations face today. History reminds us that the human race has experienced two great waves of change: the agricultural revolution and the industrial revolution. Numerous commentators suggest we are in the midst of the 'third wave'[3].

The agricultural revolution was characterised by the *farm*. Land and labour were the key inputs in the generation of wealth. The acquisition and exploitation of land was seen as a means of wealth generation. The most important output of this era was food. With the advent of the industrial age, the basic inputs shifted to that of capital, labour and raw materials. Manufactured goods were the main outputs. The *factory* became a symbol of the industrial revolution, where factory outputs driven by investments in plant and machinery generated wealth. Today we have entered the third wave.

The third wave of change is epitomised by the symbol of *personal computer*. Here the economic inputs can be classified as: hardware, software and wetware. This is made clear by Professor Romer[4]:

> "When we bake a cake or make a computer chip, we produce a tangible piece of hardware. When we teach someone how to be an engineer, we produce new wetware. When someone develops a new recipe for a cake, a new design for a computer chip, or a new procedure for processing electronic orders, this person has developed new software. Production makes hardware. Education makes wetware. *Innovation makes software*."

[3] The American futurologist Alvin Toffler coined the term "The Third Wave" to describe the current wave of change in the world.

Software[5] is the currency of the emerging knowledge society. In essence, software is the embodiment of knowledge in a codified form that can be disseminated to others. There can be virtually no limits to the supply of new and better software, as it is only limited by the human capacity to innovate. So what are the outputs in this era? More hardware, more software and more wetware, all which add up to the assets of a society. The process of innovation creates new forms of software – new products, processes, ways of working – that increase the knowledge stock of a society thus pushing it up the knowledge ladder. The escalation of knowledge is driven by innovation and is a key determinant of the competitiveness of nations.

The bedrock of innovation is ideas. Ideas are the fuel for the engine of growth in the knowledge economy. The economics of ideas represent a fundamental shift away from the economics of goods. Ideas have two very distinct characteristics. First, when an individual has an idea and develops it, it can be made available to others. Ideas can be used simultaneously. "If I use it, this does not prevent you from using it too."[6] Physical goods, however, can only exist in one place at one time. Second, ideas are not subjected to the law of diminishing utility. In knowledge-driven growth, new knowledge provides inputs that allow investment to generate increasing rather than diminishing returns.

We may not yet have a clear picture of where the third wave of change will bring us; but one thing for sure, change is inevitable. In the words of Paul Romer: "Our challenge is to understand this new wave so we can ride it and not fight it".

2.2 Innovation and competitiveness

Innovation is the key to competitive advantage in a highly turbulent environment. It is a major driving force for economic growth of nation states. The ability to innovate has direct

[4] Paul Romer, Professor of Economics at the Graduate School of Business Stanford University. Adapted from Skandia (1996:3).
[5] Software here is used to describe a procedure or know-how of executing a task.
[6] Cited in Dosi (1997:1538).

consequences for the ability to compete at the individual, firm, regional and national level. The values created by innovations are often manifested in new ways of doing things or new products and processes that contribute to wealth. When we consider a firm as a bundle of resources, skills and competencies, then the effect of innovation is to transform a firm's inner capabilities, making it more adaptive, better able to learn, to exploit new ideas. This enhanced flexibility is crucial in the face of changing market conditions. Thus innovation enhances competitiveness of firms.

There is a growing awareness and concern about the need for effective management of innovation in the UK[7]. In 1994 a report by DTI showed that during the 1980s, the UK's manufacturing productivity increased faster than other major industrialised economy. However, the recent competitiveness report published by the DTI showed that the GDP per capita of UK is 10% below that of OECD average. What is more alarming is that this figure is roughly the same as it was twenty-five years ago. While other countries have been improving their GDP per capita (notably Hong Kong and Singapore with higher GDP per capita) the UK has not.

2.3 Barriers to innovation

Given the significance of innovation, what are some of the barriers that hamper the ability to innovate? The literature[8] suggests there are many barriers to innovation and that these are both *internal* and *external* to a firm. The external barriers include the lack of infrastructure, deficiencies in education and training systems, inappropriate legislation, an overall neglect and misuse of talents in society. Some major internal barriers include rigid organisational arrangements and procedures, hierarchical and formal communication structures, conservatism, conformity and lack of vision, resistance to change, and lack of motivation and risk-avoiding attitudes.

[7] See among others, (CBI/DTI,1993; CBI/DTI, 1994; HMSO, 1995; HMSO, 1996; DTI, 1997).
[8] The OSLO Manual – OECD(1992:38) in particular provides a list of factors hampering innovative activities.

As regards barriers to innovation at a regional level, Wiig and Wood (1997)[9] provide some key findings. The factors perceived as restrictive to product/process innovation include: fear of imitation, high costs of innovation, insufficient government support, lack of information, lack of qualified personnel, no market or insufficient knowledge about markets, and shortage of support/infrastructure in the region.

The literature also suggests that there are a number of key elements in any regional economy for promoting innovation. First, the availability of skilled workforce. Second, the presence of a strong regional technological infrastructure. Third, strong public support for innovation. Fourth, the importance of trade linkages. Recognition of the key elements is not sufficient to make a region innovative. As will be shown in this review, the process of innovation is far more complex than often depicted.

2.4 Summary

This section has addressed the question of 'why innovate?'. This question has become more pressing, given the increasing pace of change in the world and the shift towards knowledge-based economies. Increasingly, the ability to innovate at the firm, regional and national level dictates the wealth generation capacity of an economy as a whole. Innovation has a direct impact on competitiveness. Within UK, there is a growing concern, as reflected in recent white papers on competitiveness, that UK firms are lagging behind some of the best-in-class in terms of innovation. The main barriers to innovation have to be eliminated if UK firms are to improve their innovative capacity. There appears to be limited understanding of what actions can be taken at a regional level to facilitate innovation, although some barriers, such as costs of innovation, lack of information and shortage of support/infrastructure have been identified. The next section looks at the key concepts of innovation; this serves as a foundation for further discussion of the issues of innovation and business performance.

[9] Based on their research of the county of More and Romsdal in Central Norway.

3 INNOVATION MANAGEMENT

This section reports the review of the literature related to innovation. The literature concerning innovation is both vast and diverse. Nonetheless, understanding of the phenomenon is not advanced by the often contradictory and inconsistent results[10] of research studies. Innovation is a multi-dimensional phenomenon that is both complex and context-specific. This review is not aimed at identifying the single theory of innovation. Instead it sets out to summarise current knowledge on innovation.

The ensuing discussion is organised in the following structure. First, some key concepts related to innovation are presented. The discussion starts by defining innovation and the dimensions of innovation. This serves as an introduction to the phenomenon of innovation. Second, the various models that explain the process of innovation are described. Here the different models of the innovation process are reviewed. Having introduced the key concepts of innovation and the various models of the innovation process, the discussion then focuses on the different levels of analysis. Three levels of analysis are apparent – firm-level, regional-level and national-level. In the third sub-section, research studies carried out at the three levels will be reviewed. Fourth, the constructs 'innovativeness' and 'innovative capacity' are analysed. In particular the determinants of 'innovativeness' and 'innovative capacity' are discussed.

In summary the following questions are addressed in this section:

- What are the key concepts in the field of innovation?
- What are the various models of the innovation process?
- What are the different levels of analysis?
- What do the constructs 'innovativeness' and 'innovative capacity' mean?

[10] Criticisms of inconsistencies are found in (Bigoness and Perreaut, 1981; Damanpour, 1988; Downs and Mohr, 1976; Kimberly and Evanisko, 1981; Rogers, 1983).

3.1 What is innovation?

In simple terms, innovation involves the exploitation of new ideas. Innovation is often confused with invention. There is a difference between innovation and invention. Innovation should not be equated to invention; an invention may not necessarily lead on to innovation. This distinction is made clear by Freeman (1982:7) when he noted that: "an *invention* is an idea, a sketch or model for a new or improved device, product, process or system" whereas "an *innovation* in the economic sense is accomplished only with the first *commercial* transaction involving the new product, process, system or device…"

Innovation can be given different meanings in different contexts. Essentially the main characteristic of innovation is *change*. Hence it is difficult to have *a* theory of innovation[11] because the notion of change is still not fully understood. For the purposes of this report the definition proposed by the OECD is adopted:

> "Innovation consists of all those scientific, technical, commercial and financial steps necessary for the successful development and marketing of new or improved manufactured products, the commercial use of new or improved processes or equipment or the introduction of a new approach to a social service. R&D is only one of these steps." OECD (1981:15-16)

It is apparent from the definition that innovation can be classified into *product innovation* and *process innovation*. Product innovation refers to the new or improved product, equipment or service that is successful on the market. Process innovation involves the adoption of a new or improved manufacturing or distribution process, or a new method of social service. This is not to mean that the two types of innovations are mutually exclusive. Process innovation for instance may lead on to product innovation. Similarly product innovation may induce innovation in processes.

[11] "there can be no *one* theory of innovation, as the more we learn, the more we realise that 'the whole' remains beyond our grasp…", Wolfe (1994:406).

Further to product innovation and process innovation, there is organisational innovation. Organisational innovation can lead to more effective utilisation of human resources that are crucial to the successful exploitation of ideas. Hence, innovations can occur in three broad dimensions – product, process and organisational. This is best summarised in the EU Green Paper on Innovation:

> "In brief, innovation is:
> - the renewal and enlargement of the range of products and services and the associated markets;
> - the establishment of new methods of production, supply and distribution;
> - the introduction of changes in management, work organisation, and the working conditions and skills of the workforce." EC(1995:2)

In terms of type, innovations can be classified as *radical* breakthrough type (launch of a new vaccine or the microprocessor) or *incremental* progressive type (the introduction of 32-bit chips to replace 16-bit chips in electronics). Having reviewed the key dimensions of innovation and the types of innovation, one can organise an innovation of interest along two axis. (See Figure 1). This framework is useful as far as identifying the typology of a group of innovations is concerned.

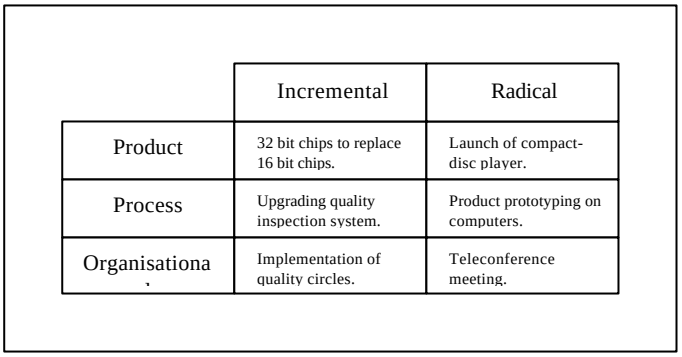


Figure 1: The dimensions and types of innovation

The key definitions underpinning the phenomenon of innovation have been reviewed. It is common to think of innovations as occurring only in high-tech environment. However, this notion is ill conceived. Innovation in products, processes and services can appear in all sectors of economic activity spanning from traditional to high-tech, public to market, industrial,

agricultural or tertiary. Many innovations are the result of new combinations of existing knowledge, new uses and creativity in product design. Nevertheless technology is increasingly becoming indispensable in terms of developing, manufacturing and distributing products and services (EC, 1995:4).

3.1.1 Diffusion of innovation

Without diffusion, innovation will not benefit society at large.

> "Diffusion is the way in which innovations spread, through market or non-market channels. Without diffusion, an innovation will have no economic impact." OECD (1992:10).

Advancement in products and processes are crucial for productivity improvement. The innovating firms are not the only ones that benefit from their innovations. When innovations are diffused, they contribute to higher productivity and higher standards of living for an economy as a whole. Therefore diffusion of innovations has an immediate impact on the well being of an economy.

Diffusion of innovation is favourable given that it help disseminate new techniques, products and services to the wider economy thus allowing the full benefit to be gained. The importance of diffusion has attracted vast amount of research interest in this area and there is a well-developed body of research looking at diffusion of innovations (see Rogers, 1983). As will be shown later in this review, diffusion forms one of the three main streams of research in innovation at the firm-level.

The main elements of the diffusion process are the *innovation* itself, the *population of potential adopters*, their *decision-making process* and the *flow of information* concerning the innovation between the manufacturers and the adopters. The key parameter used in the discussion of diffusion process is the *rate of diffusion*. This is the proportion of users who adopt the innovation against time. The rate of diffusion is different for different products. In

general, the greater the improvement that the innovation brings to the users, the greater the rate of diffusion. The lower the cost of the innovation the faster the rate of diffusion. Non-economic factors like the compatibility of innovation with current values and past experiences will also affect the diffusion rate. From a political perspective, large firms may influence the diffusion of an innovation by influencing consumer response through advertising or sales promotion. Hence the diffusion of innovations is influenced by the economic, social and political characteristics of a society.

3.2 Models of innovation

The literature review identifies various different models that attempt to explain how the innovation process works. It is useful to present the evolution of these various models and their limitations. Professor Roy Rothwell at SPRU[12] classified the models of innovation process into five generations[13]:

3.2.1 First generation: technology-push

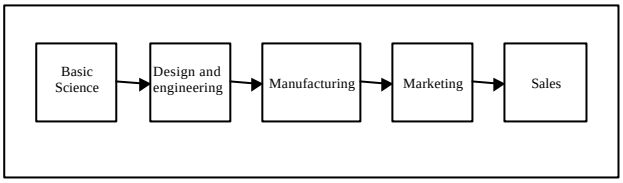


Figure 2: Technology push (1950s - mid 1960s)

The 1950s were a period of post-war recovery where demand exceeded production capacity. Economic growth came from new technological sectors. As such the dominant corporate strategy emphasised R&D and manufacturing. During this period, the predominant model of innovation was the technology-push model, also known as the linear model. In this model, innovation was interpreted as progressing from basic scientific research, to development, to manufacturing and marketing resulting in a stream of new products in the market. Essentially innovation was seen as a *linear process* with the key input being R&D.

[12] Science Policy Research Unit SPRU, the University of Sussex.
[13] See Rothwell (1994:40-50) for a full discussion.

The linear model implicitly assumes that the market is a ready sink for the output of R&D. Therefore more R&D would yield more innovations beneficial to the market and society at large. It is widely recognised now that this model is inadequate for depicting the process of innovation. Criticisms levelled at the linear model typically draw attention to two oversimplifications of the process of innovation: 1. The process is portrayed as "a series of watertight stages (rather than a to-and-fro process of interaction and feedback)..." 2. Too much emphasis is placed on R&D and "other inputs[14] to innovation are left in the background" OECD (1992:16).

The other major weakness of the linear model is the absence of *feedback paths*, within the development process and from the market. Informational feedback such as this is necessary to serve as inputs to ongoing performance evaluation of the firm. Kline and Rosenberg (1986:286) note that "the linear model distorts the reality of innovation… However, improved models have not yet come into widespread use. Consequently, the linear model is still often invoked in current discussions, particularly in political discussions."

3.2.2 Second generation: market-pull

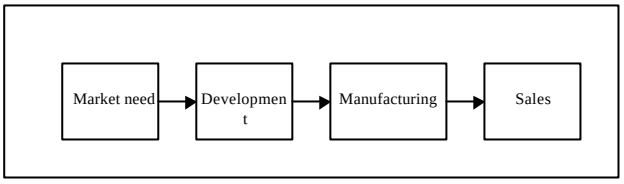


Figure 3: Market pull (late 1960s - early 1970s)

The latter part of the 1960s was an era of corporate growth. Companies were diversifying their product offerings to meet intensifying competition. There was a growing emphasis placed on marketing as a strategy. Innovation studies carried out during this period stressed the role of the market in the innovation process. Customer needs were seen to be driving the innovation process, hence the *market-pull* model.

[14] In particular the Frascati Manual – OECD (1981) emphasised 6 non-R&D activities important to the innovation process.

In the market-pull model, the key input to the innovation process is customer needs. The market was seen as a source of ideas for directing the activities of R&D. However, this model, like the linear model, neglects the other inputs that are necessary for successful innovations.

By putting market needs in the driving seat, the model fails to take into account the importance of linkages to the scientific and technological knowledge pool that are essential for innovation. The model also suggests a linear and sequential innovation process, that in practise rarely exists. Hence, it too suffers from the absence of the notion of informational feedback.

3.2.3 Third generation: coupling model

Numerous studies have concluded that the first and second generation models of innovation were oversimplified. In the 1970s, the explanation of the innovation process shifted towards the coupling model. Drawing on the coupling model, Rothwell and Zegveld (1985:50) described the innovation process as "a complex net of communication paths, both intra-organisational and extra-organisational, linking together the various in-house functions and linking the firm to the broader scientific and technological community and to the marketplace."

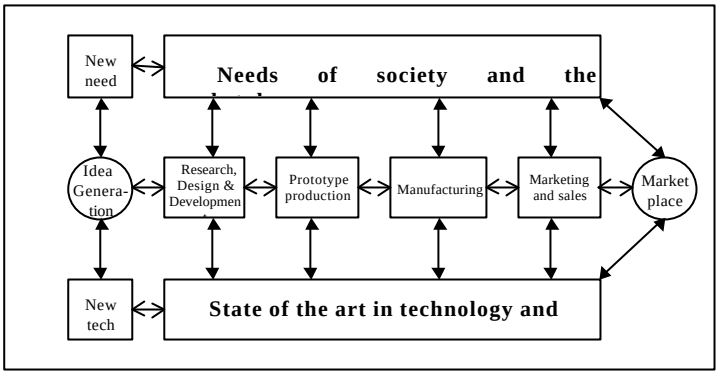


Figure 4: 'Coupling' model (mid 1970s - early 1980s)

The description draws attention to the importance of feedback, where *communication paths* link the *internal functions* of a firm to the *external knowledge pool* of the scientific and technological community and the market. In essence the process of innovation is influenced by the interactions of technological and markets forces. Though the notion of feedback is accounted for in this model, the dynamics of the process depicted are still very *sequential*.

3.2.4 Fourth generation: integrated model

The previous discussion suggests that innovation process is complex, non-linear and requires feedback. The extent to which the models represent reality as regards innovation process was seen to be increasing. However, all of the previous models depicted *sequential* flow of information. In the mid 1980s studies of the innovation process in the automobile and electronics sector in Japan provided an alternative model - the integrated model. It was found that the Japanese approach to product development was based around a high level of *functional integration* and *parallel* activities across functions, whereby information sharing in the form of joint meetings across functions were commonplace.

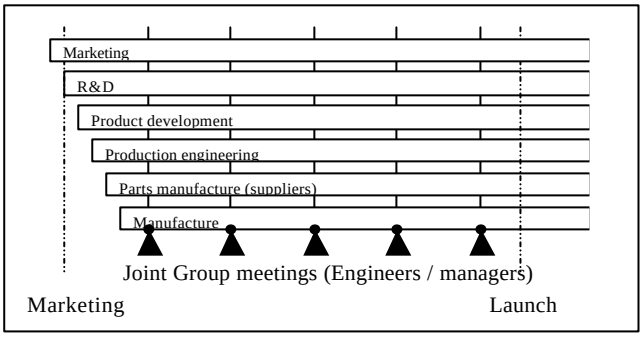


Figure 5: Integrated innovation process[15] (mid 1980s - 1990s)

This integrative and parallel nature of the 4G[16] model departs from the sequential information exchange depicted by the previous models. Scholars of Japanese product development processes have noted the advantages of the 4G model in promoting a more rapid and cost effective development process. The 4G model promotes parallel cross-functional development and more effective overall integration, which leads to higher information processing efficiency. A key element of competition in the 1980s was time to market. Many Japanese firms were able to maintain their competitive advantage by the very nature of their innovation process.

3.2.5 Fifth generation: systems integration and networking

[15] Example of the integrated innovation process – new product development process in Nissan. Source: Graves (1987) cited in Rothwell (1994:42).
[16] 4G – Fourth generation.

Innovation processes today resemble that of *networking processes*. This is a result of several key trends: increasing numbers of international strategic alliances and collaborative R&D relationships; the increasing awareness of supply chain management; networking relationships of SMEs with large firms and among small firms.

Professor Rothwell called the fifth generation innovation process the *systems integration and networking process* (SIN). This process is enabled by the use of electronic toolkits in design and development. The electronic toolkits may include simulation modelling, computer-based heuristics, inter-firm and intra-firm co-development using linked CAD/CAM systems, and EDI linkages between buyers and suppliers.

The 5G process of innovation is characterised by elements of systems integration and networking. System integration is made possible by the use of Information Technology (IT) to integrate the various functions within a firm. As regards networking, IT has enabled a firm to be connected to the outside world more effectively; for instance through the Internet, EDI[17] linkages to suppliers, Computer Aided Logistics Support (CALS) and integrated information system for supporting production, procurement and operation.

The firm's linkages to external networks and the relations to customers have been shown to be important to innovation activities in firm. (Von Hippel, 1988; Lundvall, 1988; Normann, 1991; Stevens, 1997). In particular, Stevens (1997:17) emphasises the importance of networking among firms and the role of competition in advancing innovation. Further, studies looking at the significance of geographical location to innovative capacity have identified networking as the key element in enhancing the innovative potential of firms. The 5G process of innovation is relatively new in the literature. This is an area where further research is required.

3.3 Levels of analysis

We have reviewed the key concepts of innovation and the various models for explaining the process of innovation. It is useful to point out that the phenomenon of innovation has been

studied at different levels of analysis. There are broadly three levels of analysis that are of interest to this review. They can be classified as firm-level, regional-level and national-level. What follows is a review of the literature with various levels of analysis.

3.3.1 Firm-level

In general the literature on innovation at the firm-level can be classified into three streams - *diffusion*, *organisational innovativeness* and *process theory* studies. Each deals with the phenomenon of innovation but they differ in terms of the research question, unit of analysis, and dependent variable used. They are reviewed and summarised in Table 1.

Research stream	Question	Innovation stage focus	Unit of analysis	Variables		Research model	Major data collection methods	Illustrative studies
				Independent	Dependent			
DIFFUSION	What is the pattern of diffusion of an innovation through a population of potential adopters?	Adoption	An innovation (extra-organisational focus)	Organisational characteristics Innovation characteristics Promoter characteristics	Diffusion pattern Diffusion extent Diffusion rate	Logistics growth model (based on contagion within the social system and/or 'change agent' influence from without)	Cross-sectional surveys Secondary data	Teece (1980) Easingwood et al. (1981) Norton and Bass (1987) Tolbert and Zucker (1983) Fisher and Carroll (1986) Attewell (1992)
INNOVATIVE-NESS	What determines organisational innovativeness?	Adoption or implementation	Organisational	Organisational characteristics Innovation characteristics Managerial characteristics Environmental characteristics	Innovativeness: - number or - speed of adoptions	Variance / regression models	Cross-sectional surveys	Kimberly and Evanisko (1981) Balbridge and Burnham (1975) Ettlie (1983) Moch and Morse (1977) Meyer and Goes (1988)
PROCESS: STEPS	What are the stages organisations go through in implementing innovations?	Adoption through implementation	Innovation process (Intra-organisational focus)	Innovation characteristics	Stage: - existence and/or - sequence	Stage models	Cross-sectional retrospective surveys	Pelz (1983) Ettlie (1983)
PROCESS	What factors explain the chain of events which result in innovation implementation?	Adoption through implementation	Innovation process (Intra-organisational focus)	PRECURSOR Organisational context -strategy -structure -resources -technological strength Organisational	OUTCOME The innovation process (its stages, sequences, divergent and parallel paths, feedback and feed forward	Process models	In-depth field studies	Dean (1987) Dyer and Page (1988) Schroeder et al. (1989)

Table 1: Distinguishing features of DI, OI, and PT[18] research. **Adapted from Wolfe (1994:413)**

Diffusion studies

[17] EDI – Electronic Data Interchange.
[18] DI – Diffusion studies; OI – Organisational innovativeness studies; PT – Process theory studies.

Diffusion studies focus on the explanation or prediction of rates and patterns of innovation adoption over time and space. The unit of analysis is the innovation in question. Typical data collection methods are survey questionnaire and retrieval of archival data. The research analysis focuses on the fitting of diffusion models to actual histories of diffusion.

Organisational innovativeness studies

Organisational innovativeness research looks at the factors that contribute to an organisation's tendency towards innovation. The unit of analysis here is the organisation itself. Data collection is typically of survey type. Research analysis focuses on explanation of variance in the dependent variable.

Process theory studies

Process theory research aims to explain the processes of innovation by looking at how organisations implement innovations. The unit of analysis is the process of innovation. Data collected are qualitative in nature. The focus is on theory building. These studies stress the implementation stages in introducing innovations into organisations. They complement diffusion research, which generally fails to study the implementation process.

3.3.2 Regional-level

At the core of the literature on regional innovation is the concept of 'innovative milieu'. Innovative milieu is a "complex network of informal social relationships within a limited geographical area which enhance the local innovative capacity through synergetic and collective learning processes" Camagni et al. (1997).

A growing body of research has emerged in the past decade looking at the significance of spatial elements to innovative behaviour[19]. Concepts such as 'territorial production system', 'industrial districts', 'regional innovation networks' and 'innovative milieu' continue to populate

[19] Most notably the work of 15 research teams under GREMI – Groupe de Recherché European sur les Milieux Innovateurs – since 1985 which aims to develop a common methodology and theoretical approach to the study of innovative behaviours and conducting comparable empirical studies. See Aydalot (1985).

the literature (Brusco, 1990; Beccatini, 1990; Sabel, 1989; Scott, 1988; Camagni, 1991; Maillat and Vasserot, 1988; Cooke and Morgan, 1990). This interest is in part a result of an attempt to explain innovative activities taking place in high-performing regional agglomerations such as Silicon Valley, Route 128, Baden-Wurttemberg and Emilia-Romagna to name a few.

Recent attempts to explain the innovative success of firms in these regions draw attention to two mechanisms by which the milieu enhances the innovative capacities of firms. First, regional agglomeration facilitates a *collective learning process* whereby information, knowledge and best practise are diffused rapidly throughout the local milieu, thus increasing the innovative capacities of firms. Second, a *dynamic uncertainty reduction* mechanism[20] is in place, due to the presence of a localised production system wherein costs and risks of innovation is spread throughout the region via buyer-supplier networks, technology transfer agencies, trade associations and training consortia – the soft infrastructure.

Prior to a spatial perspective on innovation, the phenomenon of innovation has always been depicted as a product of an individual or a firm with little regard to the surrounding environment of the firm. The empirical studies conducted by GREMI demonstrate that innovation and technological development is more a product of an exchange among different agents – a product of network – than that of an individual firm. Thus to analyse the process of innovation, one has to examine the mechanisms at work in the whole of the *firm-environment system*. In short, innovation "is not produced by one isolated enterprise; it is the result of an organisation built on interdependencies between territorial and extra-territorial elements" Crevoisier et al. (1991).

The concept of 'innovative milieu' has led to a new perspective of explaining innovative behaviour. The milieu restores the importance of social elements in explaining the process of innovation. As such innovation is now seen as a collective learning process reinforced by "such social phenomena as intergenerational transfer of know-how, imitation of successful managerial

practises and technological innovations, interpersonal face-to-face contacts, formal or informal cooperation between firms, tacit circulation of commercial, financial or technological information (Camagni 1991:1).

3.3.3 National-level

The national systems of innovation (NSI) is an interactive collection of institutions that support innovative activities within a country (Lundvall, 1992; Nelson, 1993). NSI plays an important role in directing and supporting the processes of learning and innovation; Chris Freeman (1987) first introduced the notion of 'national systems of innovation' to explain the differences in economic performance between countries particularly the success of post-war Japan. Studies in this field are further advanced by the work of Lundvall (1992) and Nelson (1993). The key essence of the NSI is the view that nation-specific factors are the drivers of technical change and thus innovation. Archibugi and Michie (1997) explain this: "some of these factors are institutional, such as education, public support to industrial innovation, and defence-related technology schemes. Others are rooted in history, and concern the culture, size, language and vocation of a nation".

The concept of NSI is useful in thinking about the variation observed among countries as regards their successes in innovation. Studies that seek comparison across national systems are numerous. These comparative studies are characterised by qualitative or quantitative approaches. Studies that are qualitative in nature include (Nelson, 1993; Freeman, 1987; Porter, 1990). Quantitative approaches tend to measure cross-country variation in a number of indicators like resources devoted to R&D, relative importance of public and business sectors, level of national integration and distribution of innovations across sectors (Archibugi and Pianta, 1992; Amendola, Guerrieri and Padoan, 1992; Patel and Pavitt, 1991).

[20] The milieu acts as a collective operator reducing the degree of uncertainty for firms by organising the functional and informational interdependence of local actors and informally performing the functions of search, signalling, selection, transcoding, transformer and control (Camagni 1991:132).

Archibugi and Michie (1997) summarise the literature on NSIs and draw out several key aspects that define the structure and explain the behaviour of national systems of innovation:

> "Education and training;
> Education and training are vital components of economic development. In spite of the international diffusion of education and of the increasing number of students enrolled in foreign universities, education is still largely national in scope.
>
> Science and technological capabilities;
> The level of resources devoted by each nation to formal R&D and other innovation-related activities (such as design, engineering, tooling-up, and so on) represents basic characteristics of NSIs.
>
> Industrial structure;
> Firms are the principal agents of technological innovation. The industrial structure of a nation heavily conditions the nature of its innovative activities.
>
> S&T[21] strengths and weaknesses;
> Each country has its own strengths and weaknesses in different S&T fields.... There are several determinants of national S&T specialisation, including the size of a country, R&D intensity, market structure and the international division of labour. The resulting S&T specialisation may influence a nation's future economic performance…
>
> Interactions within the innovation system;
> The propensity of the different institutions to co-ordinate their activities and to interact with other actors differs widely between countries. Governments do interact heavily with large domestic firms… In other countries, small firms have been keen to share their expertise and co-operate in developing a common competitive strategy… Such interactions are often able to multiply the effects of innovation undertaken at the country level and increase its diffusion. Its absence can hamper substantially the economic effectiveness of resources devoted to S&T.
>
> Absorption from abroad.
> Some countries, especially in the Third World, have benefited from the bilateral technology transfer. A general lesson drawn from recent research, however, confirms… that no technology transfer can be effective without an endogenous effort to acquire that knowledge…"
>
> Archibugi and Michie (1997:8-10)

The large body of NSI literature provides useful insights into the differences across countries in terms of their innovative capacity. However, "we are still far from having achieved a coherent

conceptual and empirical framework within which to explain the variation among countries in their success in innovating" contend Arghibugi and Michie. That said, the concept of NSI provides a solid foundation for cross-country comparative studies in innovation.

3.4 The constructs 'innovativenes' and 'innovative capacity'

3.4.1 What is innovativeness?

3.4.1.1 Individual-level innovativeness

In its original sense, innovativeness was defined as "the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than the other members of a system" Rogers (1962). Initially the concept was used for analysing innovation at the level of the individual. Looking at the propensity of an individual to adopt new ideas compared to his/her peers. Members of a social system are classified into five adopter categories based on individual's innovativeness: innovators, early adopters, early majority, late majority and laggards. Thus innovativeness was first explored at the individual level in diffusion studies.

3.4.1.2 Firm-level innovativeness

The construct *organisational innovativeness* soon emerged when researchers started looking at the organisation as a unit of adoption. These studies were met with criticisms on two grounds. First, most organisational innovativeness studies measured the dependent variable of innovativeness based on the number of adoption of innovations and then constructed a composite score to indicate the overall innovativeness of an organisation. This type of analysis oversimplifies the complex nature of the sources of innovation. Second, these studies typically gathered data from top executives of organisations which does not provide a true measure of the entire organisation's behaviour as regards innovation.

[21] Science and technology (S&T).

The determinants of organisational innovativeness are not well understood; it is noted in the literature that at least three sets of factors influence innovativeness. These include *organisational characteristics, managerial characteristics* and *environmental characteristics.*

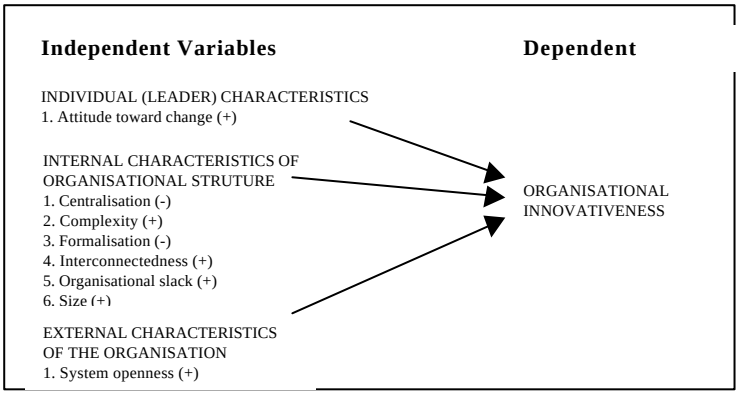


Figure 6: Independent variables related to organisational innovativeness

Source: Rogers (1995:380)

In line with the literature, we define innovativeness as "*the propensity to innovate*". Depending on the unit of analysis, the notion of innovativeness is applicable to the individual and also the firm.

3.4.2 What is innovative capacity?

The innovation literature does not provide an extensive coverage of the concept of innovative capacity. There is an issue of inconsistent semantics in relation to the concept. The terms *innovative ability, innovative capability, innovative competence* and *absorptive capacity* seems to all relate to the same concept of innovative capacity.

There is some consistency when the literature refers to the ability of a *region* to innovate. The term innovative capacity is interpreted as the ability of the region to generate innovations. This is evident in work that addresses the need to improve the innovative capacity of a society or region.

"…innovative capacity of a society - the innate ability to create innovations" Herbig et al. (1994:50)

"Enhancing the capacity of individual firms to participate in innovative activity, however, is no longer seen as sufficient. Policy is now turning to encouraging the development of indigenous regional innovative capacity" EC (1997:16)

However when the literature focuses on the ability of a *firm* to innovate, innovative capability is often cited.

"The ability of a firm to recognise the value of new external information, assimilate it and apply it to commercial ends is critical to its innovative capabilities" Cohen and Levinthal (1990)

"If firms are to survive and prosper in the 21st century, they must assess their innovative capabilities and take strategic action to improve their innovation skills" Higgins (1995:34/5)

We do not believe that an authoritative definition exists as regards the ability to innovate. For the purposes of this report the following definition will be used. *"Innovative capacity is the potential of a firm, a region or a nation to generate innovative outputs."*

George Papaconstantinou, an economist with the OECD spells out the factors that influences innovative capacity of a firm:

"The capacity of firms to innovate depends on a multitude of factors, not least the efforts they make to create new products or improve production processes, the extent of skills in their work force, their ability to learn, and the general environment within which they operate."

Papaconstantinou(1997:6)

The innovative capacity of a firm can be thought of as a *potential* of that firm to generate innovative output; this potential is dependent on the synergetic interrelationships of the *culture* of the firm, *internal processes* and *external environment* (see Figure 7).

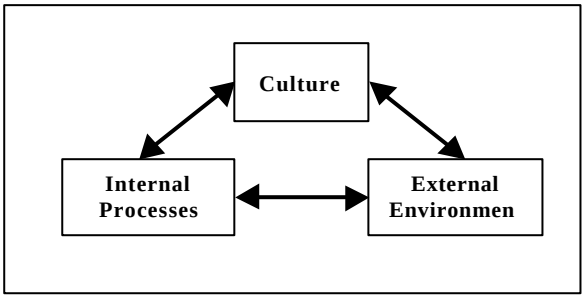


Figure 7: The dimensions of innovative capacity.

The key dimensions of innovative capacity are in line with the findings of a study carried out by CBI and DTI on the performance of UK-based companies in innovation[22]. The CBI/DTI study in particular identified the following as key success factors that best practise companies[23] demonstrate:

1. Culture

A clear sense of mission and purpose is common among innovative companies. Their strategy is well thought out and clearly articulated. Innovation is a coherent part of their strategy. The business philosophy is one of continuous improvement driven by total customer satisfaction and total quality management.

Innovative companies adopt an open, multi-functional and multi-level team-based working approach towards project and problem-solving. Employees are empowered from the lowest levels. In terms of leadership, the chief executive demonstrates a personal commitment to innovation, possesses vision and enthusiasm and encourages risk-taking and change. Constant communication with customers, suppliers, investors and employees are the norm. The organisational structure of innovative companies is flatter in general. The environment is one of openness and feedback from the stakeholders is constantly solicited.

2. Internal processes

Idea generation and capture

Innovative companies constantly generate and capture new ideas. Employee suggestion schemes are instituted as a mechanism for capturing internal ideas. Successful ideas are rewarded and failure is regarded as part of learning process. Externally, innovative companies look to customers and

[22] See CBI/DTI (1993) for a full report on the findings; CBI Technology Group and DTI Innovation Unit carried out the study during 1992. The assessment of the companies was based on structured interviews. Chief executives and senior managers of 76 companies across different sectors, sizes and types of company were interviewed. Manufacturing to services ratio was 3:1.

suppliers as potential source of ideas. Contacts between R&D, design and production, sales and marketing and customers are encouraged.

Review and implementation

Screening procedures are in place for identifying priorities among projects to ensure sufficient resources are channelled to driving the best ideas through fruition. This screening process typically involves the relevant functions such as R&D, production, sales and marketing and customers as well. Projects with spin-out potential are also identified in the review. The review serves as a forum for addressing existing developments and issues that may impact the firm at some point in time. In terms of implementation, innovative companies typically appoint project champions and multi-layered, multi-functional teams to drive projects.

Performance measures

Innovative companies constantly review their progress by measuring against milestones set. Clear targets are set and competitors benchmarked in the areas of customer satisfaction, sales trend and market share, product development times, number of new product introduced and R&D.

Training

The skills content of staff at all levels are crucial to the ability to innovate. Continuous training and development of staff at all levels are common to innovative companies.

3. External environment

Customers, competitors, suppliers

Innovative companies are proactive in their approach towards customers. Customer satisfaction is their key performance driver. They know their markets and benchmark performance against competitors and the world's best in class regardless of functions. These innovative companies develop strong supplier relationship and are actively involved in partnership sourcing[24].

Strategic partners

Innovative companies seek active collaboration with other companies and academia to maximise knowledge and minimise risk.

Investors

Investors play a crucial role in the innovation process. Innovative companies hold regular dialogue with investors informing about their innovative activities and ensuring confidence and long term relationships with investors.

[23] Best practise companies refer to those surveyed firms that are considered to be truly innovative.
[24] Partnership sourcing – working closely with a set of preferred suppliers.

Government

Innovative companies tend to regard regulation (not over-regulation) in a positive manner. They are aware of proposals for legislation which might affect them and participate in standard-setting and influence regulatory procedures. They tend to work in partnership with the government.

We have distilled from the literature the key factors that influences the innovative capacity of firms. These factors can be classified into 3 dimensions: *culture and leadership*, *internal processes*, and *external influences*.

As regards innovative capacity of a region, there are elements that are of relevance. We have already dealt with some of these key elements in the review on the concept of innovative milieu. The literature informs us that innovative capacity of a region is contingent on factors including education and training, science and technological capabilities, industrial structure, institutional interactions and networking, and absorption of knowledge from abroad. A clearer understanding of these factors can only emerged with further empirical studies looking at the determinants of regional innovative capacity.

3.5 Summary

This section has dealt with the notion of innovation. The key concepts crucial to the understanding of the process of innovation have been reviewed. The following are the main points that emerged from the review:

What is innovation?

- *Innovation is the successful exploitation of ideas.*
- *The main characteristic of innovation is change.*
- *The three dimensions of innovation are product, process and organisational.*
- *Innovation can be of incremental or radical type.*
- *Innovation is not restricted to high-tech environment only. It appears in all sectors of activity.*

- *Diffusion of innovations leads to higher productivity and higher standards of living for the economy.*

Models of innovation

- *The models of innovation process can be classified into five generations.*
- *The linear-model of innovation is inadequate in depicting the complex process of innovation.*
- *Innovation process is complex, non-linear and requires feedback.*
- *Networking is the key element in enhancing the innovative potential of firms.*
- *The firm's linkages to external networks and the relations to customers are important to innovative activities of the firm.*

Levels of analysis

- *In general, the phenomenon of innovation can be analysed in three levels: firm-level, regional-level and the national-level.*
- *The concept of innovative milieu is useful in explaining the innovative success of firms within a geographical region.*
- *The milieu enhances the innovative capacities of firms through two mechanisms – collective learning process and uncertainty reduction process.*
- *Innovation is a product of network, an exchange among different agents.*
- *To analyse innovation, the whole of the firm-environment system should be the unit of analysis.*
- *The concept of national innovation system views nation-specific factors as drivers of innovation.*
- *Factors such as education and training; science and technology capabilities; industrial structure; interactions within the innovation system, and knowledge adsorption from abroad affects the innovative capacity of a nation.*

The constructs ‘innovativeness’ and ‘innovative capacity’

- *The concept of innovativeness relates to the propensity of an individual or a firm to innovate.*
- *Firm innovativeness is influenced by three sets of factors: organisational characteristics; managerial characteristics and environmental characteristics.*
- *Innovative capacity is the potential of a firm, region or nation to generate innovative output.*
- *Studies show that at firm-level, innovative capacity is influenced by three dimensions: firm culture; internal processes; and external environment.*

4 INNOVATION AND PERFORMANCE

The last section dealt with the key concepts underpinning the notion of innovation. As stated in the Introduction, the ability to innovate has a direct impact on the competitiveness of a firm and thus its performance. In this section, the literature review will focus on the impact of innovation on business performance. Other issues of interest at regional-level will also be dealt with.

The ensuing discussion is structured as follows. First, a discussion of how innovation can lead to better business performance is provided. Second, evidence demonstrating a linkage between innovation and business performance is presented. Studies that explore the relationship between innovation and business performance are reviewed. Third, the issue of how innovations can be measured is considered. Here the difficulty of measuring a multi-dimensional construct is discussed. Fourth, the various means of collecting data for innovative activities is addressed. Two comprehensive approaches are presented.

In summary, the particular questions tackled are:

- What empirical evidence exists to show the link between innovation and business performance?
- Are there any studies that address the innovative capacity of a region and its economic performance?
- How can the output of innovative activities be measured?
- What are some of the means of collecting data on innovative activities?

4.1 The link between innovation and business performance

4.1.1 Innovation transforms internal capabilities of firm

Anecdotal evidence suggests that innovation is closely linked to business performance. But how is innovation associated with superior performance? Geroski (1994:130) suggests that there are

two alternative views. The first view holds that the production of new products or processes strengthens a firm's competitive position in relation to its rivals. But the profits and growth will be transitory and only last as long as the innovating firm can defend its position against rivals. The second view argues that the process of innovation transforms a firm fundamentally by enhancing its internal capabilities, making it more flexible and adaptable to market pressures than non-innovating firms.

Hence, innovation enhances business performance because the product of innovative activities makes a firm more competitive and the process of innovation transforms a firm's internal capabilities.

4.1.2 Innovation is necessary but not sufficient for business performance

Given that innovation can yield positive benefits for businesses it seems plausible to conclude that innovation equates to business performance. The literature reviewed suggests that such an assertion is flawed. It should be emphasised that business performance is not an outcome due *solely* to innovation. Success or failure in innovation should be viewed as a necessary but not sufficient *cause* of business performance and survival. The performance of business is dependent on a wide range of factors that are not susceptible to simple conception.

The following discussion will focus on some of the empirical evidence which bears out the impact of innovation on business performance.

4.2 Empirical evidence showing the link

4.2.1 Firm-level

An empirical survey carried out by the Cambridge Small Business Research Centre (SBRC) provides useful insights into SME[25] innovative behaviour in the UK[26]. During the study data

[25] SME – Small and Medium Enterprise.
[26] See SBRC (1992).

were collected from more than 2000 SMEs on a range of issues relating to technology and innovation. This is by far the largest and most authoritative empirical survey.
The research found that 60% of the sample had initiated a major product or service innovation in the last five years. The results suggest that SMEs are highly innovative across sectors.

The survey did not measure inputs, such as: innovation cost, proportion of resources consumed and the efficiency in resource usage, and outputs such as: impact on firm performance, market share and profitability. Therefore, it was not possible to quantify the relationship between *innovative effort* and *innovations*.

This is not surprising given the difficulties of quantifying a multi-dimensional phenomenon like innovation. It is common that clear paths of causation are not easily mapped. However the results of the survey do suggest a broad correlation between *innovation* and *business performance*. The survey in particular draws out some salient differences between innovating and non-innovating firms.

Further evidence of this correlation can be found in the CBI/NatWest Innovation Trends Survey, conducted annually since 1989. This survey is the key indicator of corporate attitude towards innovation in the UK.

In 1997 the survey shows that 80% of the companies who initiated innovations in the last 3 years improved their business performance in terms of *profits*, *market share* and *new markets penetration* (CBI/NatWest, 1997:17). The results have been consistent for the past 3 years.

This survey collects data not only on technical innovations in the manufacturing sector, but also polls the non-manufacturing sectors. The key characteristics of innovation in UK companies are measured from a broad range of information (innovation inputs, external links, innovation outputs, influences on innovation and innovation resources). The survey suggests that innovations have led to improved business performance.

Other studies such as Franko (1989) demonstrate the link between R&D expenditure and subsequent sales revenues of a firm. It was shown by Geroski et al. (1992) that innovating firms are able to achieve larger market share and higher growth rates and profits. A major research project[27], focusing on the relationship between technological factors (measured by R&D and patents) and economic indicators (productivity and stock market value), has shown that the technological performance of the firm is positively associated to its market value. Similarly a number of studies (Acs and Audretsch, 1992 using innovation counts; Simonetti, 1994 using patent indicators) have confirmed that technology and performance are associated; they also emphasised the fact that it is not easy to establish a causal link from the former to the latter variable (Archibugi et al. 1994:13).

4.2.2 Regional-level

A recent study of Italian SMEs by Camagni and Capello (1997) throw light on some key questions relating to the impact of innovation on regional economic performance. Their study aims to provide some answers to the following research questions: (a) Is it true that regions with a high share of small firms perform better? (b) Is it true that small firm regions innovate more than large firm regions? (c) If small firms innovate more than large firms, where do they obtain the innovation assets?

The study maps out the economic performance of each region in Italy. Specifically, two indicators *employment growth* and *productivity growth*[28] are recorded for each region. The findings indicate four possible patterns of regional performance: (1) *virtuous circle* where a higher than average productivity growth generates good performance in both employment and economic output. (2) *restructuring* where a higher productivity growth is achieved by severe employment cuts leading to good output performance. (3) *deindustralisation* where a vicious cycle of employment cuts erode competitiveness leading to perpetual job losses and low output

[27] Research project developed by the National Bureau of Economic Research. See Griliches (1990).
[28] Productivity growth were measured in terms of value added per employee.

growth. (4) *industrial take-off* where regions grow in employment terms notwithstanding a low performance in productivity.

The study shows that (in the case of Italy) regions with greater share of small firms are not necessarily characterised by better performance and employment growth. Some regions achieve good performance through severe cuts in employment.

As regards the second question whether small firm regions innovate more than large firm regions, the findings suggest that there is homogeneity within each region. The innovation rate of firms seems to be consistent within each region regardless of size of firms.

Cluster analysis, which aims to obtain regions with similar behaviour in terms of various characteristics defined[29] yielded four main clusters – *innovative high-tech area*; *innovative traditional firms area*; *traditional small firms area*; *large firm lagging area*.

The main findings of the study lie in the identification of various possible patterns of regional performance, cluster analysis of regional innovative behaviour, and the effect of size on innovation. The data show that innovative regions typically perform better. As regards the question of where small firms obtain their innovative inputs, the authors contend that it remains an open question.

Many studies in the literature have looked at the linkage between innovation and business performance, either directly or as part of a larger study. The results of these studies seem to suggest that there is a close link between innovation and business performance. In general there is clear evidence that innovation play a crucial role to long term profitability and growth in firms (Geroski et al. 1992; Cosh and Hughes, 1996).

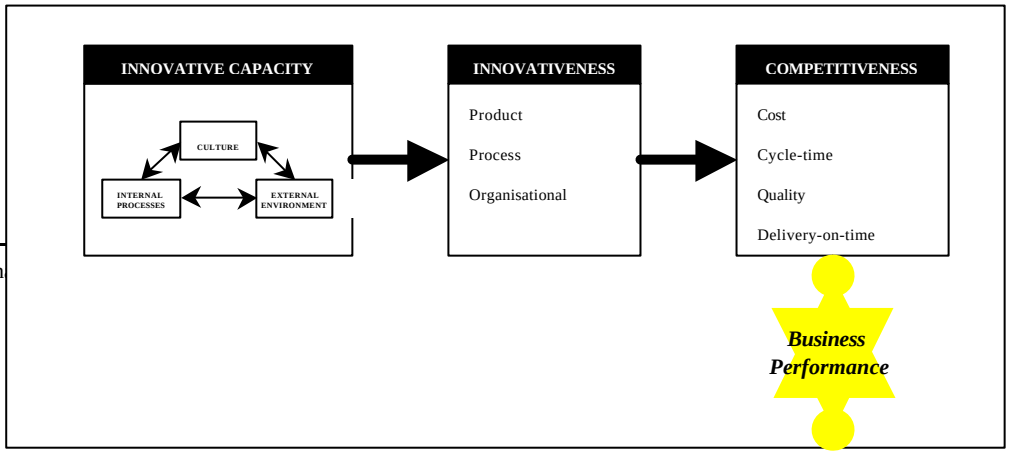
[29] Variables used include: industrial productivity, patent intensity, high-tech firm concentration, industrial structure of region, R&D expenditure, innovation rate. See Camagni et al (1997:15) for a full list.

Nonetheless, research suggests that being innovative is only *one* of the many ways to achieving enhanced business performance. This view is expressed in the NSF[30] report:

> "…neither empirical nor theoretical evidence sustains such a direct relationship between organisational innovativeness and organisational health… Success or failure in innovation is valuable, but it is usually a necessary but not sufficient cause of organisational growth and survival." Tornatzky et al. (1983:31)

In discussing the link between innovation and business performance, one should consider the process of innovation in its totality (See Figure 8). The innovative capacity of a firm determines its level of innovativeness which has an impact on its competitiveness vis-à-vis its competitors. A tangible result of increased competitiveness is enhanced business performance.

Only when all the key elements that affect innovative capacity are in synergy can new ideas be successfully exploited leading to enhanced performance. This is in line with the main finding of the CBI/DTI study. In theory, good business performance feeds back into increasing the innovative capacity of the firm which then enhances the innovativeness and hence competitiveness resulting in better business performance. In practise, a whole host of interrelated factors are involved in the innovation process. For instance, the environment of the firm plays a crucial part in determining whether its innovative capacity is high. This environment is in turn shaped by factors such as the macro-economic framework and the support mechanisms available in the vicinity of the firm. Other factors that come into play include the internal processes of the firm and the culture embedded within the firm. The dynamics of all these factors are poorly understood and beg further research to establish the robustness of the model distilled from the literature (Figure 8).



[30] Nation

Figure 8: Innovative capacity, innovativeness and competitiveness

In this section, we have tried to establish the linkage between innovation and business performance by collecting evidence from the literature to test this linkage. On the basis of the literature reviewed we conclude that innovation has a positive effect on business performance.

4.3 Measurement of innovative activities

Given that innovation has a positive impact on business performance, the next question is how can the impact be quantified? Innovation research has been subjected to rigorous empirical enquiry since the 1960s. However, the measurement of innovation is still clouded with statistical and conceptual problems. The literature reviewed suggests that most of the carried out in the area of innovation performance measurement is technically biased. This is not surprising given the fact that most studies look at innovation from the R&D perspective. Studies into measurement of innovation performance in the service sector are still relatively rare[31].

4.3.1 Common measures

The most commonly used measures of innovative activities are: *R&D expenditures*, *patent counts* and counts of major or minor innovations (*innovation counts*). As regards technical innovation, there is a tendency to use R&D statistics as metrics of performance. The advantages of using R&D statistics are twofold: first, data on R&D are readily available; second, most of the R&D indicators are standardised across countries[32].

[31] For a recent review of indicators of innovation see Tidd et al. (1993).
[32] See OECD (1997), "Science, Technology and Industry: Scoreboard of Indicators1997".

R&D expenditures

In terms of innovation in general it should be emphasised that R&D expenditures measure only one part of the total input to the innovation process. Non-R&D inputs[33] are crucial to the successful exploitation of new ideas. Further, data on R&D may not be relevant to companies without a R&D function, as Geroski (1994) explains: "…R&D is not obviously an essential input into the production of innovations: plenty of firms have introduced major or minor innovations despite the lack of a formal R&D lab or a specific accounting of R&D expenditures".

Patent counts

Patent counts do not reveal the full picture of innovativeness as well. Patents protect ideas, as such they are an intermediate outputs in the process of innovation. Also patent counts reflect the propensity to patent, not the actual innovations. This propensity may vary across firms, industry sectors and countries. Hence it is generally agreed that patent counts are highly correlated with research inputs, but not necessarily innovative outputs (Griliches, 1990).

Innovation counts

Innovation counts measure the output of the innovation process. As such they depict a fairer picture of the results of innovation. However, two interrelated issues emerge when one tries to analyse a sample of innovations. First, the unit of measurement has to be chosen so that like is compared with like. A count of two for instance should be twice as much as a count of one. This is hardly ever achieved in practise for innovations are context-specific. The impact of one innovation may be quite different from another. Studies in the literature circumvent this issue by concentrating on samples of innovations of similar significance – major innovations for instance. This give rise to the issue of selectivity. By focusing on major innovations alone, minor innovations are left in the background when the total innovative activity is of interest.

[33] Non-R&D activities: new product marketing, patent-related work, financial and organisational change, design engineering, industrial engineering and manufacturing start-up.

4.3.2 Difficulty of measuring innovative activities

The main problem with measuring innovation stems from the fact that it is a multi-dimensional phenomenon. Also innovation is context-specific making comparability of data difficult. An innovation in paper-clip design versus an innovation in microprocessor design has very different economic impact, but they both may be recorded as an innovation count.

The most widely recorded source of innovation is R&D. As already emphasised in this review, there are other non-R&D inputs which are crucial to the innovation process. Some of these have not been measured and some are not measurable.

We have reviewed some of the most common metrics used for measuring innovative performance in the last section. Given the gaps in current knowledge about the innovation process, a simple and uncontroversial measure of innovation is hard to conceptualise. The metrics used by academics, practitioners and governments are all imperfect; they only capture various parts of the whole innovation process.

The difficulty of measuring innovation is also expressed in CBI/DTI report on Innovation:

> "Innovation is widely acknowledge to be difficult to measure, but best practise companies institute formal performance targets and milestones for achievement along the way, relating to different aspects of the innovation process.
>
> A top priority is to assess customer satisfaction - monitoring of service levels and complaints with a view to driving out the possibility of a recurrence of problems. Targets for increasing market share and number of new product introductions, reductions in product development times and faster delivery from order, are common.
>
> R&D investment is appraised in relation to the number of new products introduced and benchmarked against that of competitors." CBI/DTI (1993:14)

4.3.3 Innovation performance measurement framework

Recent research into measurement of innovation has provided some useful frameworks[34] for a balanced assessment of the innovativeness of a firm. In particular, the DTI/LBS framework provides a practical self-assessment tool for companies wishing to install performance measures for tracking innovation performance (Voss et al., 1993).

The tool has been used for auditing a firm's innovative capacity. The strength of the audit framework lies in its process approach. A methodology that combines *performance measurement* (highlighting problems and needs) and the use of information to generate *action plans* for performance improvement. The tool seeks to address the managerial processes and organisational mechanisms through which innovation is generated (Chiesa et al., 1996). The benefits of this tool include the following:

- The identification of the processes that drive innovation, combining the *core processes* (product generation, product development, production process innovation, and technology acquisition) and the *enabling processes* (leadership, human, and financial resource management, the adoption of systems and tools for innovation).
- The development of performance measures for each of the process of innovation such that the overall impact of innovation on competitiveness can be assessed.
- Allowing companies to audit their innovative capacity by measuring the overall innovation performance and the performance of each innovation process. Auditing innovation processes and benchmarking against world class practise.
- A balanced assessment through a combination of performance and process audit approach using both qualitative and quantitative measures.

A summary of the key measures is provided in Table 2.

[34] Chiesa et al. (1996) provides extensive coverage of the development of the framework.

DIMENSION	DATA TYPE	METRICS
Product Innovation	Absolute, trend, versus competition	-No. of new product ideas -% sales/profits from products 3(5) yrs old -Market share -Product planning horizon
Product Development	Versus plan, versus existing products, absolute, trend, versus competitors	-Time to market -Product performance -Design performance
Process Innovation	Versus plan, absolute, trend, versus competition	-Process parameters, cost, quality, WIP levels, lead time etc. -Installation lead times -No. of new processes -Continuous improvement -Progress to lean production WIP, lead times, quality
Technology Acquisition	Versus plan, absolute, trend, versus competition	-No. of licenses in/out over last 3 yrs -No. of patents over last 3 yrs -% R&D projects leading to successful new or enhanced products/processes/licenses
Leadership	Absolute, trend, versus competition	-No./% of members from product development/technical function -% of employees aware of company innovation policies and values -No. of pages in annual report devoted to innovation/technology
Resourcing Innovation	Absolute, trend, versus competition	-% of projects delayed, cancelled because of lack of human resources -% of personnel in product development who have worked for more than 1 / 2 functions -% of projects delayed/cancelled due to lack of funding
System & Tools	Absolute, trend, versus competition	-% of designers/engineers with access to CAD screens -% of products of CAD database -% of products produced on processes with SPC -% of designers trained in design for manufacture -% of development projects using BS5750 certified processes

Table 2: Table of measures for assessing innovation performance **Adapted from CBI/DTI (1993:27-28)**

4.3.4 Importance of measuring innovative activities

From the literature reviewed, we conclude that there is no one best way to measure the performance of innovation. A particular firm's set of measures may not be useful for another. A sound principle in this regard is to draw on practical frameworks and install a broad range of measures for a well-balanced perspective. The importance of measuring innovation performance is twofold. First, the information derived from measurement serves as feedback on a firm's current standing in innovativeness[35]. Second, the gaps in performance trigger a systematic process of continuous improvement. Without performance measurement, the process of innovation will not be managed effectively and improvement will be sporadic.

The literature on the measurement of innovative activities has been reviewed. The various means of collecting data on innovation will be reviewed next.

4.4 Means of mapping innovation

Patents and innovation surveys are two of the most common means of collecting information on innovative activities of firms. These two data collection methods will now be reviewed. The review on this section is drawn largely from a background paper to the OECD workshop on innovation, patents and technological strategies (See Archibugi et al., 1994).

4.4.1 Patent analysis

Firms take out patents as a means to protect their inventions. Patent data are readily available[36] and the conceptual and operational tools for using this data are well-documented (See Patent Manual - OECD, 1994). The number of patents registered by firms give an indication of their innovative activities. Therefore patent analysis is useful for mapping innovative activities of firms. That said, there is an issue of fitness of use. Studies have shown that patent analysis is more useful for large firms as their propensity to patent is higher than small firms. Therefore patent analysis do not provide an accurate account of innovative activities across firms of different sizes. Further, it has been shown that the standard R&D surveys tend to underestimate the

[35] Data can be collected through performance measurement system or as part of a benchmarking process.

amount of R&D carried out by small firms (Kleinknecht, 1987; Kleinknecht and Reijnen, 1991).

A review of the advantages and disadvantages of patent analysis is in order. In terms of the advantages, first, patents are a direct outcome of the inventive process; patents filed are usually of inventions with expected business impact, as such they are a good indicator of the competitive dimension of innovation. Secondly, patents are classified by technical fields. This provides useful information on both the rate of inventive activity and also its direction. Thirdly, patent statistics are readily available in large numbers and stretch over a long time series.

But patent analysis suffers from a few disadvantages. First, not all inventions can be patented and not all inventions are patented. Some firms resort to industrial secrecy as a protection. Secondly, the propensity of firms to patent varies across industries. Thirdly, the protection accorded to the inventor varies across countries. This affects the intent of inventors to apply for patent protection.

We have seen the advantages and disadvantages of the use of patent data as a gauge of innovative activities of firms. We now review another approach of collecting data on innovative activities, the use of innovation surveys.

4.4.2 Innovation surveys

The Oslo Manual provides the guidelines on the methods and questions to be included in innovation surveys[37]. In general there are two approaches to collect information on innovative activities. The first approach, the *object approach*, collects information at the level of individual innovation. The second approach is the *subject approach* which collects information at the level of the firm.

[36] Government agencies and companies have collected or produced information on sources of innovation typically technological indicators and statistical data.

4.4.2.1 Object approach

The unit of analysis in the object approach is the individual innovation itself. The approach is similar to patent analysis, both are concerned with counting innovations. However, there is a distinction in terms of the sampled population. Patent analysis works with a well-defined population (inventions which are registered). Innovation survey at the individual level (object approach) works with an uncertain population of innovation counts. Most databases of innovation surveys in practise do not claim to have collected a statistically significant sample. Hence the object approach of survey monitors a lower amount of observations (less breadth) than patents but they record a larger amount of information for each innovation (more depth).

The advantages and disadvantages of the object approach will now be reviewed. The advantages are: first, they represent a direct measure of innovation as only those innovations that are considered to have significant economic and/or technological impact are recorded. Secondly, the evolution of technology can be traced as this approach captures information on when and how a certain innovation was introduced.

The disadvantages are twofold; firstly, the definition of the sample is arbitrary. It is based upon the assessment of experts, and experts' perceptions can vary in practise. Secondly, there is difficulty in developing comparable databases internationally. There is no standardisation in terms of survey design, sample definition and implementation process.

4.4.2.2 Subject approach

In the subject approach, firms are surveyed on the inputs, outputs and characteristics of their innovative activities. A wider range of topics is covered by this approach compared to the patent analysis or the object approach. Factors hampering innovation can also be solicited from the non-innovators.

[37] Oslo Manual – OECD (1992).

The OSLO Manual in particular has highlighted the limitations of the object approach. As a result of these inherent weaknesses and recent developments in harmonised Community Innovation Survey in Europe, the subject approach has become the standard method of collecting information of innovative activities in industry.

The main advantages of this approach are as follows: it provides a balanced coverage of innovators and non-innovators allowing for factors hampering innovation to be explored. The information collected can also be related to industrial structure, for instance data on innovation can be matched to economic data on production, value added, and employment figures. Information on generators and users of innovations can also be collected. This means that the service industries can be surveyed together with the manufacturing industries.

However, the approach is not without disadvantages. These include: the difficulty of gathering internationally comparable data. Also, this method does not collect information on the nature of the innovations introduced in firms. Since the use of this approach is still fairly new, time-series comparisons are not yet possible.

4.4.3 Recent developments

Recent developments in the area of analysing innovation have emphasised the notion of *networking* in enhancing innovative capacity of firms. Work done at the OECD in this regard is focusing on development of metrics of innovation in the areas of flows of technical personnel, links between institutions, formation of industrial clusters and the sources of innovative behaviour by firms. The ensuing discussion[38] focuses on the rationale behind these developments.

Innovation is a result of the *systemic interactions* between individuals and institutions who generate, distribute and apply various forms of knowledge in transforming inputs to outputs of higher value-added. Pilot studies carried out for the OECD project on national systems of innovation show that a high degree of technical collaboration, technical diffusion and personnel

mobility can improve the innovative capacity of firms in terms of products, patents and productivity. Hence, the innovative performance of a country depends on the effectiveness of the *links*[39] between individuals and institutions that constitute a collective system of knowledge creation and usage. The key to measuring innovative performance therefore lies in the ability to trace the *flow of knowledge*.

This is advocated by Candice Stevens[40] who argues that conventional metrics of innovation (R&D expenditures and patents) fail to account for the trends in innovation, growth and productivity of an economy. "Their ability to measure the general 'innovativeness' of an economy, or its capacity to produce new knowledge and technology, is limited" Stevens (1997:16). He presents four types of knowledge flows that are important in the measurement of links in innovation system:

- R&D cooperation among businesses;
- Public/private sector interaction;
- Diffusion of technology;
- Movements of personnel.

For a more comprehensive approach towards mapping innovative activities, one has to survey firms for their sources of knowledge. In particular the Community Innovation Survey and the PACE[41] Project asks firms on how much they spend on innovation; output and sales of new or improved products; sources of information; technology transfer and acquisition; technical cooperation and perceptions of factors promoting or hampering innovation. The findings of these surveys indicate that the most important source of knowledge for businesses is the interaction between the firm and its suppliers and customers and the analysis of competitor's products. The findings underscore the importance of networking in innovation (Stevens,1997).

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[38] The review in this section is drawn from Stevens (1997).
[39] These links take the form of joint research, personnel exchanges, cross-patenting, co-publication, purchase of equipment and various other channels.
[40] Candice Stevens – Head of Science and Technology Policy Division in the OECD Directorate for Science, Technology and Industry.
[41] PACE - Policies, Appropriability and Competitiveness for European Enterprises.

4.5 Summary

This section looked at the issue of the impact that innovation has on business performance. The difficulty of measuring a multi-faceted phenomenon like innovation was discussed. Some metrics of innovation that are useful in practise were presented. Recent developments in collection of information on innovative behaviour of firms were reviewed. The following are some of the key points for this section:

The link between innovation and business performance

- *Innovation enhances business performance because the product of innovation increases firm competitiveness and the process of innovation transforms a firm's internal capabilities making it more adaptive to change.*
- *Innovation is necessary but not sufficient cause of business performance and survival.*

Empirical evidence

- *Numerous empirical studies suggest that innovation enhances firm performance.*
- *Innovative economic regions show better performance in terms of employment and living standards.*
- *The literature reviewed suggest an implicit relationship between innovative capacity, innovativeness and competitiveness of a firm.*

Measurement of innovative activities

- *The most commonly used measures of innovative activities include: R&D expenditures, patent counts and innovation counts.*
- *Innovation is hard to measure because of its multi-dimensional character.*
- *The LBS/DTI framework is suitable for use as an innovation performance measurement system.*

- *The importance of measuring innovative performance are twofold. First, information feedback serves to illustrate current standing. Second, performance gaps serve to trigger systematic process of improvement.*

Means of mapping innovation

- *Two of the most commonly used methods of collecting information about innovative activities are patent analysis and innovation survey.*
- *Recent developments in innovation metrics focus on the measurement of knowledge flow.*
- *Networking is regarded as the key element of successful innovation.*
- *Innovation is the result of systemic interactions between individuals and institutions in transforming inputs to output of high value-added through knowledge.*

5 CONCLUSIONS

5.1 Summary of review

The review reported here covers the themes of innovation and business performance. The key concepts relating to innovation have been reviewed. We have seen how the phenomenon of innovation may be analysed at three levels. At the level of the firm, the prominent theoretical grounding lies in theories of organisational behaviour. The regional-level analysis is the domain of economic geographers. At the national-level, the approach centers on macro-economic analysis. The constructs of innovativeness and innovative capacity have been analysed. Innovativeness is the propensity to innovate. It was found that the concept of innovative capacity is ill defined in the literature. One can think of innovative capacity as the potential to innovate. A capacity which both firms and regions can possess. Factors hampering innovation have been reviewed.

As regards the link between innovation and business performance, our review of empirical studies show that, in general, innovation leads to better performance. However, innovation is not the only cause of business performance. The issue of measuring innovative activities has been highlighted. In particular, the review identified a practical innovation performance measurement framework for use at firm-level. The various means of collecting data on innovation are also presented in this report. Recent developments point toward the need to capture information on knowledge flow when measuring innovative performance. The rationale behind the development lies in the recognition that networking is the key in enhancing innovativeness of firms.

5.2 Potential research avenues

The review has characterised the knowledge in the field of innovation. While this review answers some particular issues identified prior to the review process, an interesting use of this review must be for informing about the potential areas of further research. This will be discussed in this section. Table 3 provides a summary of the main areas of research.

1. Regional-level:

How does regional innovative capacity affects the performance of firms within region?.

The concept of innovative capacity is not well documented in the literature. This brings with it challenges and opportunities for further research. Of interest here is the question of what constitute the determinants of regional innovative capacity. A inter-regional innovation benchmark study might throw light on how the various high-performing economic regions around the world compare. Which regions possess higher innovative capacity and why? How are these differences reflected in the performance of the economic regions and the firms within the regions? Specifically, factors that lead to the innovation performance gaps can be explored. Are there universal traits in these high-performing regions?

What form of regional innovation infrastructure is most conducive to innovation?

Research into the characteristics of the environment conducive to innovation serve to inform the design of effective innovation support mechanisms. Thus far, there has been limited work carried out at the level of the Eastern Region. The research conducted by Cooke and Morgan (1994) looking at the 'soft-infrastructure' of Baden-Wurttemberg serves as a good source of reference. Studies can be of a inter-regional comparison type. Specifically studies should address what constitute the key elements of a regional innovation infrastructure. How these elements interact to facilitate firm innovations. What are the main obstacles to innovation within this system. What forms of institutional support are most needed? What are the lessons that can be drawn from the differences in support mechanisms within high-performing regions?

What is the role of networks in innovation?

The question of how to nurture the growth of innovation networks is poorly understood. A whole host of research issues surround the concept of innovation networks; in particular, what are the main forms of networks? How can they be created and who should be the key players in them. What form of governance is most suitable? What can regional government do to

promote coordination among the key players. Increasingly the capacity to innovate hinges on the ability to form networks. Hence, the importance of the research.

2. Firm-level:

What are the linkages between innovative capacity, innovativeness and business performance.

Research should aim to establish the linkages between innovative capacity, innovativeness and business performance. Specifically how can firms leverage their innovative capacity for enhancing business performance is poorly understood. Questions about the relationships between the three constructs remain unanswered. Specifically the research output will help to relieve low innovative performance of some firms.

What are the means in enhancing firms' capacity to innovate?

Research at firm-level should address the following. What are the determinants of innovative capacity at firm-level? In what ways can the firm's innovative capacity be increased? How may firms internalise the capacity to innovate? Understanding of these immediate issues will serve to inform activities that support institutions can provide.

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Research focus	Selected research issues	Reasons why topic is important	Similar studies
Regional innovative capacity and business performance.	• What are the determinants of regional innovative capacity? • How does regional innovative capacity affect business performance?	Understanding of the impact of regional innovative capacity on business performance will help explain poor innovative performance of some firms.	GREMI Research Group
Regional innovation infrastructure.	• What are the characteristics of the regional environment that are conducive to innovation? • What are some of the lessons that can be learned from other high-performing regions as regards support mechanisms?	Better understanding of environment is key to designing effective innovation support mechanisms.	Cooke and Morgan (1994) Wiig and Wood (1997) Camagni (1991)
Innovation networks.	• What are the various forms of innovation networks? • How can they be created and what are the key players involved? • What form of governance is appropriate?	Better understanding of how to nurture growth of innovation networks serves to pave the way for exploiting the benefits of innovation.	Smith et al. (1991) Rothwell (1991) Bianchi and Bellini (1991) Higgins (1997) Project Interorganisational Networking (ION)
Innovative capacity, innovativeness and business performance.	• What evidence exists to show a link between innovative capacity and business performance of firms?	Establishing the dynamics of the relationships can help firms leverage their innovative capacity for business performance.	NatWest Innovation Trends Survey Community Innovation Survey PACE Geroski (1994)
Means to enhance firms' innovative capacity.	• How can innovative capacity be measured? What are the determinants? • How can innovative capacity be increased?	Firms require systematic process for improving capacity to innovate. Research will serve to inform this process.	CBI/DTI (1993)

Table 3: Table of potential research avenues.