The Process of Product Development in Small and Medium Sized Manufacturing Firms: Evidence from the North East of England

Catherine Hodgson

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University of Newcastle upon Tyne
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Abstract

Manufacturing SMEs are suggested to be of continuing importance to economic growth and are a target for regional development policies which have focused on innovation and learning as a primary route to increased corporate (and consequently regional) competitiveness. Despite this policy focus on SMEs there is a limited understanding of how they undertake product development *in practice*. Firm-level policies are frequently informed by 'best practice' models based on large-firm activities, and which may not therefore, be appropriate to SME contexts. The thesis seeks to understand what the process of product development in manufacturing SMEs is, and specifically, how it is managed, how inputs to the process are sourced, and which constraints might limit SMEs in their product development activity.

The thesis is the product of an ESRC CASE studentship with the Regional Technology Centre (RTC North) Ltd as the industrial partner. An initial aim of the research was (in line with the Case sponsor's concerns) to identify 'good practice' in product development management. As data collection progressed this initial way of understanding firm-level product development practices (as a process which could be reduced to a series of 'good practice' management steps) was found to be inadequate. The structure of the thesis reflects this change in understandings. The findings presented in the thesis are based on five case studies and twenty five interviews (utilising qualitative research methods) undertaken at manufacturing SMEs between November 1999 and February 2002.

Whilst particular ways of managing the product development process, which approximated to 'good practice' recommendations suggested in the literature, did appear to enable *some* companies to manage their product development processes in more efficient and effective ways, overall, the degree to which firms were able to implement these recommendations was very much contingent on their individual circumstances and characteristics, relating to, for example, the firm's industrial or market sector, the background and specialisms of the company owner or managing director, particular project-specific characteristics relating to the degree of novelty in the project for the developing firm, and the number of technical staff employed in the firm, loosely in relation to the company's overall number of employees.

The research suggests significant variety in the SME population, both overall and specifically in relation to approaches to product development. This therefore poses a difficulty for policymakers in designing or implementing a 'standard' policy solution. The research draws on the resource or competence-based perspective in order to better understand the unique position of firms in relation to the product development processes, but additionally understands product development as a political and potentially contested arena within the firm. Differences were apparent between how interviewees suggested the process *should* be managed (in terms of both 'best practice' prescriptions but also in terms of 'official' company procedures) and how this was done *in practice*. Managing product development itself appeared to be a learning process, and this suggests that it can become a key company capability. Non-technical problems arising on development projects which related to political or conflict-based issues were largely ignored by managers, and this approach is reflected in current innovation policy support which at a firm level primarily seeks to address technical problems.

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List of abbreviations and acronyms

DTI	Department of Trade and Industry
EC	European Commission
ERDF	European Regional Development Fund
ESF	European Social Fund
EU	European Union
R&D	Research and development
RTCN	RTC North Ltd (the Regional Technology Centre)
RTD	Research and technological development
SME	Small and Medium Sized Enterprise

1

Introduction and Research Summary

1.1 Introduction

> It is a common feature of all national economies that, over time, regional economies will diverge into prosperous areas and those that are laggard by comparison ... A key explanatory feature in any attempt to explain why such regional disparities occur is differing rates of technological change.
>
> *Oakey and Pearson, 1995: 4*

> Despite [*a*] strong commitment to supporting innovation within SMEs at both regional and local level, the actual processes whereby small firms undertake innovative activity remain unclear ... what we can detect from R&D and other statistics is likely to be only the tip of a much bigger iceberg, since SMEs do not necessarily innovate in formally recognised ways.
>
> *Hoffman* et al, *1998: 39-40*

The focus of this thesis is the process of product development in manufacturing small and medium sized enterprises (SMEs). As suggested by Oakey and Pearson, a key reason for such a concern is the role ascribed to technological development in achieving regional economic growth. Innovation is widely accepted as having a fundamental role in increasing the competitiveness of individual firms (Dosi, 1988; Freeman, 1982), and baldly speaking, if the competitiveness of individual firms within a region can be raised through increasing levels of innovation, then this as a whole will increase the competitiveness of the region's economy. In recent years, both regional and innovation policies have converged on a common target group of SMEs as a route to achieving higher levels of economic growth, since such firms are presumed (in policy models based on a number of academic studies) to have the greatest capacity for achieving growth in terms of employment and other economic outputs. The question of how SMEs can be made to be 'more innovative' has therefore been a fundamental concern for policymakers, but as Hoffman *et al* (1998) suggest, despite the perceived importance of innovative SMEs to economic growth, the *actual processes* by which such firms seek to innovate are relatively unexplored.

This thesis is the product of a collaborative ESRC CASE studentship, with RTC North Ltd (the Regional Technology Centre) as the industrial partner. As the regional

body responsible for delivering a considerable number of innovation support programmes throughout the North East region of England, RTC North Ltd (RTCN) have an interest in formulating an improved understanding of the innovation processes of their target client group of regional SMEs, as well as identifying ways in which such firms can be assisted to enable them to become 'better' at developing new products. The research has originated partly from these policy concerns, but is also a response to academic questions relating to the innovation process in SMEs, and in particular to our limited understanding of how such firms are able to innovate *in practice* (Hoffman *et al*, 1998). The research therefore seeks to open up the 'black box' (Rosenberg, 1982) of firm-level innovation processes. However, the research project has itself evolved over time, as initial concerns and questions raised by RTC North Ltd were modified in the light of data which emerged from the empirical stage of the study, and which pointed to the inadequacy of the initial conceptual frameworks which informed the research.

This chapter will introduce the research study and outline the contexts in which the research project has taken place. Firstly, the discussion will elaborate the importance of the product development process in manufacturing SMEs as an appropriate area for study, highlighting the role of innovation, manufacturing and the SME sector in achieving continued economic growth. Although the focus of the study is not a regional one, all empirical evidence has been drawn from firms operating in the North East of England, and consideration will be given to both the regional and academic contexts in which the research has taken place, through a brief examination of the North East region and also the industrial partner of the studentship, RTC North Ltd. Finally, the structure of the thesis will be outlined.

1.2 Key Research Concepts

The following sections will discuss key research concepts employed in the thesis, and seek to establish how these have converged to suggest the product development process in manufacturing SMEs as a suitable area for study and the interest of this topic to RTCN as part-sponsors of the research.

1.2.1 Innovation

> It is almost universally accepted that technological change and other kinds of innovations are the most important sources of productivity growth and increased material welfare – and that this has been so for centuries.
>
> *Edquist, 1997: 1*

Innovation has commonly been identified as a key driver for economic growth (OECD, 1992; Solow, 1957), and as suggested earlier, has been understood as a significant factor in explaining differential rates of regional economic performance (Buswell, 1983; Oakey and Pearson, 1995; Thwaites and Oakey, 1985)[1]. If innovation is seen as a precursor to economic growth ("technological mastery in manufacturing industry is a critical factor underpinning the wealth of nations" [Dodgson and Bessant, 1996:4]), a corollary of this is that its absence is identified as a contributory factor to poor economic performance, and innovation policy interventions are therefore made in order to remedy this. Innovation policy, it is suggested, aims ultimately to improve the capacity of firms, networks, industries, and national economies to innovate (Dodgson and Bessant, 1996:4) and so improve their respective competitive positions. If individual firms can improve their competitive position through innovation then, as a whole, this will improve the economic performance of the region in which they are located. Innovation policy has come to be explicitly recognised as a tool for achieving regional development (Bunn [DTI Director of Regional Policy], 2001), with innovation now a more or less standard component of any regional development policy model. There has correspondingly been an increased pressure from national and supra-national policy agencies to encourage regional institutions and stakeholders to put into place regional innovation strategies (Thomas, 2000: 190)[2]. An important component of such regional

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[1] Official innovation statistics (for example, ONS, 2002c) currently rely on the measurement of firm-level research and development (R&D) expenditure and employment as indicators of innovative effort, with 'core' economies characterised by higher levels of R&D and 'peripheral' or 'less favoured' regions associated with lower R&D figures (Thwaites, 1982, 1983; Thwaites and Oakey, 1985; see also *Table 1.1*). There are problems in this use of the R&D input as a measure of innovative activity which will be returned to in more detail later in the thesis. Principally the R&D input suggests a largely linear innovation process which is not reflected in actual practice (Kline, 1985; Massey *et al*, 1992), and overemphasises scientific inputs to innovation at the expense of other potential inputs (Christensen, 1995). It is furthermore suggested to neglect much SME innovation activity, which is argued to be more typically organised in a less formal way and therefore to be less amenable to measurement (Kleinknecht, 1987).

[2] In the North East, in parallel with successive rounds of Objective 2 funding from the European Commission, regional stakeholders in innovation policy have worked together to produce regional

innovation policies has been the encouragement of emulation of 'good practice' at the level of both the region and the firm. Regionally, solutions have been based on models derived from observation of successful regional economies (Hassink, 1996) characterised by high-trust and generally non-contractual supportive relationships between networks of economic actors (including firms, universities, support organisations and governance institutions). At the level of the firm, companies are encouraged to 'benchmark' their performance against that of world class businesses as "not just a desirable goal [but] a necessity for survival" (Prabhu *et al*, 2000: 113)[3].

With its focus on manufacturing firms, the thesis will concentrate on *product innovations*. Product developments have been suggested to be *the* principle driver of economic growth (Oakey, 1984), and are "the largest single means by which individual firms prosper or decline in the marketplace" (Thwaites, 1983: 36). Continued rapid growth requires the development of new products and new industries, in order to make up for reduced income from older goods for which demand has diminished (Rosenberg, 1982). It is therefore appropriate in the study to identify processes of *product development* as the principle concern of the research. Innovation in the context of the thesis is understood in terms of the processes by which firms seek to bring new or improved products to market.

1.2.2 Manufacturing SMEs

Whilst the contribution of manufacturing industries to UK GDP has fallen from 35 per cent in 1960 (Delbridge and Lowe, 1998) to just over 20 per cent in 1998 (ONS, 2002a), manufacturing nonetheless remains important to long-term economic well-being (Delbridge and Lowe, 1998; DTI, 2002; One North East, 2003; Pike and Tomaney, 1998). Supporting manufacturing industries is therefore a key government

---

innovation strategies, which aim to bring a more planned and coherent approach to RTD support programmes in the region, for example, the Regional Innovation and Technology Strategies (RITS) running between 1994-96 and 1997-99, and One North East's Innovation Action Plan, 2001-2004.

[3] In the North East for example, a regional 'Competitiveness Project' was undertaken (between 1996-98) to benchmark performance across a number of areas. This was significant in informing RTCN thinking about 'world-class' practice and is further discussed in *Section 1.3.2*.

concern, and manufacturers remain a policy target at both regional and national level[4], with, once again, innovation suggested to be crucial in maintaining and advancing the competitive position of such companies – if the firm does not introduce new products or variants on existing products, then ultimately sales will be lost to competitors who do (DTI, 2002: 6). More UK manufacturers must "match the success of the best" global manufacturing companies in terms of "new product development, innovative production processes, marketing and services" (DTI, 2002: 5). Overall, productivity in UK manufacturing is lower than in other national economies with which the UK competes, including the US, France and Germany (DTI, 2002: 6), and increased and 'better' firm-level innovation is suggested to be a primary mechanism by which this productivity gap can be closed (One North East, 2003),

> Success depends not just on cutting costs, but on continually creating goods and services that people want to buy, using innovation, investment and good business practice ... it is clear in a world of global competition that achieving high productivity and continual innovation is the key to sustained profitability.
>
> *DTI, 2002: 7-8*

Therefore the support and encouragement of innovation and product development within such firms has become a priority, with UK manufacturers suggested currently to spend less on product development than manufacturers in competitor countries (DTI, 2002: 26).

This policy focus on manufacturers is matched by a belief in the ability of small and medium sized enterprises (SMEs) to reinvigorate flagging economies through their capacity for economic growth and dynamism. Since innovation is also linked with economic growth, *innovative* SMEs would appear to have a greater growth potential than non-innovative SMEs (Storey *et al*, 1987; Thwaites and Wynarczyk, 1996), to the point where the linking of innovative behaviour to growth in small firms has become an almost taken-for-granted assumption in the policy sector (Gibb, 2000).

[4] See for example, the Government's manufacturing strategy (DTI, 2002) and the creation by the DTI of a national network of Regional Centres of Manufacturing Excellence and the regionally based Manufacturing Advice Service to support manufacturing in regional SMEs.

Much of the research on innovative small firms has been concerned with what have been characterised in the literature as 'high-tech' firms (for example, Dickson *et al*, 1997; Keeble *et al*, 1999; Oakey, 1984, 1993; Oakey *et al*, 1988; Romijn and Albu, 2002). It is characteristic across *all* manufacturing sectors, however, that continued product development and improvement can make a significant contribution to firm-level competitiveness – its importance is not limited to those firms operating in 'high-tech' areas. There is therefore a need for policymakers to understand the innovative processes of manufacturing SMEs who are not characterised as 'high-tech' but who *are* nonetheless active in innovation (Hoffman *et al*, 1998; Smith, 2000).

Innovation then, has come to be something of a policy panacea in the race to increase individual company, regional and national competitiveness, with the link between 'innovation' and 'growth' seemingly axiomatic for many policymakers and institutions.

1.3 Research Context

The following sections will elaborate on the context of the research project, with particular reference to both the geographical region from which empirical evidence supporting the thesis is drawn and the industrial partner of the studentship, RTC North Ltd.

1.3.1 North East Region

Whilst the focus of the study is not the North East of England itself, the empirical evidence on which the study is based has all been collected from within the region. In order to understand the wider context in which firms studied were operating, this section will give a brief overview of the region's economic situation.

The North East is one of the smaller English regions with a population of 2.6 million (Government Office North East, 2002), the bulk of whom are concentrated mainly in the industrial Tyne and Wear and Teesside conurbations (Buswell *et al*, 1987), with the western part of the region remaining predominantly rural. Industry in the region has historically been based around the Northumberland and Durham coalfields and the

Cleveland iron-ore fields, and in the iron and steel, shipbuilding, heavy engineering and chemical industries (Buswell *et al*, 1987: 168). A defining characteristic of the region's economy since the middle of the twentieth century, however, has been the decline of its traditional industries (Charles and Benneworth, 2001; Pike and Tomaney, 1998). Much manufacturing within the region has been reliant on very large externally controlled enterprises (Charles and Benneworth, 2001; Hassink, 1993), the result of inward investment policies designed to encourage the location of industry within the region (Pike and Tomaney, 1998) in order to alleviate problems of high unemployment. By the 1970s, some four-fifths of the region's manufacturing employment was concentrated in these externally controlled 'branch-plants', to the detriment of the region's indigenous manufacturing base (Amin and Pywell, 1989: 464). Whilst some inward investors have become embedded in regional supply-chains (with Nissan being the classic example), others have limited procurement to only lower-level services within the region (Pike and Tomaney, 1998), with such investments remaining more precarious and potentially mobile. This predominantly 'branch-plant economy' and past reliance on large industrial concerns has been suggested to have contributed towards a non-entrepreneurial culture (Charles and Benneworth, 2001) with low levels of new firm formation throughout the region.

Between 1981 and 1997 the North East lost over 110,000 jobs in primary and manufacturing industries, although manufacturing still accounts for just under 20% of regional employment (Government Office North East, 2002), and remains an important sector for the economy, contributing 27.3% of the region's GDP in 1998 (compared to a UK average of 20.3%) (ONS, 2002b).

Whilst there are variations in economic performance *within* the region, overall the North East performs below the national average on a range of economic indicators (including for example, unemployment rate and regional GDP per head of population). The region has the lowest level of business start-ups in the UK (21 start-ups per 10,000 population against a UK rate of 38 [ONS, 2002a]), and this is also popularly suggested to be a contributing factor to the region's continued economic underperformance (Bridge, 2002; O'Donnell, 2001). Whilst figures for R&D spend

in the region's five universities are in line with the national average, both business and government R&D expenditure in the region are below UK figures, with government R&D almost non-existent in the region (ONS, 2002c and *Table 1.1* below). This is also identified by policymakers as a particular problem, and there is a continuing focus on making the region more 'enterprising' and 'innovative' as a way of improving economic performance (Government Office North East, 1997; One North East; 1999).

Table 1.1 Expenditure on research and development as a percentage of regional GDP, 1999

	Businesses	**Government**	**Higher education institutes**
North East	0.5	-	0.4
North West & Merseyside	1.7	0.1	0.3
Yorkshire & the Humber	0.5	0.1	0.4
East Midlands	1.4	0.1	0.3
West Midlands	1.0	0.2	0.2
Eastern	2.7	0.2	0.3
London	0.6	0.2	0.6
South East	2.1	0.4	0.4
South West	1.3	0.4	0.2
England	1.4	0.2	0.4
Wales	0.6	0.1	0.4
Scotland	0.5	0.3	0.6
Northern Ireland	0.5	0.1	0.3
United Kingdom	1.2	0.2	0.4

Source: ONS, 2001

1.3.2 The CASE Studentship

The thesis is a collaborative ESRC CASE studentship, with the Regional Technology North Ltd (RTCN) as the industrial partner. As a piece of work in which the CASE partner has a stake (and therefore certain expectations regarding outcomes), particular constraints are imposed on the thesis. Whilst it must be remembered that the thesis is primarily an academic piece of work, the needs and expectations of the CASE partner cannot be ignored. Whilst all PhD research projects will be carried out within some restrictions (time or finance available to carry out the research for example), a CASE studentship can be subject to additional constraints, relating to the CASE partner's expectations of and requirements from the project.

A national network of Regional Technology Centre's (RTC's) were established by the government in 1987, initially pump-primed with DTI/DES finance, but with the intention that they would ultimately be self-financing (Council for Science and Technology, 1998). The Centres were intended to act as 'honest brokers' - filling the gap between universities and R&D institutions and industry (British Council, website, n.d.), offering practical help to companies and encouraging innovative activity in order to make individual businesses more competitive (*ibid.*). Whilst this national network of RTC's no longer exists, the north east of England RTC (RTC North Ltd) has gone from strength to strength. The Centre has established itself as a key player in the region's SME support network, and indeed seeks to position itself at the centre of RTD support in the region with its primary aim of "assisting small and medium sized enterprises in becoming more competitive through the adoption of new products, processes and skills" (RTC North website[5]). RTCN receives no direct funding for its activities, and instead is dependent on generating its own income, bidding for project monies from local, national and European sources. Regionally, RTCN is responsible for the delivery of a number of DTI and European Commission initiatives, including the North of England Innovation Relay Centre, DTI Foresight and the Regional Centre for Manufacturing Excellence. The company has grown steadily in size, almost trebling its number of staff over the last four years.

Within RTCN, the PhD research was managed under the auspices of the 'R&D Technical Division' (one of three internal company divisions at that time, the others being 'Technology Marketing' and 'New Products'), and was originally intended to engage particularly with R&D Technical's 'R&D Quest' project. R&D Quest was ERDF (European Regional Development Fund) financed[6], and had evolved from initial attempts to set up R&D networks amongst SMEs (based around the idea of an 'R&D club') into an information and signposting service. The project was based around a core assumption that SMEs did not have the resources to carry out particular

[5] See *www.rtcnorth.co.uk*

[6] The greater part of the North East region qualifies for 'Objective 2' status from the European Commission as a 'region undergoing economic and social conversion', and the structural funds (European Regional Development Fund and European Social Fund) are an important mechanism by which funding is redistributed to such areas.

useful product development activities, and that these (focused around the needs of SMEs to source and tap into external sources of inputs to product development) could be carried out instead through R&D Quest. RTCN then, had an interest in identifying both the sources and types of inputs which companies required for their product development processes. Furthermore, RTCN hoped that the research would give them a deeper understanding of product development processes and management in manufacturing SMEs, since this was expected to enable them to better design, target and deliver support programmes which could address these 'bottlenecks' in the product development process with which SMEs appeared to struggle. This was seen within a 'good' or 'best practice' framework, and RTCN hoped to be able to use the research to provide them with a 'toolkit' around which they could base a variety of good practice recommendations regarding the practice and management of product development in manufacturing SMEs.

RTCN then became involved in the studentship for a number of reasons, and approached the research with expectations of particular outcomes in mind. Overall, they identified low levels of R&D in SMEs in the North East and perceived this to be a problem, believing that higher levels of R&D would go some way towards raising the competitiveness of the region. However, at the same time, they suggested that a broader view of R&D was more appropriate for their SME target group, with greater emphasis on 'development' activities, particularly in terms of identifying those parts of the development process which were important for 'successful' product development. This implied a wider spectrum of firm activities was relevant to 'innovative effort' or product development than is suggested by the narrower R&D definition more commonly employed, and as defined in the Frascati Manual (OECD, 1994). This understanding was not, however, uniform throughout RTCN, with some areas of the company still focused on measuring only R&D inputs.

Also the thesis could be used by RTCN (as the commissioning agency of an original piece of research) both to support future funding applications and additionally as content for supporting literature to the R&D Quest project, which would be disseminated to actual and potential clients (suggesting the benefits of undertaking

innovative activity and illustrating 'best practice' product development management from a series of case study examples). There was therefore an expectation from within RTCN that the research would 'demonstrate' what was already 'known' by RTCN staff – the benefits of innovation to companies undertaking it, as well as the existence of 'best practice' ways of managing product development.

An important influence on RTCN thinking about innovation management (and one which informed how key members of RTCN staff approached the PhD project) was the 'Competitiveness Project', a three year part-ERDF funded project running from 1996-1998, commissioned by the Northern Development Company (which later became One North East, the North East of England Regional Development Agency), and involving a partnership by a number of regional participants, including local support agencies and universities. The project had the overall aim of improving the economic performance of the region, and this was measured through a benchmarking exercise of regional performance, business support services, and also individual company performance. A variety of company activities were scored and then companies were ranked along a scale from 'could do better' up to 'world class' (Prabhu *et al*, 2000). Part of what RTCN hoped for from the PhD research project was an insight into the product development management and processes of those companies who might be considered to be more towards the 'world class' end of the scale – how should a company be managing its product development processes in order to be 'world-class'?

It should be noted as well that RTCN's requirements from the research took some time to be settled – in between their agreement to the original proposal which was submitted to the ESRC and the first 'project meeting' between the author and academic and RTCN supervisors, RTCN's requests (as well as the nature of R&D Quest as an operational rather than a theoretical project) had changed considerably, and could not all be accommodated within the budget of the existing research proposal. At subsequent project team meetings, there were further attempts to operationalise the research proposal in a way that was acceptable to all parties.

Approximately halfway through the PhD, RTCN's involvement in the project became somewhat diluted, as the project's principal RTCN contacts both left the company (one permanently and one for a period of maternity leave).

1.4 Research Questions

Overall the thesis seeks to make a contribution to the understanding of the product development process in manufacturing SMEs. It has been suggested above that whilst innovative manufacturing SMEs are a policy target, the actual processes by which such firms undertake product development are not well understood (Hoffman *et al*, 1998), and this itself can be seen as a serious omission. Policies are predicated on the assumptions that the replication of 'best practice' from 'successful' firms is possible (and desirable), and also that manufacturing SMEs require interventions at particular points in the innovation process in order to allow them to overcome what are assumed to be largely SME-specific constraints. If the 'wrong' constraints are assumed, however, then policy money is being wastefully targeted.

The thesis makes an attempt to open up the 'black box' of product development in manufacturing SMEs, and to understand product development as it happens *in practice* in such firms. However, the thesis has also endeavoured to satisfy the requirements of the CASE partner, and this has had an influence on initial research questions, but also on frameworks that were used to guide the collection of data. As the project progressed, particularly throughout the empirical phase of the enquiry, questions and thinking (of the author) evolved, as it became clear that preliminary concepts were inadequate to understand all that appeared to be going on in companies. The data collection phase, however, was designed with *initial* frameworks and questions in made, and therefore what has emerged from this is a series of questions and areas for further study, rather than answers to these new questions. RTCN's central concern, and therefore also the initial core research problem for the thesis, related to the assumption that firms in the region needed to become in some way 'better' at product development (since increased effectiveness and efficiency in product development implicitly presumed to lead to in increases in company competitiveness and ultimately, to that of the region as a whole). To address this, it

was necessary to identify current firm behaviour (as well as how effective current practices seemed to be), and additionally those factors which might be causing projects to fail. Based on this, the following issues were identified (initially[7]) as areas requiring further study, and form the main research questions of the thesis.

- What is the process of product development in manufacturing SMEs in the North East region?
- How is the product development process managed in these firms?
- How do these firms source inputs to the product development process?
- What constraints do these firms face in undertaking product development?

With the answers to these intended to provide RTCN with a 'toolkit' of good practice management options which they could present to firms (in line with the belief developed from the benchmarking Competitiveness Project that imitating management practices of 'world-class' firms was a way to raise competitiveness amongst all firms).

1.5 Structure of the Thesis

The aim of the thesis is to contribute to an understanding of the product development process in manufacturing SMEs. The research will examine processes of product development in such firms, and explore how product development is managed and executed *in practice*. The empirical chapters make extensive use of verbatim quotes from interviews at participating companies, and this was felt to be important in allowing a sense of *actual practices* to emerge.

Chapter Two reviews literatures relevant to the core problem of the research (how SMEs in the North East can be assisted to enable them to become 'better' at product development) in order both to place the thesis within an existing body of work and to

[7] The use of 'initially' here is probably somewhat misleading, as even in the very early stages of the project, RTCN articulated various intended outputs from the project, the majority of which could not be accommodated within the research outline and budget which had been submitted to the ESRC as a CASE application. These 'original' questions (as stated here) were those which emerged following a period of negotiation between RTCN supervisors, academic supervisors and the author, and reflected RTCN's concern with developing a better understanding of product development processes, as well as a belief that product development or innovative activities were an unqualified 'good thing' (and that therefore companies should always be attempting to do more of them) as well as both the possibility and utility of a 'best practice' approach to product development management.

develop a *preliminary* conceptual outline which would guide data collection. The evolutionary economic perspective is presented as a framework for understanding firm-level product development processes. Empirical studies of firm-level innovation and the 'best practice' prescriptions arising from them are explored. Literatures suggesting 'typical' SME characteristics and behaviours are also examined to highlight areas of SME experience in product development where policy interventions might usefully be made.

Chapter Three describes and reflects on the methodological approach taken in the thesis. The thesis employs an intensive research design using qualitative methods based around case study and 'second-stage' interviews. The chapter begins with a discussion of the overall research design and then details the practical methods employed in the research project with regard to the construction of a sampling frame, company selection and procedures for data collection and analysis. Specific methodological concerns arising out of 'the corporate interview' are considered, and finally ethical issues regarding the confidentiality of the data are discussed.

Chapter Four describes in detail the process of product development at five case study companies in order to gain an in-depth understanding of how projects evolved and were managed *in practice*. Overall company approaches are profiled and a narrative account of a particular product development project at each company developed. Results are presented in the chronological order in which case studies were undertaken. Preliminary conclusions regarding the progression and management of product development processes in relation to the original research questions are identified.

Chapter Five develops the analysis to discuss product development processes and organisation with respect to a wider number of firms through evidence collected during the second empirical phase of the research project. Product development processes and management practices are made explicit in order that, in line with initial research concerns, 'good practice' in product development might be identified. Good practice recommendations from the literature are presented alongside actual company

practices, in order to facilitate a preliminary understanding of how theory and practice might equate.

Chapter Six discusses the implications of the research findings for the original conceptual framework employed, and also identifies additional theoretical perspectives which may be useful in coming to a more complete understanding of SME product development processes. It is suggested that a 'best' or 'good practice' management approach to product development underestimates the complexity of the product development process itself, the range of inputs necessary to innovation, the heterogeneity of the SME population (even within a single 'manufacturing sector' sample) in terms of the variety of contexts within which firms operate as well as the multiple choices of actions open to them and the ways in which what is achievable may be limited by firm-specific characteristics.

Chapter Seven draws together research findings and conclusions and discusses these in relation to both the study's original research questions and to those themes which have emerged during the research and which did not fit within the original conceptual framework employed. Implications of the thesis for both policy and academic audiences are explored. Areas in which the empirical results could be developed through future research projects are suggested.

2

Understanding Product Development Processes

2.1 Introduction and Overview

Chapter One has sought to establish the context within which the research project has taken place, and also to outline the main academic and policy issues relating to the thesis. The purpose of the following chapter is to examine those literatures which *at first* appeared to be germane to the issues and areas for study identified in Chapter One. Since RTCN were seeking those factors relating to innovation and innovation management which differentiated 'world class' companies (in line with Competitiveness Project thinking), initial reviews of the literature on technical change, were focused on what might be called the 'success factors' literature, which has attempted to identify those factors common to either successful innovators or successful innovation projects. Additionally, it was felt useful to examine economic accounts of technical change, which underpin much of the academic work on innovation (across a variety of disciplines and theoretical perspectives), and which highlight the role of innovation in increasing firm-level competitiveness, and which therefore go some way to explaining the policy attention paid to innovation. Literatures examining 'typical' SME characteristics were also explored, since these are reflected in the assumptions underpinning the types of policy interventions which are assumed to be appropriate and necessary in supporting SME product development activities (Smallbone *et al*, 2003).

The chapter will therefore seek to establish an initial theoretical framework within which the product development process in manufacturing SMEs (operating in the North East region) can usefully be understood. Throughout the thesis, however, it will be demonstrated that as the empirical phase of the project progressed, this initial framework was found to be inadequate to accommodate the full range of data collected. Chapter Six will, accordingly, return to the literature, both to discuss the implications of research findings for the initial conceptual framework employed, but

also to identify additional perspectives which may be useful in understanding SME product development processes more completely.

2.2 Theorising Technological Change

The following sections will examine changing conceptions of the innovation process and economic accounts of technological change, in order to establish an understanding of innovation as a process rather than an event, but also to produce a preliminary conceptual framework on which an empirical understanding of SME product development processes can be built.

2.2.1 The Innovation Process

Historically, innovation or innovative effort has been measured indirectly using proxy measures and this has itself suggested a particularly linear innovation model, which has, although its limitations are widely recognised, nonetheless informed (some) policy thinking. The data collected in OECD countries, for example, measures R&D inputs (typically R&D employees and R&D budgets) according to guidelines suggested in the OECD *Frascati Manual* (1994)[1], but other measures include patent data, bibliometric data (on scientific publication and citation), and more recently, innovation data, which seeks to directly measure the innovation process itself rather than a proxy event (Smith, 2000). For 'official' measures, however, the R&D input measurement currently remains key, and relates primarily to the numbers of formal R&D staff employed by a company as well as its total R&D budgets. Such data suffer from particular limitations - they measure an input only, for example, which does not necessarily bear any relation to innovation outcomes (Smith, 2000: 2), and also fail to give any insights into the internal characteristics or processes of innovation (OECD, 1992). Earlier research has suggested that SME development work in particular is at risk of being overlooked by a focus on R&D inputs, since it tends to be done more informally and intermittently than comparable work in large firms (without dedicated R&D staff or budgets), and to be often mixed in with other activities (Kleinknecht, 1987).

[1] See for example, the *UK ONS Survey of Business Enterprise R&D*, published annually for UK national and government office regional figures

A particular shortcoming of the measurement, however, relates to the model of the innovation process which it suggests. The measurement of R&D figures emphasises scientific inputs as the primary input to innovative activities, and so implies a *linear innovation process*, consisting of a chain of successive interrelated activities passing from basic scientific research, through to more applied and developmental research, the development of new product and process ideas, prototype testing, commercial production and finally diffusion (Massey *et al*, 1992: 56; Steinmueller, 1994). Thus in using the R&D measure, other knowledge creating activities are ignored, and significant parts of technological development efforts (in *all* firms, whatever their size) are neglected or underestimated (Christensen, 1995; Smith, 2000). In practice, the innovation process is much more iterative and complex than is suggested by this linear model, and involves feedback loops and several possible initiation points (Kline, 1985). Innovation is not directly derived from scientific discovery, but rests rather on *learning*, which can be based as much on activities which adapt existing forms of knowledge as on knowledge originating in new scientific or technical principles (Smith, 2000: 10). Thus activities more traditionally seen as part of an incremental development process can also be knowledge-generating and 'innovative' (MacKinnon *et al*, 2002; Smith, 2000). Innovation is a social as well as a technical process, and will involve interactions between firms and their environments (Asheim and Cooke, 1999; Asheim and Isaksen, 2003). There is therefore a need to understand innovation as a much more complex, iterative and interactive process, which depends to a large part on the firm's *learning ability* to acquire and generate knowledge from both internal and external sources.

A linear model of innovation, although simplistic, retains currency in some public sector policy – a progression of relatively discrete stages is a convenient way to characterise an uncertain process (Macdonald, 1983). The main element in the process is judged to be research (usually equated with scientific research), so policy which stimulates research is justified on the grounds that it leads to innovation (Macdonald 1983). Hence the attraction of the model lies in its simplicity – a policy

intervention made at one point in the chain will have a knock-on (and beneficial) effect further down the line (Massey *et al*, 1992).

2.2.2 Theoretical Perspectives

Whilst studies of technological change have been undertaken within a variety of academic disciplines (including economics, management and business studies, geography and sociology), economic theories have been pre-eminent, and have been used to underpin both management and geographical understandings of the process of technical change. The more recent emergence of theories outlining economic growth in terms of an evolutionary process of development can be seen partly as a response to the perceived inadequacies of 'traditional' economic accounts of innovation, and have become accepted as the dominant theory of economic accounts of technical change – the springboard for innovation studies in other disciplines.

Traditional neo-classical economic approaches have treated innovation as a factor which is exogenous to the firm (Carlsson, 1994), an external 'shock' to which firms will respond (Ferguson and Ferguson, 1994), and which is understood in terms of process innovations which reduce the cost of production.

> Technical progress is typically treated as the introduction of new processes that reduce the cost of producing an essentially unchanged product.
>
> *Rosenberg, 1982: 4*

The actual *process* of technological change (including the development of *new products*), and what that might involve, is not included in the analysis, since the main concern is with the effects of such changes in production processes on economic variables, such as productivity and prices (Coombs *et al*, 1992). Both the firm and the process of innovation are 'black boxes' (Coombs *et al*, 1992; Ferguson and Ferguson, 1994; Rosenberg, 1982). Inputs are entered into one end of the box and outputs are produced at the other, but what happens inside the box is apparently of little consequence (Sawyer, 1989). There is no concern for either the processes through which new products or processes are generated or the organisational context in which such activities take place (McLoughlin, 1999). Assumptions are of maximising

rationality, where all alternatives or possibilities are known or can be estimated by economic actors (Hodgson, 1988), and all decisions are made within this context of 'perfect information' (Ferguson and Ferguson, 1994) where firms have full knowledge of all available options (Metcalfe, 1995). A change in one area of the economy will always have an effect on other elements of the system, with ultimately markets tending towards the restoration of a state of equilibrium (Bannock *et al*, 1998).

The economic system, however, is not a static or stable one, and a more dynamic analysis is necessary, with innovation understood in terms of the overall evolution of the economy (Ferguson and Ferguson, 1994). Capitalist economies are continually evolving and are characterised by the emergence of new technologies and institutions (Nelson, 1987). These technologies and institutions are not an end result at any given moment in time, instead they co-evolve over time as part of a continuous process of economic growth (Carlsson, 1994). Innovation, in the form of new products *and* production processes, as well as new markets and forms of industrial organisation continuously "revolutionise[s] the economic structure from within, incessantly destroying the old one, incessantly creating a new one" (Schumpeter, 1943: 83), and it is this process of 'creative destruction' which is the essential fact of capitalism (Schumpeter, 1943: 83). This *evolutionary* perspective (building on the work of Schumpeter) therefore recognises economic phenomena as dynamic rather than equilibriating in a neo-classical sense (Hodgson, 1988), and economic development overall can be viewed in terms of Schumpeter's 'creative destruction' or innovation.

Neo-classical assumptions of maximising rationality (where all possible options and outcomes are known) are both narrow and simplistic (Hodgson, 1988), and instead the innovative behaviour of organisations can best be understood by recourse to the idea of 'bounded rationality' (March and Simon, 1993; Nelson and Winter, 1982; Simon, 1955). Innovation can be explained in terms of the exploration of a set of choices which are not fully known (and hence 'bounded'). Economic actors make decisions and operate according to a set of rules regarding how to undertake various tasks within the firm (Nelson and Winter, 1982). These rules or 'routines' have arisen in

the firm through the past actions of economic actors which can be interpreted as 'searches' to find better or improved ways of doing things (Nelson, 1987), and the firm can therefore be seen as a repository of this cumulative knowledge regarding, for example, particular products and processes (Harris, 1997). Actors (within firms) will follow routines, whilst at the same time monitoring a small (bounded) range of environmental variables. As long as feedback from this monitoring is felt to be positive, routines will be followed, however if not, changes to routines will be made on the basis of this 'bounded' review of alternatives (McLoughlin, 1999). Firm behaviour should therefore be understood both as a result of past history and as an attempt to deal with an ever-changing situation (Schumpeter, 1943: 84). Search activities for possible alternatives do not scan the whole environment, but rather are guided by previous experience; firms' knowledge is therefore constrained (Coombs *et al*, 1992: 6). Firms who do not evolve in such a way will become uncompetitive and may ultimately fail (Ferguson and Ferguson, 1994). Therefore the *learning ability* of firms is suggested to be of critical importance for their continued survival, but learning will of necessity be close in to the firm's existing knowledge, since radical leaps in knowledge involve significant risk and could stretch a firm's capabilities to a point which ultimately reduced learning capacity (McLoughlin, 1999: 35). History is important to a firm – what has been done in the past will have a constraining effect on what can be done in the future (Pavitt, 1990). Firms will therefore concentrate their technological development activities in areas that allow them to build on their existing technology base (Dosi, 1988). The adaptation of organisational routines is suggested to come about either through the imitation of the behaviour (routines) of successful firms, or through a trial and error process through which those which are believed to be more appropriate courses of action will be selected (Freel, 1998: 138).

This emphasis on firm-specific technological accumulation, however, does not mean that exogenously generated scientific advances are unimportant to technical innovation at the firm level (Freeman, 1994). On the contrary, the current state of scientific and technical knowledge, the 'technological paradigm', also limits technological development (Dosi, 1988). Such paradigms define the technological opportunities for further innovations, and thus technological development, both at a

firm and sector level, tends to be incremental and cumulative, unfolding along a trajectory or pathway where what has gone before determines possibilities for the future (Dosi, 1988). The capability to assimilate the results of scientific research and other knowledge produced exogenously to the firm is therefore critical in order to achieve innovation and growth (Freeman, 1994). Technological development at the firm level takes place through the exploitation of a mix of publicly available knowledge and tacit, firm-specific knowledge which has been accumulated over time (Dosi, 1988: 226) and so the capacity of the firm (or the individuals within it) to 'learn' and make use of this knowledge is crucial to both current and future competitiveness.

2.2.3 Discussion

A key concern of the evolutionary approach therefore is in identifying those aspects of firm behaviour in which sources of competitive advantage are believed to reside. How firms come to behave differently to each other, even when faced with similar circumstances, is of primary interest. It is suggested that a key factor in understanding this differential performance is the learning ability of firms and their capacity to transform external inputs and internally accumulated knowledge into inputs to the innovation process. However, the approach has less to say on the role of individual human agency in undertaking such learning, and also to the contexts (political and social for example) within which learning takes place. The perspective has been further criticised for taking a somewhat determinist position, where the concepts of 'paradigms' and 'trajectories' both convey overtones of a technology with its own 'natural' momentum (MacKenzie, 1992; McLoughlin, 1999), and with the role of individual actors within any processes of technical change or development largely ignored. Similarly, Harris (1997) has argued that the focus on the technological content of innovation within the perspective tends to obscure organisational processes, and there is little room within the analysis for the notion of contending or conflicting stakeholders within the firm. A somewhat supply-sided view of innovation is suggested, with the impetus for innovation coming largely from the firm, and the potential role of external stakeholders as stimulators of innovations thereby ignored.

2.3 Innovation and the Firm

The focus by the evolutionary perspective on organisational-level learning as a primary mechanism by which companies are able to accumulate resources for and undertake innovation suggests the firm as an appropriate unit of study for research which seeks to understand and explain innovation as a source of competitive advantage. In addition to this, a policy focus on innovation as a route to increased regional and national competitiveness has led to an increased requirement from policymakers for research which seeks to understand the innovation process, and how it can best be supported and facilitated. A huge volume of research has therefore been produced relating to the innovation process and innovating firms, broadly concerned with identifying those characteristics associated with successful innovation projects or which seem to be common to innovating firms.

Studies have focused on firms operating at particular regional (for example, Kalantaridis and Pheby, 1999; Veugelers and Cassiman, 1999) or sectoral levels (Alderman *et al*, 2001), as well as delineating firms according to their size (Acs and Audretsch, 1993; Albaladejo and Romijn, 2000; BCC, 1994; Freel, 2000a; Karlsson and Olsson, 1998; Khan and Manopichetwattana, 1989; Romijn and Albu, 2001; Trondsen, 1997), and comparing the performance of similar sets of firms across different regions (Balbontin *et al* 2000; Keeble, 1997; Roper, 1997; Thwaites and Wynarczyk, 1996; Tödtling and Kaufmann, 2001). Research describing and analysing the behaviour of groups of firms who are themselves policy targets, therefore for example small and medium sized firms (for example, Boly *et al*, 2000; March-Chorda *et al*, 2002; Sternberg, 1999; White *et al*, 1988), firms in peripheral or 'less favoured' regions (Kalantarides and Pheby, 1999; Vaessen and Keeble, 1995), and also 'high-tech' firms (Oakey *et al*, 1988; Romijn and Albu, 2002) has been frequent, based on the underlying theory that an improved understanding of the product development or innovation process in such firms *should* enable policies to be better focused and more appropriately delivered, as well as enabling 'less successful' firms to learn from those who are identified as 'success stories' and who may be operating in similar circumstances (for example, DTI, 1997, 1998a).

The following sections will outline the shift in innovation policy over recent years towards SMEs, as well as those characteristics which have been identified in the literature as 'typical' for SMEs, and which have been used to justify the necessity of targeted policy interventions.

2.3.1 The Policy Shift Towards SMEs

Throughout the last thirty years there has been a shift in both regional and innovation policies towards a common target group of SMEs – a group largely neglected in earlier policy efforts (Hassink, 1993, 1996). The Bolton Committee report in 1971 proposed the importance of the small firm sector as a 'seedbed' for future growth companies, and eight years later, Birch highlighted the role of small firms as significant employment creators. Birch's study (originally published in 1979), suggested that small firms were responsible for two thirds of net employment growth in the USA (Birch, 1987; Massey and Meegan, 1985; Storey and Johnson, 1987). Although its methodology was subsequently criticised (Storey, 1994; Storey and Johnson, 1987), the report was hugely influential in policy terms, apparently justifying as it did the benefits which could come from the creation of a more enterprising society, as was, for example, the aim of the then (1979) newly elected Conservative government (Storey, 1994: 161). From the early 1980s then, there was (in some regions across Europe, including the UK) a shift in emphasis away from policies intended to attract inwards regional investment towards attempts to encourage entrepreneurship and new firm formation. Previous policies, which had focused on developing national innovation champions and encouraging inward investment to structurally weak regions, failed to achieve any kind of sustainable development, and largely ignored the SMEs making up the vast majority of indigenous companies in European Community regions (Hassink, 1996). In the light of research such as Birch's, SMEs were suggested to have particular characteristics which made them potentially very dynamic and significant contributors to economic growth, particularly in terms of employment generation. Furthermore, it was suggested by later research that a minority of SMEs were responsible for the majority of positive effects observed amongst small firms (for example in terms of job creation) and that such high growth

small firms were characterised by innovation and technological change (Storey *et al*, 1987). It was expected that if increased numbers of such firms were encouraged in less favoured regions, then this could have a significant effect on local employment and output in the longer term (Thwaites and Wynarczyk, 1996: 136). This shift towards SMEs was also congruent with the neo-liberal political agenda current in the 1980s (and embodied in the UK government of the time) stressing the importance of the exploitation of indigenous capacity in improving regional competitiveness (Lagendijk and Cornford, 2000: 212; see also Massey and Meegan, 1985; Storey, 1994). The emphasis on both innovation and indigenous SMEs as routes to regional competitiveness has continued, with efforts directed towards improving the technological capacity of existing indigenous SMEs (supposedly more embedded in the region than potentially more mobile inward investment capital) as well as the capacity of individual regions to support and facilitate innovation (Lagendijk and Cornford, 2000). The role of policymakers in creating a successful regional economy (characterised by innovation) has become focused on fostering the conditions which appear to be necessary for its growth, based upon observation of systems already present in those regional economies perceived to be operating successfully. Just as mutual learning between firms is said to improve the competitive position of the region in which they are located, mutual learning between regions is suggested to have the potential to boost the innovative capacity of Europe as a whole (Innovation and Technology Transfer, July 2001: 2)[2].

At the firm level, policy has focused on encouraging the formation of high-trust and generally non-contractual relationships between companies which are predominant in those European regions identified as exemplars (so suggesting to companies the possibility of entering into (largely informal) networking relationships), but also in implementing a 'best practice' approach where companies are encouraged to adopt the management practices of firms identified as 'successes'[3].

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[2] See also *Section 2.5.2*
[3] The 'best practice' approach is discussed in *Section 2.4.1*

2.3.2 SME Characteristics[4]

Whilst the selection of a group of firms for study on the basis of particular shared characteristics (so for example small firms, high-tech firms, etc.) has been criticised by Michael Taylor as an artificial delineation which treats the firm as a "gross analytical category" removed from its economic and social context (1995: 100), SMEs have been identified in the literature as possessing specific characteristics (in comparison to larger firms) both in relation to the amount of innovation that they do and in the ways that they are able to 'be innovative' (Smallbone *et al*, 2000; Storey, 1994; Tidd *et al*, 2001), and these differences are also felt to merit particular policy interventions[5]. SMEs are suggested to have a limited resource base, and therefore activities which larger firms are able to carry out internally, SMEs may only be able to achieve through the use of external assistance and inputs (Freel, 2000b; Smallbone *et al*, 2000; Vossen, 1998). By utilising such external sources, SMEs are able to be innovative without necessarily possessing strong internal R&D activities (Tödtling and Kaufmann, 2001). Typically, SME innovations will be incremental and based on existing technologies within the company rather than groundbreaking or radical (Kalantaridis and Pheby, 1999; Roper, 1997), but this cannot be assumed to be uniformly the case (Tödtling and Kaufmann, 2001). As a consequence of their smaller size, SMEs are suggested to be less able to manage their external environments than larger companies (for example, they may have less leverage with suppliers, customers, sources of finance and so on) (Smallbone *et al*, 2000), and so may be forced into adopting a more defensive and reactive competitive strategy, for example based on price-cutting (Tödtling and Kaufmann, 2001), although again, such assumptions cannot be made about *all* SMEs.

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[4] There are problems in comparing studies where different definitions of what constitutes an SME have been used, so for example, the SME population is variously described as comprising firms with up to 250 employees (for example, Freel, 2000a), firms with up to 500 employees (for example, Bennett and Robson, 1999; Julien *et al*, 1999; Karlsson and Olsson, 1998 Khan and Manopichetwattana, 1989), or some other variation (Lybaert, for example (1996) identifies firms with between 20-100 employees as SMEs; Heunks (1998) uses a sample of firms with up to 200 employees).

[5] Although at the same time it should be remembered that the overall SME population is by no means homogenous and encompasses a wide variety of behaviours (Smallbone *et al*, 2000).

These size-related characteristics are then assumed to result in distinctive SME support needs (Bannock and Peacock, 1989; Smallbone *et al*, 2000; Storey, 1994) and hence policy measures are developed which are aimed specifically at SMEs. SMEs are therefore targeted by policymakers both because of their supposed potential for economic dynamism *and* because of presumed specific size-related characteristics which are suggested to render them at a disadvantage to large firms. Typically for SMEs, these needs are believed to relate to their requirements to supplement limited internal resources with external inputs, and so the nature of those inputs, how they are used, as well as the style and content of the firm's external relations, and the external environment of the firm, becomes of interest (Smith, 2000). It is suggested that SMEs will benefit from having a network of supportive linkages, comprising a mix of other firms (customers, suppliers and competitors) and institutional actors (Feldman, 1994b; Mackun and MacPherson, 1997; MacPherson, 1997) in order to supplement existing internal capabilities. Since the transfer of knowledge (particularly tacit knowledge) deemed necessary for firms to 'be innovative' is felt to be facilitated by spatial proximity (Asheim and Cooke, 1999; Maskell and Malmberg, 1999; Cooke *et al*, 1998), and because certain of the institutions with whom firms have relationships will be bound in to specific territories (regions and countries), there also exists a territorial dimension to innovation, and so the quality of the firm's local environment is suggested to be of importance (Tödtling and Kaufmann, 2001: 204). This therefore also informs RTCN's aim, through their R&D Quest project, to assist firms in their attempts to supplement internal capabilities and broker contact with external sources of innovative inputs.

With regard to current RTD policy for SMEs (which itself forms an element of regional development policy), there are therefore two main areas of concern for policymakers, and these relate firstly to *how* firms can manage their product development or innovation processes internally, and in particular, how they can do this *more successfully*, and secondly to the firm's *external relationships and environment* which could potentially be used to provide inputs to the product development process and supplement the company's internal capabilities. Both are underpinned by assumptions regarding the ways in which SMEs can 'improve' their

behaviour by following instances of what appear to be successful practice in other companies. Furthermore, both are fundamentally concerned with how firms *learn* and are companionable with the wider 'learning region' discourses, to the extent that Ray Hudson has suggested that learning and knowledge have come to be accepted "as a – maybe *the* (only) – route to corporate and regional economic success" (1999a: 59). These broad concerns are also found in the academic innovation literature, where two main strands of research have been identified, relating firstly to the role of *learning* for product development in SMEs, and secondly to the *external relations* which a firm has and the *external environment* in which it operates (Barnett and Storey, 2000; Smith, 2000).

SME specific constraints then, are largely expected to relate to resource constraints associated with their smaller size. Smaller firms, for example are suggested to often be lacking in suitably qualified technical staff, and this can hinder efforts to organise development work in a more formal way (Rothwell, 1991; Rothwell and Dodgson, 1991). A smaller technical resource (in terms of the number of technical staff) may also limit the firm's capacity to identify, access and absorb knowledge from external sources (Rothwell, 1991; Rothwell and Dodgson, 1991; Vossen, 1998), since an existing level of technical knowledge is suggested to be essential to the development of such an 'absorptive capacity' (Cohen and Levinthal, 1990). Accessing external sources of finance can potentially be problematic, particularly where these are intended to finance the more incrementally innovative projects typical of SME product development activity, rather than projects with a high degree of novelty outside the innovating firm (Rothwell, 1991; Vossen, 1998). Product developments can represent a disproportionately large financial risk to SMEs, who may have to concentrate limited financial resources on only one or two projects, rather than spread the risk across a number of developments (Acs and Audretsch, 1993; Rothwell and Dodgson, 1991: 127). Constraints are therefore suggested in the literature to relate primarily to resource limitations, particularly with reference to the financing and staffing of development projects. Constraints identified are largely normative and would appear to be 'solvable' through the provision or acquisition of extra resource.

2.4 Managing Product Development

The identification of those factors which are believed to be significant in both product development success and failure has, accordingly, become something of a holy grail within of innovation research. Seminal research in the area includes the SAPPHO studies, undertaken in the early 1970s by a team from the Science Policy Research Unit at the University of Sussex (Rothwell *et al*, 1974), and also the NewProd studies, carried out under the direction of Cooper (1979, 1980, *inter alia*) with subsequent additions (for example, Kleinschmidt and Cooper, 1995).

The SAPPHO study compared pairs of matched innovations (one failed and one successful) to identify points of similarity and difference. Overall the research suggested that there were five main areas of difference between successes and failures. Successful innovators had (in comparison to failures) a better understanding of user needs, paid greater attention to product marketing, were more efficient at development work, made effective use of external sources of technology and tended to have managers at a higher level of seniority designated as responsible for development projects (Rothwell *et al, op. cit.*: 259-260).

Cooper (1979: 100-101) found three particular 'keys' to product success. These related to product uniqueness and superiority (in comparison to competitor products), a good knowledge of the market and overall proficiency in marketing, and finally technical and production synergies (with existing products) as well as technical and production proficiency.

Subsequently, numerous studies have been undertaken to identify those factors which appear to be significant in new product success or failure, and to identify specifically what might constitute 'efficiency in development work' or 'proficiency in marketing, technology and production'. Long lists of variables and approaches which should either be adopted or avoided have been produced. The preferred methodology for the majority of such studies has been quantitative, with statistical relationships between particular factors and project success or failure sought out.

More recently, some authors have suggested that rather than a straight 'shopping list' of positive and negative variables for product development success, factors identified should be seen as contingent to the firm and its own unique circumstances (both internally and in terms of the sectoral, market and spatial locations in which it is placed) (Balachandra and Friar, 1997; Shenhar *et al*, 2002). A note of caution, however, is injected by Cooper (1979: 102) who suggests that any search for 'generalised' success factors may be fruitless in a situation where "the problem is so complex, and each case so unique".

The following sections discuss the 'success factors' approach in more detail, and highlight those factors which are suggested in the literature to contribute to a 'best' or 'good practice' approach in product development management.

2.4.1 Identifying 'Success Factors' in Product Development Management

A substantial volume of innovation research within the management and economics literatures has, accordingly, focused on attempts to identify those factors which make individual product development projects 'successful' and some firms 'better' at product development than others (see Balachandra and Friar, 1997; Brown and Eisenhardt, 1995; Ernst, 2002; Hoffman *et al*, 1998 and Johne and Snelson, 1988 for selective reviews of this literature)[6]. The aim is usually to try and establish what constitutes 'good practice', in order that other firms might learn from this and apply similar lessons to their own management and development processes. Underpinning the approach is the idea that "all work is a process … any process can be managed to be more effective" (Cooper, 1994: 3).

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[6] The concept of success, in relation to many areas of management, but also with regard to product development, is difficult to operationalise (Hart, 1993). Whilst the majority of studies equate successful innovation or product development with increased competitiveness for the company, as demonstrated, for example, by the ability of the firm to increase in size, market share and profitability (Clark and Guy, 1998: 364), it may be the case that an innovation may be a commercial failure for a company, but at the same time have a significant learning outcome in terms of, for example, how future product development projects will be managed (Maidique and Zirger, 1985). One way of estimating the success of a particular project is in terms of whether or not the development achieved its original objectives (and so would be both a company and project specific estimation), however, unintended learning outcomes such as those suggested by Maidique and Zirger may be overlooked by such an approach.

Product development management prescriptions can themselves be seen as a subset of the general 'project management' discipline. Project management best practice advice and training is structured around what Buchanan and Boddy have described as "the phased project life cycle" (1992: 8). The main emphasis of such an approach rests on the clear statement and definition of objectives, responsibilities, deadlines and budgets, together with effective monitoring and control – stages of a 'typical' project are identified, together with those tools and techniques suggested to be important for the management of each stage (Buchanan and Boddy, 1992: 8). In relation to 'best practice' management of product development, the influence of this approach can be seen in the 'success factors' technology management literature, which Brown and Eisenhardt have identified as the rational plan model - if a project is well planned, implemented, and appropriately supported, it will be a success (1995: 348). Ernst (2002) for example suggests that a majority of studies recommend

> The existence of a formal NPD [*new product development*] process which is comprehensive and characterised by professionalism throughout the process ... [*this*] has a positive effect on the success of new products.
>
> *(Ernst, 2002: 9)*

Similarly, Hoffman *et al* (1998: 49) note that the literature suggests that "a lack of appropriate control and management is likely to lead to high levels of risk and failure".

Many instances of what are identified as 'good' or 'best practice' can be traced back to studies of Japanese management practices and observations of multinational motor vehicle and electronics corporations (Alderman *et al*, 2001: 519; see also Cabral-Cardoso, 1996; McAdam, 2002). Questions remain as to how useful a blanket 'best practice' approach is to a group as heterogeneous as the SME population, but also regarding the extent that management recommendations based predominantly on very large firm innovation practice can usefully be implemented in smaller firms (Maffin *et al*, 1997). Thus

> SMEs often apply business improvement approaches that are fundamentally flawed in an SME context, as they do not start by addressing the key features and constraints of SMEs
>
> *(McAdam, 2002: 33)*

It should be noted that several of the studies (and reviews of studies) which explore the process of product development management do so without specific reference to firm size (for example, Adler *et al*, 1992; Brown and Eisenhardt, 1995; Ernst, 2002; Kleinschmidt and Cooper, 1995; Rothwell, 1992; Shenhar *et al*, 2002; Twiss, 1992;) and so offer a more general analysis of project success factors. However, they are nevertheless representative of the 'best' or 'good practice' advice offered to SMEs (see for example, DTI, 1999; RTC North Ltd, 1998).

The 'success factor' studies take a largely rational approach to product development or innovation, with the process broken down (for the convenience both of analysis and 'good practice' recommendations to firms themselves) into a series of stages (see, for example, Biemans, 1992), at each of which the firm should aim for a high degree of awareness and control both with regard to what it is trying to do and how it is trying to do it, and again this echoes the approaches of the 'best practice' project management literature (Badiru, 1996; Field and Kellor, 1998; Lock, 1996; Maylor, 1996; O'Connell, 1996; Turner, 2000; Vaupel *et al*, 2000; Watson, 1998). Recommendations for 'best practice' product development management are summarised in the following sections.

2.4.1.1 Strategy

Overall it is suggested that (as with all management processes) a strategic approach to product development management is taken, with the identification of medium to long-term objectives or goals, together with the outline of a route by which these can be achieved. These product development goals should both sit within the framework of, and contribute to the achievement of, the company's broader objectives (Afuah, 1998; Maffin *et al*, 1997; Twiss, 1992). Whilst Ernst (2002: 2) suggests that the role of long-term strategy in product development success is relatively under-researched, other researchers take the 'strategy question' as a given. "Fairly obviously, the firm must be clear about why it wants to undertake the project and how it fits in to the company's strategy" (Roy and Potter, 1990: 334).

2.4.1.2 Project Front-End

Largely it is suggested that the 'front-end' of project management is an area which is crucial to the product's ultimate success, and this relates particularly to identifying and selecting ideas for potential projects, implying that a thorough understanding of the market is critical (Biemans, 1992; Brown and Eisenhardt, 1995; Cooper, 1979; Maffin *et al*, 1997; Rothwell, 1992; Rothwell *et al*, 1974; Twiss, 1992). Balachandra and Friar (1997: 277) however, suggest that firms face difficulties in trying to collect accurate data on customer needs, and that such information that is available may tend to direct companies towards producing incremental product advances for existing markets, rather than significant innovations for undeveloped markets. A company will need a continuing flow of potential new product ideas (Twiss, 1992), as well as a mechanism for assessing their feasibility and potential (Thamhain, 1999; Thomas, 1999). Since companies are suggested to spend only just over half of their new product financial outlay on products which are ultimately financially successful (Kleinschmidt and Cooper, 1995), there is a need to ensure that those projects with the greatest chance of success are the ones that are selected.

2.4.1.3 Project Planning

Studies appear to be unanimous in agreeing that a level of project planning is necessary for product development success (Maffin *et al*, 1997; McGrath *et al*, 1992; Pinto, 1999; Rothwell, 1992; Twiss, 1992), although Brown and Eisenhardt (1995) suggest that different levels of planning may be appropriate for different types of project, relating to the degree of novelty inherent in the project for the company undertaking it. Similarly, Maffin *et al* (1997) found that the higher the level of uncertainty in a given project (i.e. the greater the level of innovation for the company) the less possible it was to plan in detail. However, overall it would appear that such is the value of effective project planning, its absence may in itself present an opportunity for improvement in how a company manages its product development process (*ibid.*). The formulation of clear project objectives and a well-defined specification have also been identified as having a positive impact on project success (Kleinschmidt and Cooper, 1995; Maffin *et al*, 1997; Twiss, 1992). Projects should be planned on the

basis of these, with targets and formal review points and meetings scheduled in (Cooper, 1994; Pinto, 1999).

2.4.1.4 Project Organisation

How projects are organised and managed is also suggested to be of importance. In particular the need for a strong and effective project leader is identified as crucial. Such a person is expected to fulfil several key roles, including managing the project team, ensuring the successful and timely progression of the project (particularly in relation to the project plan, which, like the project team, is presumed to exist), negotiating resources for the project throughout its duration, and in fact are often the principle communications link between senior managers and the project team, in terms of both informing senior management of progress on the project, and in reporting senior management objectives back to the project team (Brown and Eisenhardt, 1995; Kleinschmidt and Cooper, 1995; Rothwell, 1992; Twiss, 1992). It is suggested that not only should the project leader be a senior member of staff (Wheelwright and Clark, 1992) who will therefore have the authority to manage members of staff across all functions in the company, but also that they should be sufficiently *powerful*. A powerful project leader will be at a high hierarchical level within the company, will have significant decision-making responsibility and organisation-wide authority, and will therefore be in a position to lobby effectively for resources (in terms of personnel and budget) for the project, and will be able to manage and defend the project team from outside influence (Brown and Eisenhardt, 1995: 370).

It is generally suggested in the literature that projects should be staffed by a team of individuals drawn from several functions across the company, with representatives from marketing and production seen as particularly important in addition to members of staff from the company's technical function (Ernst, 2002; Kleinschmidt and Cooper, 1995; Maffin *et al*, 1997; Takeuchi and Nonaka, 1986). By increasing the amount and variety of information available to the development team, overall product design will be made more robust (Brown and Eisenhardt, 1995), customer needs will remain the primary focus of product development activity, and products will be

designed that can be easily manufactured (Boothroyd *et al*, 1994), with any manufacturing problems or market mismatches emerging early on in the project when they are smaller and less costly to put right (Brown and Eisenhardt, 1995). The importance of 'design for manufacture' is highlighted by a number of authors, suggesting that the interface between design (or development) and manufacturing can be crucial in keeping production costs to a minimum (Brown and Eisenhardt, 1995; Dougherty, 1992; Ernst, 2002; Kleinschmidt and Cooper, 1995; Shenhar *et al*, 2002).

2.4.1.5 Communications and Culture

Communications at all levels, including between project team members, between the project team and the rest of the organisation, and between the firm and its external environment, are also suggested to be key in project success (Brown and Eisenhardt, 1995; Dougherty, 1992; Ernst, 2002; Howells, 1990; Rothwell, 1992; Rothwell *et al*, 1974). The smaller size and lack of internal bureaucracy of SMEs is believed to offer them an advantage over larger firms in internal communications, meaning that decisions can be taken more quickly and that the firm itself can react more rapidly and flexibly to any opportunities which arise (Rothwell, 1991; Rothwell and Dodgson, 1991; Vossen, 1998). The internal culture of the firm is also suggested to have a significant impact on how effective it is able to be with regard to innovation and product development (Ernst, 2002; Rothwell, 1992), with the development of a favourable and supportive climate for innovation within the firm requiring the support of senior managers (Brown and Eisenhardt, 1995; Martin, 1994; Tidd *et al*, 2001).

2.4.2 Discussion

A large proportion of those studies which have attempted to identify 'success factors' in product development management have made use of quantitative research methods, and such an approach is suggested here to be unsuitable to capture the detail of the *process* of product development.

The popularity of quantitative methodologies in 'success factor' studies perhaps reflects a concern that data should be seen to be 'representative' of the wider firm

population[7], but also offers perhaps a cheaper and less-intensive (in terms of researcher time required) option than for example a case study or participant observation methodology. Whilst there is a need for large-scale quantitative surveys which give an overview of the innovation system as a whole (Smith, 2000), such an approach does not (and when it is focused on the overall picture, is not intended to) generate a clear understanding of the *processes* by which firms develop new products, or indeed *why* they do what they do and how they have arrived at that position. It is suggested here that where the objective of a study is to illuminate the *process* of product development in SMEs, then quantitative methods (for example, postal questionnaires and structured interviews) and analysis techniques (focusing on statistical relationships between a number of variables) are not appropriate. They fail to capture the behaviour of participating individuals which may be significant to project outcomes, but also do not give any insight into *how* firms conduct their product development processes, and so offer at best only a partial picture of firm behaviour and the context in which the firm operates (see for example Albaladejo and Romijn, 2000; BCC, 1994; Chaston *et al*, 2001; Freel, 2000c; Karlsson and Olsson, 1998; Khan and Manopichetwattana, 1989; Romijn and Albu, 2001). Likewise, the economics literature involves the analysis of predominantly large datasets, with the overriding concern to establish statistical relationships between variables (for example, Acs and Audretsch, 1993; Cohen and Levinthal, 1989; Malerba, 1992; Pisano, 1996), and so similarly is unable to elaborate on *how* product development is undertaken in practice, or the meanings given by actors to the processes in which they are involved.

As Brown and Eisenhardt (1995) suggest, a problem with such studies is the vast number of possibly significant variables which are reported – "too many variables and too much factor analysis" as they describe it (*ibid.*: 353). Balachandra and Friar (1997) suggest that a more realistic stance (if the overall goal is still to find 'successful' ways of managing product development) is to accept that a much more contingent approach will be necessary.

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[7] As illustrated by Ernst's (2002: 2) concern to include in his review of product development research only those studies which can demonstrate the statistical significance of results.

In their review of the 'success factor' literature, Balachandra and Friar (1997) further note this proliferation of potentially significant variables identified across studies, and a certain lack of consistency between factors identified in different studies. Where studies are produced by the same authors, however, there is more consistency amongst factors that are identified as significant. This would seem to suggest that in addition to those groups of factors which Balachandra and Friar suggest are contingent on the firm's individual circumstances, the author and the discipline within which they work may be a further influence on those factors which are identified as significant. Studies by researchers from a marketing background appeared to put more emphasis on internal factors which are organisation related, whilst authors with a technical orientation place more stress on external factors which are market and environment related (*ibid.*: 281-282).

Whilst some studies have supplemented quantitative approaches with more in-depth interviews (for example, Cabral-Cardoso, 1996; MacPherson, 1997), others have adopted a qualitative approach entirely, using semi- or unstructured interviews, sometimes as part of a case study methodology (for example, McAdam, 2002; Maffin *et al*, 1997). However, with regard to the study of product development in SMEs (and in particular manufacturing SMEs), this body of literature is very much in the minority, leaving a gap in our knowledge regarding "the detailed workings of innovation within SMEs" (Hoffman *et al*, 1998: 49).

An underlying assumption of much of the technology management literature is the utility of a 'best practice' approach – by imitating the behaviour of 'successful' companies, a firm will be able to increase its own chances of competitive success. However, this may not be readily achievable. Competencies (including managerial competencies) must be built over time. They are a source of competitive advantage to the firm only because of this inimitability, and hence replication of best practice may not be possible (Leonard-Barton, 1995; Teece *et al*, 1997). Also as suggested earlier, questions remain as to how useful a blanket best practice approach can be for SMEs, particularly when many best practice prescriptions have been based on large firm

activities (Alderman *et al*, 2001; Cabral-Cardoso, 1996; McAdam, 2002; Maffin *et al*, 1997).

2.5 Sources of Inputs to Product Development

'Good practice' in product development is not restricted to project management recommendations however. How firms are able to acquire necessary inputs to the product development process is also suggested to be of importance. Inputs may be sourced both from within the company and from a variety of external sources, and may involve the recombining or adaptation of existing forms of knowledge (Smith, 2000: 19). Thus, with reference back to the earlier discussion of the evolutionary perspective, both how the firm is able to learn (and to manage that learning), as well as the potential sources of inputs to which it (or its members) have access, and the ways in which these are put to use, are important.

2.5.1 Organisational Learning.

Within the firm, learning from external sources is suggested to rely on the company's 'absorptive capacity', in other words its ability to recognise the value of new information, assimilate it and apply it to commercial ends (Cohen and Levinthal, 1990: 128). In order to assimilate and use new knowledge, the firm requires a certain level of prior related knowledge (Cohen and Levinthal, 1990: 129), and hence new learning will be (by necessity) in some way related to what the firm already 'knows'. Learning is suggested to occur throughout the firm, for example in marketing, production, design and engineering and in relation to management and organisational processes, and at all levels is linked to sources of knowledge which can be internal or external to the firm (Malerba, 1992: 847).

Existing firm knowledge (as has already been suggested in the discussion of evolutionary economic approaches to innovation, *Section 2.2.2*) can reside within a company's routines. These routines, encompassing rules, conventions, formal procedures, belief structures and cultures that guide behaviour within the firm (Levitt and March, 1988), can be altered over time in response to changes in the firm's external environment (McLoughlin, 1999). Whilst this learning is dependent upon the

actions of individuals, at the same time, it is more than simply the cumulative outcome of individual learning. Individual actors may join or leave the firm, but organisational routines continue to exist independently of such movements (Dodgson, 1993). Organisational routines can therefore be seen to be independent of the individual actors who execute them (Levitt and March, 1988: 320).

2.5.2 External Relationships

The question of a firm's external relations is also suggested to be of importance, not only in relation to the nature and content of those relations, but also with regard to the quality of the firm's environment, and the possibilities it offers in terms of useful product development inputs. It has been suggested that an openness to external ideas and assistance is one characteristic which distinguishes successful from unsuccessful firms in the product development process (Rothwell, 1992). Customers and suppliers can be particularly valuable sources of inputs (Malecki and Poehling, 1999; Reed and Walsh, 2000; Rothwell and Dodgson, 1991; Sohal *et al*, 2002; von Hippel, 1988), but also of potential significance can be trade and professional associations, universities, public sector support agencies and consultants, amongst others (Bennett and Robson, 1999; Feldman, 1994; MacPherson, 1997; Mackun and MacPherson, 1997; Meyer-Krahmer, 1985; Sternberg, 1999). Cultivating relationships with particular *types* of customers has been identified as a potentially beneficial strategy (Rothwell, 1992; von Hippel, 1988). 'Lead users' have been described by von Hippel (1988) as customers at the cutting edge of their markets, and who therefore may require particular solutions and products in advance of other users, thereby giving an indication of where future market directions might lie, and indicating that the development of new products can be regarded (in some markets) as an interactive process with significant customer involvement (Biemans, 1992). 'Leading-edge customers' are similar in that they are willing to take risks in the adoption of new innovations and relatively novel and untried technologies, and can be a primary source of information on product performance which is used to indicate possible post-launch improvements (Rothwell, 1992). Suppliers can provide critical problem-solving inputs to particular projects, and the use of subcontracted services can enable SMEs to supplement internal resource limitations (Freel, 2000b: 246).

Firms can thus be characterised as embedded in a *network* of relationships with other economic agents (Biemans, 1992; Conway, 1997; Coombs *et al*, 1996; DeBresson and Amesse, 1991; Joyce *et al*, 1995; Steward and Conway, 1996; Uzzi, 1997; White *et al*, 1996), with furthermore, a suggestion that no firm (of any size) can hope to innovate or survive without the support and inputs that can be drawn from such a network (*ibid.* 1991: 369). It would seem that all firms will be involved in *some* external relationships (with suppliers and customers as a minimum), however, the extent to which these relationships can provide inputs to the product development process (or indeed are called upon to) will vary between firms, with the assumption that 'successful innovators' will be more open to searching externally for beneficial inputs (Rothwell, 1992). It has also been suggested that for SMEs, informal relationships with external contacts are particularly significant in the innovation process (Conway, 1997; Steward and Conway, 1996), and may be especially so for transmitting particular types of (tacit) information (Senker and Faulkner, 1996)[8], thus facilitating learning processes. More formal linkages, for example in the form of inter-firm collaborations, may also provide a means for SMEs to supplement internal capabilities and also be an opportunity for further organisational learning (Rothwell and Dodgson, 1991).

The types of relationships and environment within which firms operate have also been used to explain spatial variations in technological change, and thus the relatively poor innovation performance of some regions in comparison to others. In addition to examining the nature and extent of relationships cultivated by the firm with its external environment, investigations have focused on the types of environment (regional and national) best suited to supporting and facilitating the innovation process at a firm level. Those localities identified as exemplars of successful regions are suggested to typically feature localised buyer-supplier networks and robust local institutional support mechanisms (Cooke and Morgan, 1994a), with a particularly high importance placed on the role of SMEs in economic development.

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[8] Although the content of exchanges within such informal relationships will not necessarily be limited to that which is tacit (Conway, 1997).

Informing current policy thinking therefore, are these ideas of innovation as (ideally) a collective social endeavour, where small firms especially are reliant upon the expertise of a wider (though predominantly local) social constituency, including suppliers, customers, technical institutes, support agencies and trade associations (Cooke and Morgan, 1994a: 26). The regional level is suggested to be the most appropriate at which to support and promote innovation, since geographical proximity confers certain advantages, particularly in terms of tacit knowledge transfer (Innovation and Technology Transfer, July 2001: 2) and in facilitating these necessary 'dynamic collective learning processes'. Regionally, innovation can be shaped by a variety of shared rules and conventions and also the social atmosphere of the region in which organisations (including firms, financial institutions, support agencies, universities etc.) are embedded (Cooke *et al*, 1998). These "'soft' infrastructural capacities" (Hudson, 1999b: 7) are said to be crucial in encouraging and facilitating the types of high-trust network relationships which are suggested to characterise many of the successful regional economies (Camagni, 1995; Cooke and Morgan, 1994a; Keeble *et al* 1999; Lawson & Lorenz, 1999), and which allow learning and knowledge transfer to take place, and which are therefore key in fostering the region's capacity to facilitate innovation (MacKinnon *et al*, 2002).

2.6 Conclusions

This chapter has reviewed existing literatures in order to outline the preliminary conceptual framework which was used to guide the data collection phase of the research project.

It has been suggested that whilst innovative manufacturing SMEs are a target for policymakers who seek to encourage regional economic development, in practice, the innovative processes of such companies are not very well understood (Hoffman *et al*, 1998), and this can be seen as a significant omission in our understanding. The thesis will accordingly seek to investigate processes of product development in manufacturing SMEs, and the ways in which these are managed in order therefore, to address academic concerns, but also to provide RTCN with data in respect of their

core areas of concern in the research project – namely how firms can be assisted in order to become 'better' at the practice of product development.

Product development and innovation are understood to take place largely incrementally, and to a considerable degree are path-dependent based on what the firm has done before. How the firm is able to utilise knowledge and learning from both internal and external sources is suggested to be of importance, and therefore both the learning ability of the firm as well as those inputs which it is able to access (both internally and externally) will be crucial to how it is able to innovate (since not all firms are equally placed either to sources of inputs or the ways in which they are able to make use of those inputs).

In line with RTCN's core research concerns, literatures which seek to identify 'good practice' in product development, including both prescriptive advice for effective management of the process, as well as good practice in accessing inputs to the product development process (from sources which can be either internal or external to the firm) have been examined.

In the following chapter, the practicalities of researching SME product development processes will be discussed, in addition to the methodologies employed in the research project.

3

Researching Product Development Processes

3.1 Introduction

The overall purpose of the research project is to investigate the *process* of product development in small and medium sized manufacturing firms (SMEs) in the North East region of England. This involves looking beyond aggregate statistical representations of the region, which present a picture of low levels of R&D (and therefore, by implication, innovation) in comparison to other UK regions. The research questions with which the project began were as follows,

- What is the process of product development in such firms?
- How is the process of product development managed by such firms?
- How do such firms generate inputs to the product development process?
- What factors constrain product development activity in such firms?

Research methods chosen must therefore be appropriate to address these questions. In addition, as a CASE studentship, the research must attempt to meet the requirements of the CASE partner organisation, RTC North Ltd (RTCN), who have an interest in forming a deeper understanding of how manufacturing firms undertake product development, believing that this will enable them to improve the targeting, content and delivery of support programmes to such firms. Furthermore the research has also been subject to resource limitations with regard to the time and financial support available to the project. These considerations have therefore been borne in mind both in the design of the research and throughout the duration of the project.

The choice of research design has been influenced by research aims, by RTCN requirements and by the overall theoretical position which initially framed the research (discussed in Chapter Two). In order to achieve an understanding of firm level *processes* of product development, qualitative data were sought, with an intensive research design utilising face-to-face interviews. Five case studies were carried out initially, and themes arising from these were then explored in semi-

structured interviews at a further 27 firms. Throughout the case studies and second-stage interviews, 61 interviews were conducted in total.

The purpose of this chapter is to explain the methods by which the data underpinning the thesis were collected and analysed. Baxter and Eyles' (1997: 506) criteria for establishing rigour in qualitative analysis have been used as a guide in this, and it is intended that by detailing procedures used in the collection and analysis of data, the plausibility of both research designs and accounts constructed will be demonstrated. The chapter begins with a discussion of the research design, before detailing the practical methods employed for firstly the case studies and then the second-stage interviews of the research project, with regard to the construction of a sampling frame, methods of selecting and approaching companies for interview, and procedures for data collection and analysis. Consideration is then given to specific methodological concerns arising out of what can be called 'the corporate interview', and finally, ethical issues regarding the confidentiality of data are discussed.

3.2 Research Design

A methodology had already been suggested (and agreed by the CASE partner) in the original studentship proposal (which pre-dated the author's involvement). RTCN had, prior to the start of the studentship, completed a survey (in the form of a postal questionnaire) investigating the 'R&D needs' of SMEs. It was originally intended that this would be used as a framework for developing initial constructs and propositions which could then be investigated in more depth at a smaller number of firms. Respondents to RTCN's survey would also form a sampling frame for the PhD project.

However, following the start of the studentship, and after a more detailed examination of the survey, this plan was amended. Questions which had been included in the survey did not shed any new light on the research area, and so, in consultation with both RTCN and academic supervisors, a revised methodology (with the same basic case study and interview components, but requiring the construction of a sampling

frame and the development of constructs and propositions from existing literature rather than RTCN's survey results) was agreed.

Whilst there was not (perhaps) the same freedom to design a research methodology 'from scratch' as there might have been on a non-CASE PhD project, at the same time, there were felt to be valid academic reasons for selecting the methods and approach chosen, given the time and resource constraints of the project and the overall objective to study product development "in practice". There was, to an extent, a trade-off between the fact that RTCN wanted results that could be applied to as many firms as possible, but also were keen to gain *detailed* knowledge of firm-level product development processes. Resources were limited (both in terms of time and finance) and so the focus of the methods was on detail rather than extensive coverage.

It should also be noted that as the empirical phase of the project progressed, data were identified which appeared to be significant for the progress of development projects, but which the methodology had not been designed to capture (particularly relating, for example, to the role of specific individuals within projects, to differences between functional communities within firms, and also to what might be termed 'political considerations'). Case studies were more efficient at uncovering these, but it is likely that had the methodology (and initial theoretical framework which informed constructs employed in *aide memoirs* and interview schedules etc.) been differently designed, they would have been evident on a greater number of projects. Thus my own thinking about the 'problem' also changed as the research progressed – initially the route proposed in discussions with RTCN (including finding 'best practice' instances) seemed realistic and achievable. It was only as data collection progressed that such a framework seemed to be increasingly inadequate (by itself) as a means to understand the product development process at the firm level.

Following Sayer and Morgan's (1985) delineation of 'intensive' and 'extensive' research designs, an intensive approach was decided to be appropriate. Extensive research is characterised by the use of aggregate statistics, quantitative surveys and statistical analyses, in contrast an intensive approach can (and should, suggest Sayer

and Morgan) be used to explore in detail how a process works in a specific case or number of cases (*ibid.*: 151). Since a principle objective of the research was to get *beyond* aggregate statistical patterns (which suggest low levels of regional innovation using the proxy measure of R&D figures), it seemed clear that an intensive research design (and its associated methodologies) would be appropriate for the research project[1].

R&D spend and number of R&D employees (the principal measures employed in official surveys to measure levels of R&D as a proxy for innovative effort or innovation) are presumed to be an input to a process, the end result of which is expected to be 'innovation', but these figures do not give any indication of what that process might be. To note that companies in the North East account for only 1.5% of the total UK business R&D expenditure (ONS, 2002c) gives no indication of what those firms actually *do*, or how they might do it differently. However, an investigation into the processes that companies go through in order to bring product development ideas to fruition could be beneficial in enabling a deeper understanding of SME behaviour through illustrating a range of possible ways of *doing* product development.

Intensive research is not intended to produce representative results. Whilst individual firms are unique, at the same time they are operating within an overall structure of interdependencies, within an industrial sector and within local, national and international economic relations (Massey and Meegan, 1985: 10). In attempting to delineate relations between phenomena (or parts of a process) which are *contingent* (to the specific case) from those which are *necessary* (to the process), it may be possible to make statements about a specific case which can then be generalised to other examples of that process (Sayer and Morgan, 1985). It is therefore appropriate to identify which factors are specific to individual cases and which are common across a number of cases.

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[1] Limitations of an extensive quantitative approach have been further discussed in Chapter Two, *Section 2.4.2.*

The most appropriate method for such exploration is suggested to be the face-to-face informal or semi-structured interview. Such interviews will inevitably be interactive (there cannot be complete standardisation between such interviews), but rather than attempt to minimise this it is better to consciously *use* the interaction, and by building a rapport with the interviewee, to maximise the information flow (Sayer and Morgan, 1985: 157).

For this particular piece of research therefore, it was decided that, since the process of product development in manufacturing SMEs was relatively undisclosed in the literature (the majority of studies having made use of extensive and quantitative methods), detailed case studies would be conducted initially to investigate the process in a small number of companies, and themes arising from these case studies would then be explored more widely in face-to-face semi-structured interviews with a larger number of firms, (so covering the same ground in each interview, but without a standard list of questions). Firm-level processes would be uncovered, but at the same time, companies would be recognised as "institutional agents embedded in a complex network of internal and external relationships" (Schoenberger, 1991: 181). These approaches are discussed more fully in the sections which follow, which detail the *procedures* used for data collection and analysis at both the case study and interview stages of the research.

3.3 Case Studies

3.3.1 Rationale

The product development process in small and medium sized manufacturing companies is not well detailed in the literature. There is a recognition that much SME product development activity is missed in official R&D statistics, since what is done in SMEs is often characterised as 'informal and intermittent', performed without either formal R&D staff or budget, and therefore is not amenable to statistical counting (Kleinecht, 1987), but exactly what this 'informal and intermittent' activity is, is not well documented, and, this, without disregarding formal activities, is what the research project seeks to explore. It is suggested that where answers are sought relating to *how* particular phenomena or events occur, "when the focus is on a

contemporary phenomenon within some real-life context," a case study approach is appropriate (Yin, 1994: 1).

3.3.2 Case Study Design

A twelve month period was allotted to the collection of data, and it was concluded that six case studies was a feasible number to conduct in this length of time, and would also enable a sufficient variety and amount of data to be generated in order to develop propositions regarding the product development process which could then be further explored amongst a wider number of companies in the stage two interviews. Case studies were to be set up and run largely sequentially, although with some overlap (to avoid the possibility of all companies requiring interviews to be carried out at the same time), and were to be based around a particular named product development project at each company. This would allow the study of an *actual* project rather than a generic or normative 'ideal type' repetition of 'official' company procedures regarding the management of product development. A retrospective design was felt to be the most appropriate, with projects selected to be either recently completed or close to completion, enabling coverage of the complete product development process in each case. A longitudinal design with projects followed through in 'real-time' was also considered, but rejected as unsuitable, given the possibility of a project being either abandoned or downgraded in importance during the research period, and indeed the unlikely possibility that a project would run neatly and in parallel with the time available to complete the study.

A possible limitation of the retrospective model was that individuals were to be asked to remember events which had happened in the past, and about which they might have limited recollections, but it was hoped that this could be avoided by the inclusion of accounts from several individuals within the firm (in order to build up a coherent narrative of the project), by the selection of *recently completed* projects and by using available documentary material from within the firm to validate and triangulate what had been said in interviews. At each company, all available staff who had been involved in the project selected for study were to be interviewed.

3.3.3 Company Selection and Participation

The basic criteria for participating firms was that they were manufacturing SMEs (using the EU definition and therefore with between 11-250 employees), and were active in product development. Micro-firms (with less than 11 employees) are therefore excluded from this SME definition[2].

Companies were to be manufacturing SMEs with their own product or product range, since these firms could be presumed to be at least *potentially* innovative (with the assumption that they would be working to either improve existing products or to develop additions to their portfolio in order to remain competitive). They were to be drawn from several industrial sectors in order to allow insights to be developed across a range of manufacturing firms and to reflect RTCN's diverse client base. This latter stipulation also meant that companies taking part in the case studies would not be in direct competition with each other, thus reducing any potential confidentiality issues. Companies (for the case study stage of the research) were to be 'successful'. Definitions of success are problematic, both in relation to overall company performance and the product development process in particular (Hart, 1993). The firms selected for case study were identified as 'successful companies' by RTCN, and this was reinforced by credit scoring checks on all five companies, using two commercial credit rating services (FAME and Dun & Bradstreet), with all firms achieving an average or above average score.

RTCN were instrumental in securing access to all of the firms who ultimately agreed to take part in the case studies, and sampling was 'purposeful' (Baxter and Eyles, 1997), since those firms selected were expected to provide information rich cases as innovative manufacturers (based on the insights of RTCN staff who had nominated them). It was hoped that RTCN's positive relationships with a number of companies would persuade them to participate in the case studies (which would require a significant commitment on the part of participating firms), and also that the

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[2] In practice, however, two of the firms interviewed for the survey component of the research (and included in the final analysis) were operating below strength, and so did have less than 11 employees at the time of the interviews, although both were expecting to recruit again to fill vacant positions in the near future.

cumulative experience and knowledge of members of RTCN staff regarding the local company scene would enable them to suggest potentially suitable firms. Suitable companies who were known to be 'RTCN-friendly' were to be approached by RTCN staff. It was felt that as well as increasing the likelihood of their agreeing to take part in the study, this could give the research added legitimacy, with the approach coming from a recognised regional policy organisation, and would mean that companies selected for the case study part of the research were open to using external assistance and support in the product development process, which had emerged from the literature review as a suggested characteristic of successful innovators (Rothwell, 1992).

Initially the intention was to conduct six case studies, since it was felt this would be feasible within the time constraints of the PhD, and would also produce sufficient data to generate propositions regarding behaviour within a variety of manufacturing contexts. In total, however, it was decided that somewhere in the region of ten potential sites would be identified to allow for a number of 'reserve' companies. In practice these 'reserve' companies were not contacted as the first six firms approached agreed to take part in the case studies. Firm F in fact ultimately dropped out, but since this came at quite a late stage in the case study section of the research, it was decided to go ahead with the remaining five rather than attempt to recruit a replacement. The reserve companies were, however, approached as part of the stage two interview sample.

The case study sampling approach could perhaps best be described as "planned opportunism based on the mobilisation of personal networks" (Winch, 1994: 184; after Pettigrew, 1990). A number of companies were suggested as potential participants (by what could be described as 'informed individuals' from RTCN's staff) who met the research criteria. Of these suggestions, it was fortuitous that all those approached agreed to take part in the case studies. McDowell (1998) has suggested that whilst research can be written up in such a way that it appears to have followed an orderly progression, this is rarely the case, in practice

> Somehow you have to get in there, and although we often, in writing up our results, talk blandly of our samples or our case studies, letting the reader assume that the particular industry, location, site and respondents were the optimal or ideal for investigating the particular issue in which we were interested, we all know that the 'reality' is a lot messier. A great deal depends on luck and chance, connections and networks, and the particular circumstances at the time.
>
> *McDowell, 1998: 2135*

For this research, RTCN's co-operation and assistance in contacting firms, and the cumulative knowledge and experience of those staff who were instrumental in this, was thus invaluable in facilitating the negotiation of case study contacts.

The broad industrial sectors from which participating firms were drawn were food and beverage processing, engineering (which in very broad terms accounted for three of the firms studied) and electronics (instrumentation), representing respectively SIC codes 15, 29, and 33 (1992 UK SIC schedule)[3].

Table 3.1 Number of local units in manufacturing industries in Government Office North East region in 2000 (SIC 1992 division by employment sizeband)

	1-9	10-19	20-99	100-499	500+	Total
SIC 15/16	270	75	70	35	10	460
SIC 29	230	70	90	30	10	425
SIC 33	85	15	25	5	0	135
All NE manuf.	3,105	660	780	330	55	4,930

N.B. These figures represent number of employees at each business unit, and do not give any indication of independent ownership (i.e. 'true' SME status)
Source: Size Analysis of United Kingdom Business 2000, Business Monitor PA1003 (ONS, 2000)

3.3.4 Procedure

As recommended by Yin (1994) a case study protocol was written detailing initial theoretical propositions guiding the collection of data (based on theories discussed in the literature review), as well as procedures for data collection and early thoughts on how analysis might proceed.

[3] See *Chapter Four* for a summary of participating case study companies and project characteristics.

An initial approach was made to each company by a member of RTCN staff[4] who had a pre-existing relationship with that company. If the company was willing to go ahead with the research, this was followed up by a phone-call from the author to arrange a preliminary interview. Both this phone-call and the interview that followed were a further opportunity to explain the nature of the research, and allow the company potential 'get-out' points if they felt that they would rather not participate. It was always stressed (by the RTCN member of staff in their preliminary contact, and in subsequent contacts and interviews) that the object of interest was the product development process itself and the way that this was managed, rather than any specifically technical or commercially sensitive information. Assurances of confidentiality and anonymity in the reporting of the research were also given, and these more fully explained at the time of the first interview, but also in subsequent interviews with other members of staff[5].

The number of site visits and interviews at each firm was contingent on access allowed by participating companies. The first interview at each site was sought with a senior executive of the company, either a director or the managing director. This interview was intended to establish the company's strategic approach to product development, and overall management and organisational structure, as well as allow some exploration of the markets in which the company was operating and the nature of its production processes. This interview would also identify a particular product development project which the company felt was suitable for further study, as well as the key individuals who had been involved in the project.

Interviewing a senior member of staff was felt to be important, both as a matter of courtesy, and also to give the study (it was hoped) legitimacy within the company and to facilitate further access and co-operation. All interviewees were asked to identify those individuals who had been involved in the project, and through this snowballing technique it was hoped that no significant involvement at any one company would be

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[4] Each member of RTCN staff who made an initial contact with a company was given a summary of the research project, which could also be passed on to any potential participants.
[5] Issues of confidentiality are explored more fully in *Section 3.6*.

overlooked. There were two instances (at separate companies) where key individuals had left the firm and also moved out of the area, and so could not be contacted. Interviewees at each firm were therefore those individuals who were suggested by participants to have had significant involvement in the project (and hence there were variations between the numbers of interviewees at each firm and the functional areas of the firm these interviewees represented[6]). Once the initial interview had been arranged, but prior to its taking place, background information was collected on each company, using commercial sources such as FAME and Dun & Bradstreet for financial information, RTCN's contacts database, (which for each company included a brief history taken at the initial RTCN contact interview), conversations with any RTCN staff who had already had contact with the company, and also internet and newspaper searches for any further background information on the company (Healey and Rawlinson, 1993).

Whilst a scripted, formalised questionnaire approach had been rejected as unsuitable for an intensive research design, there was a need to ensure comparability between case studies for both the initial and subsequent interviews. A proportion of the information to be gathered from the initial senior manager case study interview was standard, whereas the subsequent case study interviews were to be much more fluid. Two schedules were therefore produced (see *Appendices 3* and *4*), the first covering more formal company and strategy questions, and the second relating to the interviewee's role in the selected development project.

At only two companies (Firms A and E) did those individuals identified as key in the initial (senior management) interview include representatives from production staff. At two of the remaining companies (Firms C and D, both operating in the engineering sector and both discussing 'contract' rather than 'off-line' development projects), use had been made of temporary production staff, and elements of the production process contracted out by each firm, although it seemed as well at both companies that product development was felt to be mainly the preserve of the engineering

[6] This is itself of interest and indicative of *who* in the company was felt to 'do' product development, and this varied between firms.

department. The fifth company (Firm B) employed a production engineer who *was* interviewed, who although technically a member of the design department, was also effectively a bridge between production and engineering (see *Table 3.2* for a complete list of case study interviewees by job title).

Table 3.2 Case study interviewees

Company	Interviewees	Total no. of interviews
Firm A	Technical Director; Marketing Director; Logistics Director; PA to Technical Director; Purchasing Manager; Manufacturing Supervisor	8
Firm B	MD; Operations Director; Technical Manager; Purchasing Manager; Project Engineer; Design Engineer; Production Engineer; Marketing Manager	9
Firm C	Marketing Director; Technical Manager; Senior Design Engineer; Design Engineer	4
Firm D	Technical Director; Senior Engineer; Project Engineer; Project Engineer	4
Firm E	Development Director; Brand Manager; Marketing Manager; Marketing Assistant (TCA); Operations Manager; Quality Manager; Product Development Technician; Line Supervisor; Engineer	9
Firm F	Marketing Manager *(Case study abandoned due to constraints on Firm F's time, but interview transcript included in stage two analysis)*	1

Of the five companies who eventually participated in the case studies, two (Firms C and D) chose projects which had largely gone to plan (and both of which had been produced as 'contract' developments for specific clients). The remaining three selected developments (at Firms A, B and E) had involved major problems, possibly seeing some benefit in having such projects reviewed by someone external to the company. This proved beneficial to the research in bringing to light issues relating to the differences between 'contract' and 'off-line' development projects, as well as differences between canonical and non-canonical practices in project management (Brown and Duguid, 1991).

Following the initial meeting with a senior manager, interviews were set up with those individuals suggested to have had significant involvement on the nominated project. These interviews were structured around one main question relating to the interviewee's role in the selected development project, but with a number of thematic

areas relating to the management and evolution of the project to be raised if they were not otherwise covered in the interviewee's narrative (see *Appendix 5*). These thematic areas had been based around the prescriptive recommendations of the technology management literature (regarding 'good practice' in technology management), and approximating to what Buchanan and Boddy have called the "phased project life-cycle" (1992: 8). They were intended to act as a starting point rather than a rigid framework, with additional areas of interest incorporated into the analysis as they emerged during the course of interviews. It was hoped that interviews would be conversational (with the respondent leading the discussion) rather than question and answer sessions. The practicalities of interviewing in a corporate setting are discussed more fully in *Section 3.5*.

3.3.5 Analysis

Whilst there is no standard procedure for analysing interview texts, Baxter and Eyles (1997: 509) suggest that an elaboration of how this has been done is necessary to enable an estimation to be made regarding the overall robustness of the analysis. This section will therefore detail procedures used to analyse case study interview texts.

All interviews were taped and transcribed (verbatim) as soon as possible after the interview. Additional notes were made with reference to particular impressions of the firm, the interview or the interviewee, and these were appended to interview transcripts and highlighted using bold or italic fonts. Transcribing was done by the author, and it was felt that this was important in both enabling a familiarity with the content of interviews, but also because hearing *what* was said prompted recollections of *how* things had been said. Transcription thus constituted a first stage in analysis Completed transcripts for each company were read through singly and then again together, to enable all materials for a particular case to be read as a whole to allow a 'feel' for both the project described and the company itself to develop. Themes and interesting issues pertaining (broadly) to the original study research questions were highlighted and noted.

Since the case study process required a significant investment of staff time from participating companies, it was hoped that the offer of two case study reports might indicate appreciation towards the companies for their participation. Each company was to receive both a single case report pertaining to their *own* project, and also a cross-case report comparing projects at all five participating companies. These reports were not intended to be critical or to offer prescriptive recommendations. The single company report gave both an overview of each company's (overall) approach to product development, and also a narrative account (synthesised from all interview accounts) of how the project had progressed. The report was both an opportunity for the companies to verify the version of events presented, but was also a preliminary analysis, constituting what has been called a 'within case' analysis (Eisenhardt, 1989), allowing the development of a familiarity with both the interview transcripts and the 'story' from each company that was emerging, and was also a way of identifying those issues which would be further explored in stage two. In general, interviewee accounts about the substantive points of the narrative agreed, although on occasions where they did not, these differences (or tensions perhaps) were interesting in themselves. For example, at two of the case study companies (Firms A and B), there was confusion and a difference of opinion amongst respondents regarding who had lead the development project, and this confusion perhaps itself had an impact on how the projects had progressed. Familiarity with each 'story' was consolidated through the production of an anonymised version of each company report written as a deliverable for the CASE partner.

In order to develop a thematic analysis of the case studies, the analytic framework proposed by Miles and Huberman (1984) was used. A list of codes (a number of broader heading thematic codes, plus sub-codes which were felt to fit 'beneath' these) was drawn up following the initial readings of the interview transcripts, which related to overall themes felt to have emerged from the interviews, and which covered different stages of the product development process, the company's management and strategic approaches and other 'softer' issues which had been identified, and which had had a bearing on the development process, (for example concerning communications and internal company politics). The transcribed interview texts were

coded in line with these, and some revision of the original coding scheme occurred, as new themes became obvious in later interviews, and with earlier interviews then re-coded. New word processed documents were then created for each company, with one document relating to each thematic code, and then itself divided into sub-codes. The coded interview transcripts were then copied and pasted into these new documents, so that for each company, all coded statements relating to particular issues or themes could be read through together. These documents were themselves then read through several times and further distilled into note form (cross-referenced with the original transcripts). This corresponded to Miles and Huberman's "data reduction" stage, a "process of selecting, focusing, simplifying, abstracting and transforming ... 'raw' data" (1984: 21).

From this 'reduced data', four matrices were constructed, relating to overall company characteristics, strategic approach, a chronology of the product development project discussed and finally, the management of that process (corresponding to Miles and Huberman's "data display" stage, "an organised assembly of information that permits conclusion drawing", [1984: 21]). Each company's data was entered into these matrices and this allowed for easier comparison between cases, and therefore facilitated further analysis.

Whilst it is recognised that coding data has limitations, (as Silverman has said, "Every way of seeing is also a way of not seeing", and although coding is helpful in organising data analysis, it could deflect attention away from uncategorized activities [2000: 147]), it was felt that a method which allowed the organisation of such a large amount of data was beneficial. Final analysis of material was in fact done mainly from the second stage documents (where interview transcripts had been cut and pasted into new documents relating to thematic headings), with the matrices useful as general reference guides to the material.

For the second written report, (the cross-case comparison report), those themes which had been identified in the 'within case' analysis and subsequent coding were expanded and compared. Where appropriate, examples from the technology

management 'good practice' literature were included, and compared with what was actually being done in the case study companies. It was stressed in the report that the intention with the research was not to identify a 'better' way of managing the product development process, but rather to present a range of alternative approaches illustrating how various elements of the process had been managed (and how this had worked or not worked) at participating companies. It was intended that such a report could be beneficial to those participating companies who had an interest in reviewing their product development procedures, and also satisfied the requirements of RTCN who wanted examples of what they felt were 'good practice' ways of managing the product development process. It was also invaluable as a further stage of analysis, and was an additional opportunity to offer participating companies a chance to review and verify outputs from the research.

For the purposes of the thesis, the data was again reviewed, and the procedures by which this was done are highlighted in *Section 3.4.5* in the discussion of second-stage interview data analysis.

It was felt to be important to include quotations from respondents in written reports and the final thesis, since these are "important for revealing how meanings are expressed in the respondents own words rather than the words of the researcher" (Baxter and Eyles, 1997: 508). Quotations were selected which were felt to be particularly illuminating or which seemed representative of a phenomena which appeared in several different interviewee accounts, and were intended to allow a sense of *actual practices* to emerge.

3.4 Second-Stage Interviews

3.4.1 Rationale

These second-stage interviews were intended to provide a way of further confirming (or refuting) propositions which had been developed in the initial stages of case study analysis. It was hoped that it would thus be possible to construct and refine theoretical propositions regarding the management of the product development process in manufacturing SMEs. The interviews also extended the coverage of the

research to companies who did *not* have a pre-existing relationship with RTCN (as the case study companies had done).

3.4.2 Interview Design

Interviews were again structured around a single product development project, although this time (in view of time constraints), only one interview per company would take place, and it was intended that this would be with the individual responsible for product development or technical management within the company. Interviews were again face-to-face and semi-structured around a set of themes set out in a schedule or *aide memoir* (see *Appendix 6*).

This schedule was a synthesis of the two case study schedules (from the initial senior manager interview and subsequent project focused interviews). There was an additional constraint in that the interview was to last an hour at most (although occasionally interviewees talked for longer than this), and the fact that both the more formal company questions as well as the more fluid product development process questions had to be fitted in meant there was a need to keep a tighter control on the structure of interviews as they progressed. Initially, the more formal 'factual' questions had been asked at the beginning of the interview (for the pilot interview and the first 'official' stage two interview), as it was thought that such questions would be useful to 'warm-up' the interviewee and help develop a rapport. However, it quickly became clear that interviews were going to overrun if they were structured in that way, and switching the order around (so that product development process questions came first), helped the interview to flow more smoothly and also speeded things up. Many of the more formal questions could be fitted in to the product development conversation as it progressed, and then any remaining questions which had not been covered added on to the end of the interview.

3.4.3 Company Selection

As stated earlier, prior to the launch of the studentship, RTCN had themselves completed a survey of the R&D needs of SMEs in the Northern region, and the original intention was to make use of this as a sampling frame. On examination,

however, the survey was not found to be as useful as had originally been claimed, and so it was necessary to construct a new sampling frame.

To allow both data-sets (case study and second-stage interviews) to be broadly comparable, it was decided to use the SIC codes of the case study companies as a further search criteria to identify interview companies. It was not possible to identify sufficient firms to make up a sample at 4 digit SIC level, and so this was broadened out to 2 digit level. No single source of company information was felt to constitute an adequate sampling frame, and therefore one was constructed from a number of sources. These are listed in *Table 3.3* Company details contained in these sources were presented in a range of formats, and so considerable effort went into constructing the stage two sampling frame, and verifying the information that was contained within it.

Table 3.3 Stage Two Sampling Frame Components

Source	**Description of content**
CURDS	Internal database constructed for previous study of regional firms, could be searched for manufacturing SMEs who claimed to be active in PD
Dun & Bradstreet Business Registers volumes 6 & 7 (NE region)	Includes all NE companies with more than 5 employees or an annual sales turnover in excess of £250,000 and their branches
Dun & Bradstreet Key British Enterprises (KBE)	Every company listed meets at least one of the following criteria • all UK businesses with 65+ employees • all UK businesses with sales turnover of £6m+ • all UK businesses with total assets of £12m+
Bureau van Dyke FAME (Financial Analysis Made Easy)	UK limited companies (based on Companies House data)
Kompass	General policy on inclusion • industrial or industrial service companies • trading nationally
RTCN Regional Companies Database (RCD)	Aims to include all manufacturing companies in the North East region

The assignation of a SIC code to companies was itself found to be problematic. Limited companies themselves, in the records they submit to Companies House, assign themselves a 4 digit SIC code from the UK schedule. Other commercial data sources sometimes use these codes (for example, FAME, which uses Companies House data as the basis for its financial analysis service), whereas others re-assign what they feel to be the most appropriate code (for example, Dun & Bradstreet, who

assign both UK and US SIC codes). RTCN's own regional companies database introduced a third level of coding, with their database manager also assigning a UK SIC code to individual company records. Not surprisingly, there was little consistency between databases regarding SIC codes to which companies had been assigned, and this further reinforced the decision to search for companies using 2 digit SIC codes, (most databases seeming to concur with regard to the broad industrial sector a company should be allocated to). However, after initial lists were compiled, there was still a considerable amount of list 'cleaning' to be done. Company information from commercial sources such as Dun & Bradstreet was further protected by publishers copyright, and could not be used to produce lists - any required lists must be requested and bought directly from the publisher. Where this could readily be done through RTCN's on-line services, it was. Where this was not possible (for example, where the database was only available in hard copy or where costs were felt to be prohibitive[7]), any companies appearing in such databases had to be verified from another source, for example from RTCN's own database.

An initial sampling frame of some 300 firms was produced, and from the firms listed, attempts were made to find out further information to ascertain which met the research criteria using a range of sources, for example, the internet, newspapers, and RTCN's own collection of company information (held separately from their regional companies database). Finding a sufficient number of suitable companies (who met the research criteria) to participate in the second stage of the research was problematic, perhaps indicating low overall regional numbers of independent manufacturers operating in the targeted sectors and with their own product range. The majority of companies who appeared to be suitable from the sources used to compile the sampling frame in practice were not[8], and this prolonged the process of recruiting a sufficient number of companies. The sample size for this component of the research

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[7] Also, since separate publisher's lists would still require a considerable amount of work to amalgamate them into a single sampling frame, it was decided to continue to construct a database of companies with sources that were readily available.

[8] It was not possible to search RTCN's database by company size and so a number of companies were included who did not meet SME criteria. Furthermore, using SIC codes at such a broad level meant that a number of companies were listed who were purely subcontractors or service companies and did not have their own product range.

was ultimately restricted by both the time available for the research project and the difficulties encountered in producing a sampling frame of suitable companies.

Ultimately, 50 companies were contacted as potential second-stage interviewees, with 28 of these agreeing to take part in the project but eventually with only 26 interviews going ahead due to pressure of work and family commitments at the two companies who dropped out. Interviews took between 30 minutes to 2 hours to complete, with the average interview taking between 45 minutes to 1 hour. The point at which recruitment of companies stopped was decided partly by the time constraints on the research project, but also after discussions with academic and CASE supervisors, when it was decided that sufficient interviews had been undertaken to allow for a meaningful comparison of case study and interview data.

3.4.4 Procedure

Approaches to companies were done in batches of ten, in order to enable a steady and manageable workflow with regard to the number of interviews conducted and the transcribing that this generated. An initial phone-call was made to each company to establish (usually from the switchboard) the most suitable person to contact with regard to the company's new product development. This often was the company's technical director or manager, though particularly with firms at the smaller end of the sample, tended to be the company's managing director or owner-manager.

This individual was then contacted via a letter (see *Appendix 5*) explaining the nature and purpose of the research. It was stated that the research was part of a PhD project and though was partly financed by RTCN, was completely independent from them. Again, the confidentiality of the project was stressed, as was the fact that the interest of the research lay in how the company managed its product development process, rather than with any commercially sensitive information. Participants were again offered a comparative report (this time of the second-stage interview results). It was felt that interviews should be as brief as possible, in order to prevent the demands on participants becoming too onerous. Interviews were expected to take between 40 minutes to an hour, and this fact was stated in the initial contact letter. This letter was

then followed a few days later by a phone-call to ascertain the company's willingness to be involved in the project, and if the response was positive to arrange a time for interview. This phone-call was also a further opportunity to explain the nature of the research and the expected structure that the interview would take, as well as of course, to answer any additional questions the potential interviewee might have.

A number of respondents initially declined to take part in the research, but all who did so were politely pressed to give reasons for their refusal. Some suggested that what their companies did was not 'proper' product development and so would be of no interest to the research[9], and with these firms, the value of their potential contribution was stressed, and a number subsequently agreed to participate. Of those companies who did refuse to take part, pressure of work was the reason most often cited for their refusal, although on several occasions, companies who had been identified in the sampling frame sources as independent manufacturers turned out to be either distributors or part of a larger (non-SME) group of companies and therefore unsuitable.

The majority of second-stage interviews involved only one respondent, usually the individual within the company with primary responsibility for technical development issues, and this individual was sometimes also (particularly with the very small firms contacted, i.e. with less than 20 employees) the company managing director. On two occasions, two individuals participated in the interview, and so it became more of a three-way conversation.

3.4.5 Analysis

The intention with the interview stage of the research was to further explore themes which had been identified in the case studies as being of interest or significance. The procedure for analysing data was broadly similar to that followed through the case studies.

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[9] This is perhaps similar to Woolgar's experience in studying a sociology of science when "the science is always elsewhere", where practitioner's repeatedly informed him that what their laboratory did was not 'real' science (1985: 563).

Almost all interviews were taped on to a mini-disc recorder, improving both the quality of recordings as compared to the case study interviews (which had been recorded on to cassette tape), and thereby reducing the time required for transcription. On three occasions interviewees declined to be taped, and notes were taken throughout the interview instead. These interviews became more of a dictation on the part of the respondents and less of a conversation, and the time that they had to think whilst waiting for their comments to be written down perhaps made their responses more considered[10].

Recordings and written interview notes were again transcribed, with supplementary observations made during or after interviews incorporated into transcripts, (as were any thoughts which occurred whilst transcribing), and these were highlighted in bold and italic font to distinguish them from surrounding text. All transcripts were read through initially in date order of interview, and each was then reread more closely, both times highlighting themes that seemed to be important or significant. Interviews were again coded, with the initial list of codes based around interview themes, which had themselves arisen from the case study analysis. New documents were created for each code and then coded sections from interviews copied and pasted into these, so that segments from *all* interviews (and therefore companies) relating to a particular code could be read together in one document. This again facilitated analysis by allowing group data to be more easily compared and contrasted.

The comparative report promised to interviewees (with all identifying company details omitted), again constituted a first stage of analysis of the interview data. It was based around the same thematic headings as the cross-case report, and included references to the 'best practice' literature. As with the cross case report, the intention was to present a range of possible approaches to the product development process rather than to be prescriptive.

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[10] Although it should be noted that none of these interviewees appeared to 'hold back'. One in particular was highly critical both of his managing director and the company he worked for, so perhaps felt more secure that there was no taped recording of his comments.

Two second-stage interviews were ultimately not included in the final analysis. The first of these was due to a technical fault with the recording equipment, which meant that there was no record of the interview, with insufficient notes to base any analysis on. A second company, although listed in directories and RTCN sources as being within the target size range of companies, had in fact laid off several members of staff, and subsequently it was decided that as the company had been operating as a micro-firm for some considerable period of time and had no immediate recruitment plans, it was not suitable to be included in the final analysis.

Further analysis was undertaken for the purposes of the thesis when both case study and second-stage interview transcripts were again read through a number of times, with references made back to matrices and coded documents produced in original analyses. Themes relating to research questions were identified and emphasised, and comparisons made between data emerging from the two research stages.

3.4.6 Limitations

A potential limitation of the second-stage interviews in comparison to the case study method concerned the number of interviewees at each site. As stated earlier, in the main, only one individual at each stage two company was interviewed, at the two companies where more than one individual was spoken to, this took place with two individuals in the same interview rather than two separate interviews (and thus potentially giving the interview a different dynamic, particularly where one interviewee was in a more senior position to the other). Overall then, although documentary material from each interview site was obtained where possible (for example, project plans and generic product development procedures), triangulation of different viewpoints was not possible to the extent that it was at the case study companies, where several individuals were interviewed about the same sequence of events.

Speaking to only one person (and so getting only one viewpoint) meant that it was potentially difficult to distinguish where an individual was speaking 'as themselves' or in their company 'role'. Oinas (1999) has suggested that a respondent can speak in

a number of different 'voices' throughout an interview, and this was a concern which had to be borne in mind throughout the analysis.

Furthermore, whilst stage two respondents were requested to talk about a specific project, there was sometimes a tendency to talk about how a project would *ideally* be managed. This was dealt with in the interview by verbally nudging the respondent back towards the project in question ('Did that happen on *this* project?' for example), but has in fact been of interest in uncovering the differences between how respondents felt they 'ought' to manage projects and how this was done in practice, something which has emerged as a significant theme in the research.

3.5 The Corporate Interview

Both the case studies and stage two of the research were based around face-to-face semi-structured interviews, and so consideration in this section is given to methodological issues arising from this, and which were common to both stages of the research project. All interviews took place at the companies concerned, and the majority in some form of neutral space, usually a meeting room, but on two occasions in the company coffee room. The remainder took place in the interviewee's own office or work space, which would sometimes be a shared space with other individuals present though not actually involved in or contributing to the interview.

There is a growing literature on the utility of the corporate interview as a research method (for example, Clark 1998; Healey and Rawlinson, 1993; Hughes, 1999; McDowell, 1992, 1998; Oinas, 1999; Sayer and Morgan, 1985; Schoenberger, 1991), and a discussion of some of the methodological considerations raised in these literatures is of relevance here.

In the main, it seems, the 'corporate interview' is taken to be synonymous with the 'management interview', with little consideration in the literature given to interviewing anyone other than senior managers. One aim of the case study component of the research was to speak not just to those who *were* senior managers, but also to those who *weren't*, but who had nonetheless had an involvement in a

product development project. The research was only partly successful in meeting this aim, with some companies taking a more 'design' or 'engineering centred' view of the development process than others, but this in itself is an interesting finding. Sayer and Morgan (1985) have suggested that interviewing only managers serves to reinforce 'the view from above', but that, however, interviewing workers presents problems in terms of feasibility, as well as raising an ethical question of taking up their time without being able to give anything in return. Accessing shopfloor production staff for interview was only possible at two out of the five case study firms, with a production engineer (so with some production involvement, though not actually with assembly or manufacture) at a third. Largely, as has been suggested, access to production staff depended upon the role that they were perceived to have in product development within the company. Whilst an element of production on both of the remaining case study projects (Firms C and D) was either subcontracted or completed by temporary labour, the company's own production staff (in both instances) did have some involvement, although this was seen by engineering staff and overall managers of the product development process as largely peripheral. Those companies who did enable significant access to production staff were also those who appeared to have the greatest investment in taking part in the case studies, in that they were very actively reviewing their own approaches to product development management, and were hoping that the case study reports would be of benefit in this.

Whilst managerial staff were perhaps more used to holding the floor and putting their own point of view across, this was not the case for all interviewees, and the nervousness of some was occasionally evident. It seemed that the best way to handle this was by trying to create a relaxed and comfortable atmosphere in the interview from the beginning. Questions were phrased straightforwardly, and usually as the interviewee became aware that the discussion was going to progress informally, and that they were not going to be 'grilled' or expected to come up with the 'right' answer or taken to task over their actions, they would visibly relax[11].

[11] An early interviewee at one of the case studies however, remained (literally) quite rigid throughout the interview, giving very brief answers, and only opening up and becoming conversational once the tape recorder had been switched off and the interview definitely appeared to be over.

Whilst the usual assumption is that the balance of power in interviews lies with the researcher (Clark, 1998), Schoenberger (1991) suggests that the ease and familiarity of managers in putting their own view across, together with their expectations of being in control can sometimes work against a productive interview, with the risk that the respondent will impose their own agenda on the interview. This appeared to happen in the initial interview with the managing director of case study Firm B. He gave very little away, and it seemed that nothing of any interest had been uncovered in the interview, and several of the questions which he had managed to avoid answering were subsequently gone over again with the company's engineering manager.

Both interviewer and respondent is in a position to adopt different roles throughout the interview (Oinas, 1999), and since this will have a bearing on the progression of the interview it must be borne in mind. McDowell (1998) for instance, in her research on banking elites in the City of London, found that she was presenting herself in different ways to different interviewees, depending on how she initially sized up the respondent. For this research project, the position adopted in interviews (stressing a non-technical background), perhaps helped respondents to feel more confident that the information sought was to do with the management of the product development process rather than commercial secrets, and so become more relaxed about including technical information by way of explanation.

Several authors have suggested that not only the 'face' that the interviewer presents, but also certain unalterable characteristics of the interviewer (for example, age, race, gender) can all have an effect on the outcome of the interview (Clark, 1998; Healey and Rawlinson, 1993; Herod, 1993; Hughes, 1999; McDowell, 1992, 1998; Oinas, 1999; Schoenberger, 1991).

> (E)xperience shows that one's gender, age, ethnicity, and status may all (together or separately) matter a great deal in establishing contact and encouraging the exchange of confidences
>
> *Clark, 1998: 81*

It is difficult to gauge the impact of this however, since it can never be possible to know how it might 'otherwise' have gone had the researcher's characteristics been

different (or had the interview been conducted by another researcher). McDowell (1998: 2141) suggests that the narrative that emerges from unstructured or semi-structured interviews should be characterised as a 'variable truth', a single story told at a particular moment in time to a particular audience. This does not mean it has no validity, however. By careful questioning and by coming back to issues throughout the interview, and by placing one person's version of a narrative against others, it is possible to build up a consistent picture.

There is therefore a degree of "'impression management' or 'self-presentation'" (Sayer and Morgan, 1985: 156) going on from both sides of the interview. To simply accept at face-value what has been heard would be naïve, a degree of scepticism is called for, and this was felt to be a particularly salient point for the second-stage interviews where no alternative account was available.

> People usually try and answer in a way which puts their actions in the best possible light, though this of course may shade into deceit.
>
> *Sayer and Morgan, 1985: 156*

Similarly, Clark, suggests that while researchers usually feel obliged to fully report the voices of those who are not ordinarily heard, it should not be forgotten that those being interviewed could be attempting to portray both the organisation and their behaviour, in a particular light (Clark, 1998: 80). Whilst it may be the case that individuals are more likely to portray their own behaviour in a favourable light, this may not always be the case when they are talking about the behaviour of others or of the organisation itself. It is further possible that some interviewees may be feeding the interviewer their favoured version of events or circumstances in the hope that the interviewer may pass these on to other respondents, or perhaps include them in their final report (Clark, 1998: 80). In interviews with production staff at case study Firm E a significant amount of dissatisfaction with how their role in product development projects had in the past been managed was expressed. It is possible that there were unspoken expectations that this would be reported to management, although they were given no assurances of this, and it is equally possible that they were 'letting off steam' to a confidential and neutral third party.

Whilst Sayer and Morgan propose that the account of any one individual should be corroborated by others (1985), it may be that this simply serves to uncover a collective viewpoint, which has become the accepted version of events constructed for example, by a particular functional department within a company, or by the company as a whole, and again this should be borne in mind throughout analysis to produce an analytical rather than simply reported account.

3.6 Ethics and Confidentiality

It was felt to be important that all respondents were guaranteed confidentiality and anonymity, both within and between companies, since it was felt this would facilitate the disclosure of information by interviewees. In initial approaches to the company (and again in interviews as required), it was stressed that the interest of the research was with how the company approached the management (in the broadest terms) of its product development process, rather than in the technical details of its products and production processes. Whilst interviews were (on the whole) recorded, permission was always sought, and it was stressed that the recordings would be listened to only by the researcher, and were made to benefit the fluidity of the interview. Interviewees were always given the option of having a transcript of the tape returned to them for review, although in practice only three asked for this, and none of these interviewees asked for any changes to be made or any parts of the interview to be omitted from analysis. Interviewees would often carry on talking once the tape recorder had been switched off, and in such cases, notes were either made at the time or written up as soon as the interview was over (with the confidentiality of the information ascertained). Interviewees were told that if they wanted particularly to talk about something 'off the record', then the tape recorder could be switched off. In practice, no-one availed themselves of this offer, although in a number of interviews, a statement was proceeded by the proviso that 'this is confidential', and in such cases the comment has not been included in analysis, or has been anonymised in such a way as to make its source (either company or individual) unidentifiable.

In the reports produced from both stages of the research, steps were taken to preserve confidentiality. In the single case report which went to each participating case study

company, no reference was made to any individual's opinion or point of view either by name or job title and no quotations were used. Quotations from interviews were used in both the cross-case comparison report and in the stage two report, but their origin was disguised. In the cross-case report they were attributed by job title only (and if the job title was specific to that company and could have resulted in identification it was changed to a more general but still functionally descriptive one), and in the stage two interview attributions, job title and the broad industrial sector of the company were given (so for example, 'Engineering Manager, Electronics Company'). Some context information was given about each participating company in the cross-case report (and is repeated in this thesis in *Chapter Four, tables 4.1 and 4.2*), but this was reviewed and checked by supervisors, sponsors and the companies themselves to ensure that it was accurate but did not allow identification or the disclosure of commercially sensitive information.

Each case study company received a copy of their single case report and also the cross-case report, both to review and verify the content of the information and its presentation. No requests for alterations were received. The second-stage interview report was also sent out to participating companies, and no negative comments or requests for alterations were forthcoming.

RTCN, as sponsors, obviously had an interest in the outcomes of the research and certain deliverables were promised to them as part of the research 'contract'. Again, all information they were presented with was anonymised. They received a redrafted (anonymised) version of each single case study report, with all identifying details omitted, and a copy of both the cross-case and stage two reports, but only after these had been approved by the participating companies. Two members of RTCN staff, as CASE supervisors, had heavy involvement in the research project, and themselves knew the identity of case study companies, and were also involved in discussions around the construction of the stage two sampling frame. It was agreed, however, that this information was all confidential to the 'research team' (the author plus university and RTCN supervisors). Whilst it was recognised that to an extent RTCN staff would have some knowledge of who had been approached and interviewed, there was

concern that the confidentiality of respondents should not be compromised, and particularly the situation was to be avoided whereby RTCN used the information contained in the reports as 'sales leads' with which to lever their way in to particular companies, although it had to be accepted that RTCN were intending to use the reports in a more general way as indicators of where possible future service developments might fruitfully lie.

3.7 Conclusions

This chapter has outlined the reasoning behind the overall research design and choice of methods. An intensive design utilising qualitative methods was felt to be appropriate to investigate the *process* of product development within individual firms, whilst bearing in mind their connections to wider social and economic networks. The procedures for company selection, methods of data collection and analysis have been discussed for both case study and second-stage interview components of the research. Difficulties encountered and potential methodological limitations which have been encountered during the course of the research have been detailed, as have those steps taken to counter these. Finally, pertinent methodological concerns relating to the corporate interview and ethical issues relating to the confidentiality of interviewees and data have been explored.

The following chapter will describe in detail the process of product development at case study companies, and identify those themes which were to be further explored in second-stage interviews.

4

Product Development: Case Study Evidence

4.1 Introduction

The overall aim of the research project is to examine and understand the processes by which manufacturing SMEs develop new products or improve existing ones, in the context of the CASE partner's primary interest in identifying instances of 'good practice' in product development management. As outlined in Chapter Three, an intensive methodology (Sayer and Morgan, 1985) has been identified as most suitable for achieving this aim, and the research has therefore been carried out primarily through face-to-face interviews with individuals within the target group of manufacturing SMEs who have had involvement in product development projects. A series of five case studies was undertaken to gain an in depth understanding of how projects had evolved and been managed *in practice*, through the accounts of all individuals within the firm who had had significant involvement in each development. By examining in detail and making explicit what processes of product development were at the case study firms, as well as how these were managed and organised, it was expected that initial research questions could be addressed. In order to meet RTCN's core concern of identifying 'good practice' in product development management, it was felt to be necessary to clearly establish processes and management practices, in order to try to establish what seemed to be more effective for the companies concerned, as well as any areas of difficulty which had been encountered.

The case studies are presented in the (chronological) order in which they were undertaken (although there was some degree of overlap between cases). The analysis is also presented as it developed sequentially, so, for example, comparisons are made between Firm B and Firm A, and then between Firm C and Firms A and B – so each subsequent case is informed by those that preceded it.

4.2 Overview of Case Study Companies and Projects

Case studies were intended to give detailed insights into the process of product development in a small number of manufacturing SMEs, and also the management of that process. Participating companies (as discussed in Chapter Three) were drawn from non-competing industries operating in three broad industrial sectors. Described at two-digit SIC code level (from the 1992 UK schedule) these were SIC 15 (manufacture of food products and beverages), SIC 29 (manufacture of machinery and equipment not elsewhere classified) and SIC 33 (manufacture of medical, precision and optical instruments, watches and clocks). A brief (and anonymous) profile of participating companies is outlined in *Tables 4.1* and *4.2*.

Previous research has suggested that a major influence on the actual process employed in a product development project is whether that development is a speculative one for the company[1], (and which can be said to take place 'off-line') or whether the development takes place as part of a contract to manufacture for a specific customer (Alderman *et al*, 2001). Firms A and B were both attempting to launch a more speculative product development on the market, for which they had no guaranteed customer. Firms C and D were both working on contract projects for specific customers. Firm E's development project was something of a hybrid between contract and speculative. Whilst the development was a contract for a named customer, Firm E decided to launch their own version of the product (identical in content but with different branding) concurrently. An overview of firm-specific project characteristics is outlined in *Table 4.3*.

A significant feature of the product development process at all case study companies was the difference between espoused and actual practices in the management of the process (canonical and non-canonical practices in Brown and Duguid's (1991) terminology), with the former illustrated through official company procedures, and the latter witnessed through the discussion of projects as they had happened. One intention in structuring case studies around an *actual* project was to avoid collecting only accounts of an 'ideal type' project management, which perhaps rarely happened

[1] Albeit one which may be aimed at meeting a well-established market need.

Table 4.1 Case study company characteristics I

	Sector	Year of Inc.	FTE	Turnover	Geographical Markets	Quality Accreditation	Competitive Criteria	Nature of Production*
Firm A	Engineering	1976	c.80	£1-5m	Largely UK and Europe, hoping to expand into USA.	ISO 9001 IIP	Technical; staff and company culture	MTO
Firm B	Electronics	1982	c.120	£6-10m	c.60% of UK market for core product. Sell internationally, but mainly N Europe	ISO 9001 IIP	First to market with products; reputation from being early market leader with core product	MTS
Firm C	Engineering	1978	c.180 (seasonal)	£11-15m	c.85% of business is in the UK, but also have overseas facilities	ISO 9001 ISO 14001 IIP	Technical; long established reputation for quality of products.	MTS CMTO/ETO
Firm D	Engineering	1971	c.90	£20+m	World-wide	ISO 9001	Technical and engineering capability; in market early for core product, so able to build reputation	CMTO/ETO
Firm E	Consumer	1930	c.100 (seasonal)	£6-10m	c.99% UK based. NE market is important.	IIP	Price increasingly important; looking to move into niche products with higher returns.	MTS

Key to Nature of Production categories: made-to-stock (MTS); made-to-order (MTO); customised-made-to-order (CMTO); engineer-to-order (ETO)

Table 4.2 Case study company characteristics II

	Markets	Competitive Environment	Internal Organisation	Company Culture
Firm A	c.90% of sales to original equipment manufacturers (OEMs) & remainder to distributors. Current aim is to set up own distribution company, hoping that this will bring them closer to customers allowing for an improved understanding of the market.	Competitors located mainly in Europe & the USA. Sector is becoming more vulnerable to low-cost competition & so Firm A is developing technologically 'value-added' (harder to imitate) products. Considering relocating manufacturing overseas.	Underwent management restructure during case study. Moving away from traditional functional departments towards cross-functional teams with a project-based focus (senior managers with specific area of responsibility, leading cross-function project-based teams).	Heavy investment in company-wide training. Interviewees suggest progressive approach to management (moving away from more autocratic regime of original founder). Four family members still on Board & holding senior management positions. Paternalistic sense of responsibility to "our people".
Firm B	Company has a diverse customer base with no over-reliance on any single customer or industrial sector.	Four main UK competitors & significant competition from Far East companies who offer low-cost high-quality products. Legislation monitored as this indicates where new market opportunities might lie.	Organised along traditional functional lines with engineering manager reporting directly to MD (although during case study project, had been to operations director, a post that was then phased out).	Currently the owner-manager (OM) takes a central role in the running of the company. Whilst a senior management team is in place, in practice most decisions fall back to him.
Firm C	Hire & service business (of Firm C's products but also engineering staff) accounts for c.60% of current business. Intending to reduce this to c.40% through corporate expansion. Customer base diverse in terms of no. of customers served, but somewhat over-reliant on oil & gas sector.	One significant UK competitor who was recently taken over by US firm, so now operating with significant financial backing. Several companies operate in one of Firm C's areas of expertise, but no others in both. Former design engineer has recently set up local competitor, also poaching some of Firm C's clients.	Senior management team of traditional functional areas, although with human resources managed by individual department heads. IT set up as separate subsidiary business and out-sourced off-site.	Interviewees suggested culture change has taken place over last few years, associated with current MD. Control has become less centralised with more power and decision-making delegated to senior managers.
Firm D	In its core product area has 95% of the global market (due to its early entry into the marketplace). This is under threat, however, as competitors emerge with their own rival systems. One customer accounts for 20% of turnover.	The only company offering a 'complete spread' of products in their core market, so have different competitors relating to different product areas. Were the sole global supplier of their core product until c.4-5 years ago.	Traditional functional areas are represented in the organisational structure, but the company sees itself as primarily an 'engineering firm' rather than a firm with an engineering dept. Few staff outside the engineering function. Fabrications normally contracted out.	Interviewees suggest a flexible and informal approach to management & a relatively flat and non-bureaucratic structure. Formal procedures in place, but the company is said to be not procedure-driven – things get done regardless. Preference is to not make use of external assistance except as a last resort.
Firm E	Products are split between those produced as 'own-label' for customers (multiple retailers who require an own-label version of a well-known brand) & Firm E's own branded products which are sold both through wholesalers nationally and direct to retailers in the North East.	Markets are becoming increasingly competitive and price-driven, dominated by multi-national corporations. Increasing numbers of small producers are going out of business.	Company is organised into traditional functional areas. Production and head office facilities are based on separate sites, six miles apart.	Current MD is a descendant of the original founder, but is trying to move away from a "family-firm mentality" towards a "more professional" approach. Some interviewees suggested the company retains a 'blame culture' where any mistakes made (even after a management-sanctioned risk) are publicly picked up on.

in practice. However, discussions also took place regarding the management of a 'typical' project in the company, both in the initial case study interview, where questions were posed regarding the company's overall approach to product development management, and also throughout the majority of interviews, where respondents frequently made reference to 'what we should do'. *Appendix 1* describes case study companies 'official' (canonical) approaches to product development management, and it can be seen that the formality of these varies between companies. What is described in the following case studies, however, is the project 'as it happened', or at least as it was described as happening by interviewees, and these accounts can therefore be seen as descriptions of non-canonical approaches to product development management.

4.3 Approaches to Product Development

The case study companies were not uniform in their approaches to product development, although all seemed to be attempting to move towards a more 'planned' and 'controlled' approach, characterised by interviewees at Firm E as a process of becoming 'more professional'.

All companies produced an annual business plan usually broken down into departmental targets, and which referred, with varying degrees of explicitness, to the company's product development plans. At Firms A and E, product development was treated (in the business plan) as a company-wide activity. In the planning of Firms B and C, it was equated with engineering department activity (although 'officially' at Firm B it was referred to as a company-wide concern, in practice this came down to engineering department targets and budgets). At Firm D, which, unlike the other four companies, primarily produced 'engineer-to-order' projects with very little speculative development work, product development was included in the business plan only in terms of an overall aim, along with an indication of where future sales might lie (in contrast to Firms A and C for example, who set a target for the number of new products to be developed during each business planning cycle).

Firms A and D additionally had more long-term product development strategies, although both of these were understood relatively informally. Firm A's was described as "not quite back of an envelope" (*Technical Director*) and was discussed on an on-going basis amongst senior managers and Board members, though to no particular timeframe. Firm D had no written product development strategy, but a shared understanding existed amongst senior managers and company engineers as to what it was. Firm E's business plan articulated an overall vision of how product development was to contribute to the company's future development, and there was a similarly shared understanding of this throughout the company.

With the exception of Firm E (for whom it was not appropriate), all companies were accredited with ISO 9001, and as part of this had written generic product development procedures in place. Firm E were in the process of introducing a more structured and controlled approach to product development management, and rather than a list of procedures, had produced a flowchart illustrating the route of a 'typical' product development project through the company, and highlighting 'critical control points'. Managers in the company were reluctant to introduce any more formality to procedures than this, fearing that an over-rigid approach might constrain product development activity. This was in contrast to Firm A for example, who had an extensive and detailed list of procedures which was said by two interviewees to go above and beyond that which was required by ISO.

Companies also exhibited varying approaches to who in the firm was involved in product development activity, as well as how this involvement was organised. Firms A and B both appointed project-specific cross-functional teams, although as has been suggested earlier, at Firm B, most product development activity fell back to the engineering department. Firm C exhibited a more 'over-the-wall' approach, with projects passing relatively sequentially between departments. Cross-departmental contacts (particularly between design engineers and production staff) were important however, but happened informally, rather than as a consequence of any planned cross-functional interactions. Firm D set up project specific teams which were then co-located to a separate 'project area'. These teams were largely composed of specialist

engineers (although as Firm D interviewees suggested, the majority of company employees *were* engineers), with input from production managers once a design went into production (and this would be fed back into future development projects). Firm E had a single product development team who managed *all* development projects with, in theory, members drawn from all functional departments. In practice, however, there was minimal involvement from production and operations staff, resulting in much discontent on the shopfloor.

Companies also had differing attitudes towards involving individuals external to the company in product development. Suppliers were uniformly accepted as able to provide potentially critical inputs and advice to projects. Firms A, B and E all believed that customer input was important to product development, but had difficulties in accessing such information. Firm C was cautious about involving customers in product developments, having concerns about divulging commercially sensitive information. Firm D, in contrast, sought to cultivate particularly close customer relationships, and was able to use these to its advantage in persuading customers to take risks on more novel development concepts.

Firms A, B, C and E were all open to and enthusiastic about using 'extra' external sources of inputs and assistance (for example, universities, trade associations, consultants, innovation support services and industry experts) as ways of supplementing their own internal resources and capabilities. Firm D, however, would only make recourse to such sources when no other option was available, seeking to enlarge their own internal capabilities in preference to relying on external assistance.

The remainder of the chapter describes a detailed (though anonymised) account of each case study, and is followed by a discussion of the themes which emerged through the course of this first stage of the analysis and which were then examined amongst a wider number of firms in the second stage of the research project. Project narratives should be read in conjunction with company and project descriptions presented in *tables 4.1*, *4.2* and *4.3*.

Table 4.3 Case study product development projects

	Project Description	Project Objectives	Assessment/ Justification	Specification	Planning	Project Team	Project Leader	Meetings/ Reviews
Firm A	*Development project* Scaling up (in size) of core product, so that co would produce full range of sizes & essentially be –one-stop-shop' for that product	To complete portfolio. US sales agent had identified market need & forecast high sales. Would extend co's sales area to the US.	Formal assessment stage of generic PD procedures bypassed in attempt to hurry product to market Justified 'in a touchy-feely way' (Director)	Product was already manufactured by the co in a smaller size, so essentially they felt they were just copying what was already there	Wrote project plan, but timescales were vastly underestimated. Were working to generic PD procedures which were written with much simpler projects in mind & weren't appropriate to the complexity of this one.	Initially had 1 large team, which wasn't felt to be working and so was split down into an executive team and a number of sub-teams relating to functional areas of the project.	Named project leader in place, but conflict between demands of project and his day-to-day responsibilities. Some confusion amongst sub-team members as to who was leading the project.	Sub-teams had frequent meetings (daily at some points), but executive team failed to meet. Project review went ahead 9 months later than scheduled in plan.
Firm B	*Development project* Part of large redesign of existing product range. Would build on platform of existing products.	Redesign of existing product range to improve aesthetics and technology. Part of overall drive to reduce inventory.	Originally approved by Board, then had been on back-burner for some time while other projects went ahead. Was kick started again at instigation of MD. No formal scoring system.	Software spec written by design engineer. Hardware was already in use on companion product, so no spec written.	Project plan written by engineering manager. Subsequent changes made to technical specifications of product, but no corresponding changes made to project plan.	Cross-functional team (though with bulk of development done by engineers). Project engineers working next to each other and this facilitated communications.	Had both project leader (responsible for day-to-day management) & project manager (overseeing project). Some confusion amongst interviewees as to who was in place. Conflict suggested for proj manager between his departmental responsibilities & project demands.	Large amount of informal contacts between engineers. External contact (from university) brought in to chair design reviews (& this ensured they went ahead on schedule). Post-launch review of product (not project).
Firm C	*Contract project* Based on co's core capabilities rather than existing products. Initially 1 unit produced for client, with subsequent re-order with slightly changed spec.	To meet client requirements. Felt project would be a useful addition to their portfolio & might be of use in securing further orders.	No formal assessment – felt there was merit in doing the job.	Very detailed specification from client company (which was felt by engineers to facilitate design).	No planning done by Firm C because engineers felt they were short of time and also because they believed that close client contact would make it unnecessary for them to produce a formal plan.	Firm C design engineers worked directly with client company engineers. No other involvement from Firm C. (Fabrication was subcontracted).	Project was led and managed by engineers from the client company.	Weekly meetings with client on initial unit, plus phone contact. Fewer face-to-face meetings on second unit, but daily contacts between client & Firm C engineers.

	Project Description	Project Objectives	Assessment/ Justification	Specification	Planning	Project Team	Project Leader	Meetings/ Reviews
Firm D	*Development & Contract* Initial development project to demonstrate novel technology to clients, and two contract projects which followed on from this.	Co were being squeezed on price with one of their products, and so decided to redesign in order to give them a technical advantage over competitor products (for which they could charge a premium price).	Co engineers invited to brainstorm & subsequently review possible ideas. Final decision was with the MD and the Board. No formal scoring system.	Initial development project had brief rather than spec since it was classed as an 'internal project'.	Plans written for both development and contract stages of project. Emphasis on the plan as a living document. Two plans in existence – one which the client will see and an annotated version which is the engineers working plan.	Almost all employees are engineers, so felt to be little scope for cross-functional involvement. Project team is co-located to separate area. Production staff involvement from when first unit is built.	Project leaders for both development and contract projects.	Most contact on project is informal & facilitated by co-location of project team. Some design reviews scheduled into plan which client will attend.
Firm E	*Contract & development* Initial approach from existing client to produce a 'match' for a product already on the market. Firm E decided to do parallel development of their own branded version of the product.	Volumes required in initial approach by client were too low to justify cap ex which would be necessary to go ahead; Firm E thought it worthwhile doing an own branded version (since this would fit in with their strategy of niche production) & this also justified expenditure.	Have formal scoring system, but will use this flexibly, i.e. this project was not initially within their capabilities (and so would have achieved some low scores) but was felt to be worth pursuing because it fitted in with their overall strategy.	Brief from client.	With this project Firm E were for the first time trying to put some structure into managing the development process. Had a timetable in place & generic flowchart of how project would be expected to progress through the company, but no written plan.	Cross functional team is responsible for the production & launch of the project, but not for the development phase, which is managed by the senior management team.	Absence of effective leadership was raised by several interviewees. The company plans to introduce a product champion role to address these concerns on future projects.	Team responsible for bringing product to market meet every two weeks to discuss all on-going development projects. Meeting to brief production staff was held c.3-4 weeks before the product was due to be launched. Aware of need for post launch review of project and product.

4.4 Firm A

The company was established in 1976. The original founder of the business retired in 1981, when control of the business passed to other members of his family, with four family members currently having a seat on the board in addition to their involvement in the day-to-day management of the company.

4.4.1 Project Narrative

The project identified as suitable for further study was the extension of an existing product range, where a current core product was to be scaled up in size, allowing the company to offer the product in an expanded range of sizes, believed to be required by the marketplace.

The original stimulus for the project was a perceived demand from customers to be able to deal with the company as a 'one-stop shop'. A US sales agent for the company (and ex-sales president of one of their competitors) forecast sales of $3 million dollars within two years if the complete product range was available. It was hoped that this would go some way towards correcting the company's over-reliance on a European sales area, and was to be targeted towards the distributor market, thus attempting to address the perceived OEM/distributor sales imbalance. Since the project basically involved the scaling up in size of one of the company's existing products, it was perceived to be a realistic and achievable aim.

The company's American sales agent collected information on similar products available in the US, through acquiring either drawings or actual products which could then be reverse engineered (a way of learning from competitor products [Pavitt, 1990]). The marketing director was assigned as project leader, and began to pull this information together in a database. The technical director assisted in rationalising this data and in advising what was technically possible in terms of media and dimensions. At this stage the project was seen as a marketing exercise, with attempts to pull together information on marketplace pricings and costings.

The project was approved by the senior management team, and this decision was ratified by the board, although no formal or serious justification was done at this stage. Initial stages of the generic product development procedures were bypassed in an attempt to hurry the product to market and satisfy perceived customer demand.

A project plan was written in line with the company's generic product development procedures, however, it proved to be unrealistic with its suggested timescales, the size and complexity of the project having been vastly underestimated.

A team structure was set up to manage the project, initially comprising a single team with members from all functional areas, scheduled to meet on a weekly basis. This quickly proved to be unwieldy and failed to meet targets, and so was split down into an executive team of senior managers (comprising the finance director, logistics director, technical director, marketing director and manufacturing director) and a number of sub-teams. The executive team was intended to meet on a monthly basis in order to review progress. The sub-teams addressed what were felt to be the key areas of the project (purchasing, design and production), and each had targets in place and team leaders who were intended to liase with each other and report back to the executive team.

The leaders of the sub-teams met with each other on an almost daily basis, but lacked confidence in the information they had available, and whilst a number of technical problems were overcome, they ultimately felt unable to make any significant decisions or progress the project. The executive team failed to meet its target of a monthly meeting, assuming that the sub-teams were making satisfactory headway with the project. Some months in to the project, the sub-team leaders were feeling increasingly frustrated and demotivated by their lack of progress.

Eventually two sub-team leaders arranged a meeting with the technical director to discuss their concerns. Following this, a new sub-team was created (of which the technical director was a part), and existing project responsibilities were redesigned, and new actions and timeframes agreed.

The project was reviewed nine months later than originally scheduled, with the assistance of consultants already working for Firm A on an unrelated issue. At this meeting, the decision was taken to terminate manufacture of the product temporarily, and instead to buy in component parts for assembly, until such time as there was an increase in the volume of orders and manufacturing became economically viable.

4.4.2 Issues Affecting the Progress of the Project

The project apparently promised a solution to several of Firm A's concerns regarding the company's over-reliance on a European sales area and low sales to the distributor market. Projected sales by Firm A's US sales agent were used to justify the project going ahead.

BOX 4.1

This guy in America said that if you get me these big ones then I can sell the whole range … It was obvious that we had to have a full range, because they wanted a one-stop shop. They liked what we already produced, they said we don't want to swap suppliers yet, we want to be able to buy the full range. *So we knew the market was there.*

Director of Logistics [emphasis added]

[*The sales agent*] came on the scene and that was the real pick up and drive. He said he could get us three million dollars worth of sales in the US in two years if we had a product line to give him.

Technical Director

However, in practice, sales failed to meet anything approaching these initial expectations, and interviewees suggested that in retrospect a significant problem had been their only partial market analysis - they had only been able to gather inadequate information regarding potential market size and had taken the projected sales figures suggested by their sales agent at face value. The company went into production without knowing either how much individual units of the product would cost to make or what they could be sold for. It seemed, however, that the American sales predictions were too good not to believe, and the project was allowed to go ahead by both the management team and the company's board of directors (although in fact, there is considerable overlap in membership between these two bodies), without any

formal assessment or justification process, as is stipulated in Firm A's quality procedures.

BOX 4.2

The fundamental mistake was we actually didn't work out, when we said yes, we said yes at a sort of touchy-feely level, instead of actually how much money we would get from the project.

Marketing Director

To be fair to this, basically on such a major project we're going to go ahead and do this aren't we? ... There was always a desire, you might say a slight disease, saying let's get on with it, rather than shall we consider whether we should really do this or not. You can always kill something just by analysing it to death, there's got to be a balance, but our balance was far too heavily geared towards activity rather than analysis.

Technical Director

Whilst a project plan was written for the development, both the size and complexity of the project were underestimated. Since the development involved the extension of one of the company's existing product ranges, it was felt initially to present only a minimal technical challenge and to be well within the company's existing technical capabilities.

BOX 4.3

There was a gross underestimation of the work involved from day one ... It was a big project, bigger than people thought, more part numbers and more technical things to it than we first thought, it grew to be bigger than we expected.

Director of Logistics

The problem was that we'd imposed an unrealistic timescale of being six months or something, and it really needed to be a year and a half. So I mean we threw out... the problem is if you throw your plan out then you've got nothing to travel with, you've got no map. That was part of our problem, we were unrealistic in our timescale, which created problems.

Marketing Director

Project leadership on the development was suggested by interviewees to be largely ineffective. Whilst a named project leader (the marketing director) and an 'executive team' were theoretically in place to oversee the sub-team structure and keep the project on track, in practice they failed to make any interventions in the project until quite late on. There was confusion amongst sub-team members as to who the named project leader actually was, and as the executive team failed to meet, or to offer any

guidance or assistance to the sub-teams, sub-team members felt increasingly abandoned. The marketing director, although nominally in charge, was at the same time attempting to set up distribution channels for the project in the USA, and so the attention he gave to the project was suggested to be diluted. Assumptions were made at an executive level about the abilities of sub-team leaders to 'project manage' the development, although in fact none of the sub-team members had received any project management training.

BOX 4.4

[*The executive team*] was meant to meet once a month to review progress ... That team started off meeting, but didn't meet. It assumed that the other teams were going on alright and didn't make the time to meet ... People's commitment to get things done was very high from the operational team. Where it fell down was at an executive level ... On such a major project there needs to be a senior manager always leading the review process, and that was left to drift a bit. We let it drop down a level assuming that that level would actually deal with it, but it was too much too soon.

Technical Director

Whilst executive team members failed to meet in their project team capacity, all members of the executive team additionally were part of the senior management team and also the board of directors, and so were more regularly together at these management meetings. Assumptions that were made at the executive team level regarding the satisfactory progression of the project were carried through to senior management and board level, and no formal review of the project was carried out until nine months later than scheduled in the original plan, by which point, timescales had slipped to a significant degree.

At the sub-team level, communications between members were frequent. Meetings were held (at some points in the project) on a daily basis in order to try and progress the development. However, since the executive team did not meet, there was no forum for the sub-team representatives to report back to, and the development at this operational level appeared to hit a wall beyond which the sub-team members felt unable to progress. Whilst company executives emphasise the existence of an open culture characterised by the approachability of all members of staff, in practice it was several months before the sub-teams drew attention at a more senior level to their lack of progress.

4.4.3 Discussion

Managing product development has been suggested to be a learning process (Bessant *et al*, 1996) and Firm A could be seen to be in the process of learning to manage product development in a more formal way. Whilst the company had bought into (at least at a canonical level) the idea of a formalised approach to managing development projects (a 'best practice' approach), and had established an elaborate set of product development management procedures, in practice, they struggled with several parts of the process. Retrospectively, whilst senior staff within the firm are critical of what they perceive as failures in project management, the project has come to be seen as seminal in influencing the way that future projects will be managed.

BOX 4.5

This one, along with [*an earlier project*] basically pioneered the structures for how we run our projects in the future. And we still got a lot of things wrong with [*this*] project, but it's how that then needed to be improved, so it's quite an important project for us. Regardless of whether it was a success or failure, it's highlighted where we can do better next time.

Marketing Director

There was minimal customer involvement on the project, and this is perceived by Firm A to be a general problem. Currently, their knowledge of the 'end-customer' comes second hand from distributors and sales agents. The company feels itself to be remote from its market, and this is compounded by a dearth of commercial market research on their product areas. There is a belief within the company that an increased closeness to customers would be beneficial in ensuring that customer needs are understood. Product development is framed in terms of 'problem identification' - if customers' 'problems' can be identified, then Firm A will be able to come up with a design which 'solves' those 'problems', and such 'solutions' are then expected to have greater market potential, because they will reflect more closely customer needs.

BOX 4.6

We're not getting as many [*ideas*] as we would like bubbling up from within the company, and I think that's partly due to people's exposure and what they're exposed to in the marketplace. If they're not exposed to the problems then it's difficult to come up with the solutions ... if everyone was given fair chance to hear – here's the problem, let's get the ideas out – I'm sure everybody could put ideas in. It's not so much the ideas though, it's identifying the problem in the first place that I think is difficult.

Technical Director

The 'front-end' of the project was suggested to be particularly problematic, both with respect to establishing the potential market available for the product, and, linked to this, the absence of any formal or adequate justification for whether the project should go ahead. Planning the development also caused difficulties, with both the size and complexity of the project substantially underestimated. The development deviated from the original plan, but also in several places from the company's generic product development procedures.

BOX 4.7

It didn't follow our procedures, probably because it had to be got to market fairly quickly.

Director of Logistics

That's what we should follow ... all this first part was bypassed in a rush to satisfy [*the company's American sales agent*]. So all the justification, business plan, justification review was all done during the project and not at the start.

Technical Director

One particular supplier involvement in the project was felt to be critical, and this was an alternative manufacturing technique for one of the bought-in components of the product, which reduced the finished cost considerably. Overall, however, senior managers suggested dissatisfaction with the company's supplier relationships, and the area of purchasing was one which had been reassigned between managers in the interval between initial and follow-up interviews.

Although 'other' external relationships (for example with trade associations, universities, support agencies etc) were not critical on this particular project, Firm A maintains a database of potential contacts and sources of inputs, and the technical director in particular stressed the importance of this network of potential contacts as a way of supplementing what the company itself was not able to do.

In summary, therefore, the case study of Firm A highlights several issues which appear to be significant regarding the product development process and its management. Undertaking product development can in itself be an opportunity to learn about what does and does not appear to work in product development

management. Mistakes or areas of difficulty highlighted what could be done better in the future. Implementing 'best practice' management techniques could, however, be problematic - whilst a company may have formal procedures in place, it may also experience difficulties in working with these. Effective project leadership appears to be important in ensuring that projects are not allowed to drift, but instead meet planned targets and objectives. The front-end of a development project, including the selection of projects and the subsequent planning of those developments, may be an area of particular difficulty. In particular accessing sufficiently accurate market information may cause problems. External contacts have been suggested as a potentially critical source of inputs to product development projects.

4.5 Firm B

The company was established in 1982 by the current owner-manager. Phases of growth in the company's history have largely been associated with the introduction of new products. Firm B bought out a company offering similar product range (based in the South of England) some five or six years ago, and are intending to expand further (also through acquisition).

4.5.1 Project Narrative

The company's core products, whilst still functional and in use, were felt to be in need of an aesthetic and technical redesign to stay ahead of competitors who were attempting to challenge Firm B's position in the marketplace. Several new products were introduced as part of this overall programme of redesign, each of which built on some aspect of the technology of the previous new product to have been introduced. The product chosen by the company for study was the most recent and also the simplest of the developments, and was intended to be a low-cost and relatively unsophisticated device, characterised as 'entry-level' and aimed at the novice user, or those users without extensive technical needs.

The plastic enclosure that the electronics and software of the product would be housed in had been in existence for about four years at the time of the first interviews. This enclosure was designed externally by a design consultant, and the project

management of the manufacture of the mould tool contracted out to a local company, who subsequently themselves (and with Firm B's agreement) subcontracted the project to a company in Korea. One of Firm B's design engineers put together a brief user interface specification document detailing how the project would work, and this was circulated to senior management.

A key objective was to replace existing products with a more aesthetically appealing range, however, problems emerged in the development of the enclosure mould tool and there was a breakdown in relations between Firm B and the original company to whom the project management of the mould tool had been contracted. Further to this, other contracts came along which meant that the development of the product, intended to be both manufactured and sold at a low-cost, was put on a back-burner, as product developments with higher revenue earning potential went ahead.

Both the product and its sister product, of which it was a simplified version, were to be housed in the same plastic enclosure, with only minor modifications to the plastics necessary. These could be done in-house by Firm B. Additionally, the two products shared a number of common components and assembly procedures. Once the sister product was ready to ship, development began in earnest on the simpler version, some four years after the initial decision had been taken to go ahead with product redesigns.

A product requirement specification was written by the marketing manager, detailing product functionality and an initial development schedule. This specification was not, however, assessed or reviewed by the board (a 'stagegate' set down in company procedures). Based on this specification, the engineering manager put together a project plan and assembled a project team, with initially himself, but later the operations director in place as overall project manager. Two design engineers were allocated to the project, one of whom was assigned project leader. The remainder of the team was made up of a mechanical engineer, (who also doubles as a production engineer for the company), and representatives from marketing, finance, purchasing, the manufacturing cell responsible for assembling the product, PCB assembly and a materials scheduler.

Schematics for the project were drawn up by the two design engineers. No technical specification was necessary for the hardware of the project, as it was essentially identical to its sister product, which by this time had gone into production. Software specifications were written by the project leader and an outside contractor, based in the north west of England and regularly used by Firm B, was commissioned to write the software.

The product was operated by means of a rotary switch, and since the company had no experience of working with such a mechanism, assistance was sought from an industrial design centre at a local university with whom Firm B had a pre-existing relationship.

Conformance testing was carried out on the product in-house. Three or four models were sent out on customer field-trials arranged through the sales department. Information which came back from these was not felt to be as useful as had originally been hoped, and Firm B's engineers therefore designed a series of 'customer abuse tests', intended to simulate the worst operating conditions a unit would be expected to have to meet. It was decided that for the first time, the unit would be calibrated automatically (the expectation was that ultimately this would cut development times), and to this end a parallel project to produce a calibration rig was set up. Whilst this rig had its own project number, no additional resource was made available to progress it, and the length of time it took to develop served to delay the original project.

Project meetings were held throughout the development, principally in response to problems which arose or deadlines which were approaching, but were mainly informal. Frequent informal contacts between engineering staff were facilitated by their working in a common space. For a period of some six months, a representative from a local university industrial design centre came into the company to assist in the chairing of design reviews on the project. The engineering manager was concerned that review meetings, seen by project staff as 'non-value adding' tended not to go ahead, and bringing in an external representative to these was designed to counter this.

The project overran its initially estimated timescales. Design engineers suggested that this was partly because changes had been made to the original specification for the project, although without corresponding changes to the project plan, but also as a result of difficulties in estimating the duration of subcontracted work. The software subcontractor had been asked for an estimate of how long the software would take to develop, and this had been included in the original project plan, however, he failed to complete within his estimates.

A post-introduction review was held three months after the launch of the product, where some necessary design changes were flagged up. Feedback was also given to the engineers from the production department and the sales team regarding issues which were felt to need attention.

4.5.2 Issues Affecting the Progress of the Project

In common with Firm A, Firm B appeared to have difficulties in their management of the 'front-end' of the project, particularly with regard to their reading of the potential market for the product. At the follow-up interview with the engineering manager, it was suggested that had sales projections been more accurate, the development would not have gone ahead. Sales were far lower than predicted, with customers showing a preference for the more sophisticated sister product. This perhaps indicates there was a need for more complete market information prior to the start of the development, or an improved justification or assessment process. The gap between the time when the company initially decided that the development was necessary, and the point some four years later when it finally went ahead, was ample time for the market to have changed. Although company procedures suggest that any potential product ideas must be presented to the board, in practice, this did not happen for the project discussed, and was suggested by one engineer to be in all projects less negotiated than it appeared to be in official procedures.

BOX 4.8

Primarily between [the other project engineer] and myself, with input from [the purchasing manager], and having come to - well you can either choose that way or that way, then we present it to marketing - take your pick but this is the one we prefer, and [*name*] at that time was the marketing guy, he gave us some useful pointers as to how he thought the market ought to be. And of course the final say really was [*the MD*], who if it's something he doesn't like will make it very plain it ought to be done another way.

Design Engineer

Again in common with Firm A, problems were experienced in project planning. Timescales were underestimated, particularly the length of time it would take to develop software for the product, possibly reflecting the fact that historically, software has not been part of the company's expertise, involving a reliance on subcontractors. Specifications for the product were changed (to enable a 'European' variant to be designed), but the project plan was not correspondingly altered.

BOX 4.9

We're just finishing now [*six weeks late*] and that's basically due to slippages and people changing specs ... if someone wants something changing we'll change it, and we don't take into account what's happening in engineering, the time it might add to our job.

Project Engineer

These difficulties in planning were suggested almost as an inevitable part of project management, and were not thought to be specific to Firm B.

BOX 4.10

We don't hit targets at the minute in terms of development times, it always overruns. The more people I talk to, including our competitors, it's a common disease in product development. Everyone puts a timescale down and overruns it.

Engineering Manager

Some confusion was evident amongst project team members as to who was in place as either project leader or manager. This perhaps indicated misunderstandings regarding the management structure of product development projects within the company, with both a day-to-day project leader and overall project manager in place. It was argued by the operations director that whilst engineers were expected to act as project leader, this was hampered by the absence of any project management training. The parallels with Firm A are again striking. Overall, however, it was suggested that the position

of project manager (ultimately overseeing and managing the project), should be held by a senior company manager, since there was a need to have someone in place with authority over members of staff across all functions of the firm.

BOX 4.11

The other issue sometimes is the level of authority they have within the business. If you have someone who's below manager level as a project manager, they don't have the same clout ... because it's a cross functional project team, if there's an issue with the performance of someone from outside the engineering department, someone at managerial level could go along to another head of department and say there's a problem with xyz.

Engineering Manager

Finally with regard to project management, it was suggested that a commitment to managing a development project comes at the expense of 'real' work in the company. Project managers, operating at a more senior level, were suggested to focus more on their 'regular' management duties at the expense of the project, whilst for engineers, day-to-day project leadership could be a distraction from their 'real' design role.

BOX 4.12

There's supposed to be a manager over the top, a project manager, and they're supposed to push things along... [in some cases] the project manager has had very little to do with the project. Obviously they look after their own work best, and new products are left in the engineering department.

Production Engineer

[T]he design engineer has a big input in the project and quite a lot of control, and a high level of responsibility, but the difficulty is that they're so involved in the design process, that project management if you like, is a distraction from their core activity.

Engineering Manager

The company experienced some difficulty in the management of subcontractor relationships, both with the software contractor, and also with the company contracted to manage the development of the mould tool, where the relationship completely broke down. However, some technical problems on the project were overcome because of the company's close relationship with existing suppliers, and cultivating these relationships was a deliberate strategy.

BOX 4.13

Once you build up a relationship with them, you know they get repeat business, and buyers have one set of relationships with people and they fight over prices, and engineers speak to different sets of people in an organisation and build up a relationship with technical guys who they can discuss problems with, or they'll give you a phone number or another contact. It's just networking really, it saves you so much time if you've got direct access to people who know the answers.

Engineering Manager

People do let us down, but in other ways people are very good with us, turn things round in days sometimes.

Lead Design Engineer

I have a fairly close contact with the suppliers, I'll happily go off-site to see them, especially when we've got new products. Sometimes it's easier to sit down and say - this is what I've got, this is what I want to do, can you think of a better way of doing it. Rather than me waste my brain cells, I give them the problem because they're the experts... see what they can come up with.

Production Engineer

4.5.3 Discussion

As has been suggested in the preceding account, many common features can be identified between Firm A and Firm B's case studies, suggesting perhaps that particular areas of the product development process are both more difficult *and* more critical to get right. Specifically, both firms struggled with the 'front-end' of their project, substantially overestimating their sales forecasts and thereby going ahead with projects which, with the benefit of hindsight, would not have been undertaken. Also, both firms experienced difficulties in planning projects, underestimating the length of time that each development would take. The engineering manager from Firm B suggested this to be almost a universal problem, common to all companies undertaking product development, and this overrunning has been identified by earlier studies to be so common as to be almost thought of as the norm (Maylor, 2001).

Like Firm A, Firm B have instituted sets of quality management procedures (including ISO 9001), and have a detailed set of generic product development procedures arising out of this. Both firms, however, struggled in keeping to these procedures. Neither project went through a formal justification stage. Procedures were recognised to be in place, but were not necessarily followed. Thus, as Brown and Duguid have suggested (1991), there was a visible difference between canonical (official) and noncanonical (actual) procedures.

BOX 4.14

There's always been systems there, but they haven't been adhered to, and there were impulse decisions perhaps that we should embark on a project or on gut feel, rather than on business processes.

Engineering Manager

We need to keep a tighter rein on what's happening, people just don't sign off things, we don't draw lines under it... There are procedures in place, but they're not followed as tightly as they should be.

Lead Design Engineer

Retrospectively, senior managers at Firm A have come to see their project as a seminal learning experience for future product development management. This has not been the case at Firm B, however, where project reviews have focused on how the product is performing in the marketplace. Learning how to manage product development processes appears to be a central concern at both companies. Being 'better' at product development (by which interviewees meant having less developments which ultimately failed in the marketplace), was identified as a way of increasing competitiveness. Firm B senior managers took a more general overview of past project failings ("We always overrun" for example), whereas Firm A senior managers named specific projects as their sources of learning for future project management frameworks.

The importance of informal interactions in facilitating learning during the design process was also suggested by interviewees at Firm B. The co-location of project teams was felt to be a desirable goal because it was believed this would increase and enable informal learning. Allowing engineers to work together on projects was recognised as having already produced specific benefits.

BOX 4.15

We found that if we put two engineers on a project we get big benefits, not just pro rata in terms of the fact that there's two heads, but there's an interaction between the two, there's almost an on-going review process as well, so mistakes are less likely, and in terms of slippages, there's always another person around to pick up issues, there's always two people up to speed on what's going on.

Engineering Manager

> [The other project engineer] and I work literally on adjacent desks, so there's a lot of conversation between us. He tends to do most of the conformance work, whereas I do more of the electrical design. So if we come up with a problem, we sit down and we try and figure out what the problem was and how to solve it.
>
> *Design Engineer*

Cross-functional teams were suggested by the engineering manager to be particularly beneficial in producing a robust product design, but also in promoting a shared sense of 'ownership' around a project.

> *BOX 4.16*
>
> Anything that involves people from different backgrounds and different ideas, different ways of thinking, it's not so blinkered. Engineers are engineers, they're great at certain things, but you need input from other people to give the thing a broader horizon ... Everyone gets so excited about it, everyone wants to contribute. When there's a problem people ... get away from the idea of 'that's an engineering problem, it's not my job' to 'how can I help, it's my project'. Once you get people enthused about it, certainly when you have these cross-functional teams, they all want to contribute, not to their own little bits but to all other aspects.
>
> *Engineering Manager*

Conflict was suggested as inevitable when people with different functional backgrounds worked together, but this was not viewed negatively.

> *BOX 4.17*
>
> You've got to have conflict to make it work, people have got to disagree to discuss it. If everyone goes into a project meeting and agrees with each other, they just move as a collective in whatever direction. So you need people in there with different outlooks, attitudes, backgrounds.
>
> *Engineering Manager*

However, the size of the firm meant that there were limitations to how cross-functional teams could be staffed and used. Firm B's experience is therefore suggestive of a basic tension between the 'best' or 'good practice' prescriptions offered to firms (for example, in the 'rationalist' technology management literature) and what they are able to do in practice.

> *BOX 4.18*
>
> We have project teams, they're cross-functional. But of course the problem with small businesses is that you've got this one guy going from one project meeting to another.
>
> *Managing Director*

> We're a relatively small business so we haven't got the resource ... we only have one buyer, one purchasing person, one materials scheduler, one marketing guy, so we can't have big project teams comprising a full set of people on each one. We have to consider that in the planning process.
>
> *Engineering Manager*

As at Firm A, external contacts were seen to be of potentially crucial importance. Bringing in external assistance on a project was suggested to be a strategic decision, and one which could ultimately be of benefit, not only in bringing additional knowledge into the company, but also in ensuring that project objectives were met.

BOX 4.19

> There is a time when you need outside help, and it's recognising that. Rather than beating people over the head and saying get that done, it's recognising when people have done their best, if you leave them any longer the project timescales are going to slip, and it's making the strategic decision to involve someone else, even though there's a cost associated with that.
>
> *Engineering Manager*

In summary, Firm B's case study appears to reinforce a number of issues suggested by the experience of Firm A. Managing the product development process is itself a learning process for companies. Whilst a company may have a set of formal (canonical) procedures in place, these do not necessarily reflect how things will be done 'in practice'. Project selection and assessment again appears to be a particularly problematic stage of the product development process, and as at Firm A, great value was placed by Firm B on the external sources which they could tap into for supplementary inputs into the product development process. Project planning and effective project management were again suggested to be of importance, but as at Firm A, were not felt (by interviewees) to have been satisfactory on the project discussed. The seniority of the overall project manager within the company was highlighted as important in ensuring effective project management. Finally, the importance of informal learning through everyday interactions between engineers within the company has been suggested.

4.6 Firm C

The company is independently owned and was established in 1978, with the original owner-manager of the firm still in place as a director of the firm. Initially the company acted as a UK sales agent for a US manufacturer (now a competitor), but products that were sold were not felt to be entirely suited to the UK market. Firm C therefore set up its own operation, designing and manufacturing a range of products built around a particular technology, for the oil and gas, power generation, civil engineering and heavy engineering industries. Subsequently, a hire and service business has developed around these products, with not only Firm C's products, but also specialist engineering services hired out

4.6.1 Project Narrative

The project selected for study was an atypical development, both in the nature of the product itself in that it was a design 'solution' for a specific customer, with little in common with core products, but also in the way that the project came into and was managed within the company. The product was a development for a company in Lancashire, who had not had any previous contact with Firm C, but who had remembered their name and expertise from a trade exhibition.

The client company made an approach to Firm C requesting tooling for a particular application. Unusually, this request was made direct to the design department rather than the more common route of through sales, however, it was suggested by the lead engineer on the project that this was because of their client's desire to deal only with technical people. The project had little in common with Firm C's existing products, but was based around their core technology. Specifically it would incorporate two areas of their particular expertise, and it was felt by the technical manager that the development would be a useful addition to their portfolio in terms of securing future orders. All contact on the project between Firm C and their client company was via the respective engineering departments.

A specification was sent through by the client, and Firm C put together a proposal estimating pricing and delivery times. The client was not happy with Firm C's initial

design suggestions, and came back with a concept of their own, based on another product which they had seen, in the form of drawings and a more detailed specification. Delivery dates were also to be moved forwards. Firm C did some more basic design work and this time the order went ahead.

The client initially ordered three units. Design was done on Pro/ENGINEER, with one designer doing the initial design and finite element analysis or FEA (to identify points of stress on the design), and a second working on the detailed design and sourcing of materials.

An initial meeting with the client company engineers took place at Firm C's headquarters, and this was followed by weekly meetings between engineers from both companies to check on progress and resolve any problems. Meetings were minuted by an engineer from the client firm, and a copy of these sent to Firm C to be included in their design file. Engineers at Firm C had a significant amount of informal contact regarding the project between themselves. Formal design reviews at Firm C were not felt to be necessary, given the frequency of meetings with the client.

The agreed time for the development was twelve weeks, which left Firm C engineers feeling themselves to be working under pressure. No project plan was written by them, as the engineers felt that they didn't have the time to plan - the pressing need was to get on with the development. However, it was also believed that the frequency of meetings with the client would keep the project on track. Effectively therefore, Firm C handed over responsibility for planning and managing the project to the client company engineers, working to weekly deadlines which had been set for them.

Manufacture was subcontracted, since the product required welding and Firm C's own machine shop was unable to do this. The decision of who to subcontract to was made by Firm C design engineers working on the project, and again this was unusual, since such a decision would normally be made by the purchasing department.

Once component parts had been manufactured, they were returned to Firm C for assembly. Also because of perceived time constraints, the prototyping stage had been skipped, although as the product was not a highly stressed piece of equipment, this was not felt to be a problem. Assembled units went straight into strain-gauge testing, and since there was a high correlation between these results and the FEA, further redesign was unnecessary. The client company witnessed some of the testing that Firm C did, but also trialed the units for a period of time once they had been delivered.

There was no post-introduction review for the project. However, the client company subsequently ordered a further three units in a different size and built to a slightly different specification. There was therefore some redesign to the original product, and at a meeting at the client's facility in Lancashire, engineers from Firm C were able to observe some further problems which had emerged on the product since it had gone into use. These issues were also addressed in the redesign, and took into account comments from the client company's operators who had been working with the product in the field. Meetings with the client on this second phase of the project were much less frequent, occurring at the rate of about one a month over a four month period, however, phone contact between engineers at the two companies was almost daily, and was felt by Firm C engineers to be very important.

4.6.2 Issues Affecting the Progress of the Project

Both the regular and intensive contact which Firm C engineers had with the client company, and the detailed specification produced by client company engineers were felt to facilitate the design.

BOX 4.20

It went well because of the high specification from the client. If you have a good set of parameters to begin with you're quite focused, and you can get through things more quickly ... That tends to be how it is with specials and customer projects, you tend to get a good spec from external customers.

Design Engineer

It was suggested by Firm C's technical manager that an area with which the company's design engineers sometimes struggle is 'defining the problem' which needs to be solved by a product development solution (as at Firm A – see *Box 4.6*). On 'special' and 'solution' contract projects, this problem has already been made explicit by the contract client company. When a project is an improvement to or new version of a core product for the company, engineers are less clear about what they are designing for.

BOX 4.21

Our design team are very good at designing answers to problems, where we fall down sometimes is creating the problems for them to design. For instance, if we look at a solution, we did a concept for a client, we had two weeks to turn round the concept - we did it. If you'd said that was a new product, we'd have been three months to get to that stage... and the thing is, the customer's identified it, he's got a specific problem, and what we need is to get our specific problems identified.

Group Technical Manager

This particular project was handled by the design engineering department in the company, with no other functional involvement. On core product developments (i.e. speculative projects rather than contracts for specific clients), whilst the sales and marketing director suggested some involvement for other parts of the company, it would appear that this in practice can be quite limited, and that the company takes an engineering centred view of the product development process. It was suggested by engineering interviewees that a marketing input to projects is often lacking, due to resource constraints within the marketing department.

BOX 4.22

We try and bring marketing and sales, and technical support, and design and manufacture and service personnel into a group when we're discussing a particular product development. So that we're getting input from all the people who can have knowledge of the existing products, not just ours, but our competitors.

Sales & Marketing Director

I think ideally we'd love for someone to come along from marketing and say that's the design specification, design something to that, but I don't think at the minute... we haven't got the people to do it.

Design Engineer

Informal communications between the design and production departments were important, and were facilitated by the fact that the company's design engineers have all previously worked on the shopfloor, and so understand the company's production capabilities, and also have established relationships with production staff.

BOX 4.23

It's not that big a place you know, so you just nip down and have a bit crack with the lads, and they're always coming up and asking what do I do with this, what do I do with that ... myself and all the lads in the design department have got quite a good engineering background, we've all served our time, we've all worked on the shopfloor, we've done all the machine work, we know how things go together and what you can and can't machine ... and I think a lot of the time we tend to speak to production and say what do you think, would you like to make it slightly differently or whatever.

Design Engineer

It was suggested by the group technical manager that a weakness of Firm C's project management was its more 'over the wall' approach, with the project passed relatively sequentially between functions and no-one in overall charge of a project, championing it through the firm from start to finish. As at Firm B, where engineering staff became involved in project management, this was seen as potentially marginalising their 'real' work.

BOX 4.24

I'm finding that what we haven't got is someone who runs with the product, it's tending to be the designer. Now what that means is he's then not designing, he's doing bits of everything and being a project leader.

Group Technical Manager

Project planning and management was effectively taken out of the hands of Firm C's engineers by the client company, who largely drove the project in terms of arranging meetings and setting actions and targets. Firm C staff appeared happy for them to take this responsibility, and did not implement any project management of their own.

4.6.3 Discussion

The development was said by interviewees to be not typical for Firm C, and therefore, perhaps not surprisingly, illustrates the largest degree of deviation from 'official' procedures amongst the case study company examples, with project management and

planning largely left in the hands of the client company. Firm C's approach to project management also demonstrated the most sequential process amongst case study companies, with development projects passing from the control of one department to another, with little *planned* cross-functional communications (although informal communications, particularly between design and production, were important).

The fact that the project progressed to the client's satisfaction, was suggested by interviewees to illustrate the benefits of a detailed project specification (relating to the group technical manager's point about the importance of problem definition) as well as the tight control which the client company had maintained over the project.

The possibility of competing functional agendas within the firm was also raised by interviewees.

BOX 4.25

In the past there have always been difficulties in terms of the link between design and manufacture. Design want to prototype, manufacture want to produce lots of. So there is a sort of conflict potential that has proved difficult in the past.

Marketing Director

Sales tend to want to fire everything in to design direct, and I'm saying no, put it in through marketing, let marketing filter it. Because the problem we've had, every salesman thinks I've got the chance of a sale, might only be one sale but to him we must have it. It needs to go to marketing to say there are five enquiries for that, so that should go to the top of the list.

Group Technical Manager

Overall then, as at Firms A and B, there is a deviation from 'official' company procedures in how the project is managed. 'Problem definition' is suggested to be of importance in the early stages of a development project. On contract projects, where a specific 'problem' is suggested by a client company, engineers find it much easier to come up with a solution, and this can speed up the progress of a development. Project management is felt to be a possible distraction from 'real' work in the design department. There are potentially competing functional interests and agendas within the company, and these *may* have a negative effect on the progress of a development project.

4.7 Firm D

Firm D is an independently owned firm established in 1971 as a spin-off company from one of the region's universities. Expertise within a university department led on to consultancy work, and as a result of this, a novel technology was developed which became a core product for the company, and which initially was the only technology of its type, allowing the company to develop a very strong presence amongst its potential customers. Related products have subsequently been developed by Firm D around this technology. Since its formation, the company has, partly through a process of acquisition and partly through further spin-outs, built up a group of companies comprising a further four small firms. The company founder has now retired from the day-to-day running of the business, but is still involved in the business as chairman of the board.

4.7.1 Project Narrative

The project identified for study was a development project, initiated from within the company rather than in response to a customer enquiry, and was intended to demonstrate an improvement to one of the company's existing products, one which would give them a technical advantage over their competitors. The development project aimed to produce a quarter-scale model of the solution the company proposed, and was very quickly successful in securing contracts for two full sized systems.

A product that the company were supplying had only a marginal technological advantage over competitor products, and it was felt that sales were being lost as Firm D was being undercut by competitors on price. In line with the company's overall approach to product development, it was decided that an attempt would be made to introduce a technically more superior product for which a higher price would be charged. If this could not be achieved, the company would cut its losses and withdraw from the market.

Senior managers therefore instigated a brainstorming session amongst engineering staff, and the idea eventually selected (after a review by company engineers, and the informal presentation of those which seemed to have most potential to some of Firm

D's existing customers) was a lapsed patent, which had previously belonged to a company Firm D had collaborated with in the past. The idea behind the patent was felt by company engineers to be fundamentally sound, but would require some development to make it commercially and technically viable.

The solution incorporated in Firm D's reengineering was novel, and they expected companies in their target market to be sceptical of it. It was therefore decided, in a somewhat unusual move for the company, to first produce a quarter-scale model rig to demonstrate the benefits and feasibility of the technology to potential customers. To this end, a development project was set up, with a project team and manager in place. The project manager wrote a brief, specification and project plan, with the project forecast to be complete two months later.

About halfway through this development project, an existing client of Firm D submitted an order for the new product, subject to their satisfaction with the technology once they had seen the demonstration rig working. A project to develop the full-size system was now set up in parallel to the demonstration rig, with a separate project leader. This project team was co-located to another building on the company's site, and a number of contract engineers and draughtsmen employed to supplement existing personnel resource.

The demonstration rig was completed and built in-house. The contract customer and other potential clients were invited to test runs, but problems emerged, and the contract customer submitted a list of concerns to Firm D, which were subsequently addressed to the client company's satisfaction in a report written by the project manager of the main system. A second order for a full-sized system was now secured, also from a company for whom Firm D had previously worked, and with whom they had developed a close relationship. The majority of development work on the project was done on the two commercial systems.

Part of the control system of the unit was novel to the company, and assistance was sought from a local university for advice on selecting a company to subcontract this element of the development to.

Fabrication of the project was subcontracted. Systems were then assembled in-house by teams led by Firm D's own production staff, but consisting almost entirely of temporary contract fitters who had recently been laid off from a neighbouring firm.

Testing took place over a two month period at Firm D's site, and involved both continuous-run and environmental testing. Customer approval tests also took place, witnessed by the two contract companies.

Installation of the systems was completed on schedule by Firm D, however, after the units became operational, further problems emerged. On most product introductions, the company would expect to have only one unit out in the field while such 'teething troubles' could be ironed out. In choosing to satisfy two orders initially, there has been increased pressure and workload on the company's engineering and maintenance staff, exacerbated by the fact that both installations have taken place overseas. The company's end of project review (relating mainly to financial aspects of the project, but also involving liaison with production staff to assess ease of manufacture) was late in taking place, and this was suggested to be due to the pressure to start working on subsequent projects.

4.7.2 Issues Affecting the Progress of the Project

The contract developments which formed the latter part of the project discussed in the case study were both completed on time, and this was suggested to be the case with the vast majority of Firm D's contract projects (i.e. those developments undertaken for named customers). In contrast, however, interviewees suggested that where the project was an 'internal' development with no fixed customer imposed delivery date, projects were much more likely to drift on past originally planned completion dates. The presence of an external customer (and externally imposed delivery dates, possibly incorporating penalty clauses for late delivery), thus seems to be associated with an

extra discipline in sticking to project plans and meeting targets. This could perhaps be related to the issue of 'problem definition', the importance of which was suggested by Firm A's technical director and Firm C's group technical manager. On contract projects, the 'problem' which engineers must solve has been to a large extent already defined, perhaps facilitating the design process. The 'front-end' of a (speculative) development project was suggested to be more problematic.

BOX 4.26

It's difficult to know which developments are the right ones that will make the product more saleable

Technical Director

Contract projects, with a customer imposed deadline, were also suggested to be easier to manage overall.

BOX 4.27

Unfortunately we're very customer-project oriented, and it's very hard to get enthusiasm and timescales and deadlines on projects that... we're not very good at setting our own deadlines and enforcing them.

Senior Project Engineer

It was suggested by the technical director and also by the senior engineer interviewed that the company faces a constant struggle in managing its staff resource. Recruiting the quality of engineers required is a problem, and resorting to temporary staff, particularly contract engineering staff, as on this project, is not felt to be an ideal solution. Considerable time has to be taken to bring temporary engineers up to speed with the company's systems and working practices, and this is then lost once the contract is terminated.

Both customers for the initial two contract orders have close working relationships with Firm D, built up over a period of time and involving a high degree of trust. This was important in allowing Firm D to sell a relatively untried concept, and to secure orders whilst the technology was still largely in its development stage. However, the fact that major problems emerged on the unit post-installation was suggested by one interviewee as potentially very damaging to the company's reputation. It was hoped

that through close co-operation with the customers concerned to bring a swift resolution to these problems, there would be no lasting harm to Firm D's relationships with them, although the news that problems emerged on this new development will have travelled round what is a relatively small industry.

4.7.3 Discussion

Whilst Firm D's development was also (in the latter stages) a contract project, it was somewhat different to Firm C's contract, where the 'problem' to be solved had come from the client company. In contrast, Firm D's project originated from within the company itself: the existing product needed to gain a technical edge in order to distinguish it from competing products in the marketplace, and it was Firm D's engineers who identified the 'problem' in the existing design which could be improved. The project is illustrative of the benefits of cultivating relationships with what Rothwell (1992) has called 'leading-edge customers', who are characterised as early adopters of innovations, and as such, willing to take a risk (based on the trusting relationship built up between firm and customer) on a relatively untried development.

BOX 4.28

There are other customers, particularly the newer customers who are up against some of our established customers, they are very willing to explore anything which will give them an edge to help them win contracts against our other customers. So the established ones are much more conservative, and to some extent they want to control, they want to keep the standard, because that's what they've got. Whereas the new entrants or the up and coming installers want something different to offer, and are much more willing to take a risk on new ideas.

Technical Director

The two contracts we got on this particular prototype were two very trusting clients ... we said we had a good idea, most people would say no, we want something tried and tested. In this case two clients said they'd have a go.

Project Engineer

Firm D's 'collective identity' (Fiol, 1991) included the ideal of a relatively informal approach to management, and so whilst the company had formal written procedures as part of its quality accreditation, it was suggested that things 'got done' anyway, and the company's product development strategy, although 'understood' by senior managers, was not in any way fixed or written down. Procedures were suggested to mirror more closely what was 'done' in the firm, rather than be an ideal to which

project managers 'should' aspire. It was felt to be important to keep written procedures minimalistic and flexible, in order not to overly-constrain staff in how they were able to manage projects, and also to allow procedures to be applicable to different types of project. Firm D's experiences thus suggested that a blanket approach to project management was neither possible nor desirable.

The company's view of itself as an 'engineering firm' (rather than a firm with an engineering function), can perhaps be used to explain its reluctance to use one-off external inputs in the product development process, as such a reluctance was itself identified by interviewees at other companies (Engineering Manager, Firm B and Operations Manager, Firm E) as an 'engineering trait'.

BOX 4.29

We have some [*external links*], not very significant ones ... we're pretty self-contained in that respect, and we like to understand a new technology ourselves, we'll buy it in from outside.

Technical Director

The project team was co-located to a separate physical area, and it was suggested that this facilitated informal learning between team members on the project (although only engineers or associated staff are expected to be part of this team, production staff have an input into a project only when it reaches the workshop).

BOX 4.30

When we start a new project we're not constrained by departmental barriers. We know something's coming up, we pick up everyone who's going to work on that project and put them in one area, so we're all sitting co-located, so a lot of information passes informally.

Project Engineer

We all sat in the same office, apart from the workshop people, but all the engineers who were working on it moved in to an office with the draughtsmen, so we were in one room, open-plan office, most of us. So mostly you can just pull a few people together and discuss something, make it rather informal.

Senior Project Engineer

Overall then, the case study of Firm D suggests that a blanket approach to product development, even within one firm, may not be possible (or desirable). The importance of informal interactions (particularly between technical staff) is again

suggested as a source of learning on product development projects. The project illustrates the benefits of cultivating close relationships with particular types of customers. Firm D's customers approximated to 'leading-edge' customers identified by Rothwell (1992), but von Hippel's (1988) 'lead users' (who may be able to give an indication of future market requirements, by virtue of their advanced position within the marketplace) are also expected to be beneficial for some companies.

4.8 Firm E

The company is an independent family owned firm, established towards the end of the nineteenth century and incorporated in 1930, manufacturing and distributing a consumer food and drink product. Until roughly ten years ago, the manner in which the company was run had changed little over the years, and business was focused mainly on subcontracting for other companies in the same industry (and with a reliance on one particular customer) and with servicing predominantly local markets. Company management recognised the precariousness of this position, and seeing other businesses with similar outlooks go to the wall, decided to attempt to introduce a more formalised approach to running the firm, and to try and establish a national presence through the building of brand names and the supplying of own-label products to national retail chains.

4.8.1 Project Narrative

Firm E were approached by a national retailing company with whom they had an existing relationship as a supplier, to produce a match for a competitor's product which the customer company would then sell as an own-label brand. Although initially Firm E had few of the capabilities in place which would enable it to fulfil the request, since the customer (with whom they had a pre-existing and significant account supplying other 'own-label' products) was valuable to them, it was decided to go ahead with the development. At first Firm E looked at the possibility of themselves subcontracting the development, but felt that this could potentially compromise their relationship with the retailer, who might prefer to deal directly with the subcontractor rather than through Firm E. They also had difficulties in sourcing a firm who could meet all the requirements necessary to bring the product to market,

and it was this which persuaded senior management that if they were to pursue the development in-house, they would be both increasing their own capabilities and potentially putting themselves in an advantageous position with regards to winning future business, since once the facilities were in place, they could be used to extend Firm E's own range of products.

A further stumbling block to accepting the contract was that the volumes requested by the retailer were not in themselves sufficient to justify the capital expenditure necessary for the development to go ahead, and Firm E therefore decided to produce their own branded version of the product in parallel with the own-label development. Although the projects essentially ran together, they were nominally headed up by different individuals, with the development director leading the contract project for the retail client, and Firm E's brand manager in charge of their own brand development.

Firm E received assistance from one of their regular suppliers in formulating the product, and this was achieved in a fairly short space of time. Formulations then had to be approved by the retailer, and this took several months to agree, with some difficulties in communications occurring between Firm E and their contact at the retailer's London head office. Some modifications were felt to be necessary by the retailer and this resulted in further delays as new formulations were created. Agreement was finally reached almost a year after initial formulations were suggested.

The packaging of the product which the retailer had requested could not be handled by Firm E's existing production line equipment, and this necessitated the purchasing of new machinery. An ingredient of the product was subject to rapid deterioration once exposed to air, and so this also necessitated a further capital expenditure for a preservation system.

Exclusive packaging was felt to be necessary for the product, and it took some time to secure this to the satisfaction of all parties. A particular design had been seen which

was felt to be suitable, however, a competitor had purchased the sole rights to its use. Fortuitously for Firm E, this competitor went into receivership, and they were thus able to themselves secure the design. The project was further delayed as Firm E then investigated the possibility of buying out this former competitor as a way of acquiring the necessary capabilities for the product and negating the necessity of any equipment purchases. However, it was decided not to pursue this course of action, and capital expenditures went ahead as originally planned.

A launch date was now set, and some three to four weeks prior to this expected launch, a meeting was called to communicate details of the new product to production and operations staff, who had not until then, been involved in the project, despite the fact that such a novel formulation (for the company) could have serious production handling implications. In-house tests on the product, the responsibility of the company's product development technician, had not been carried out prior to production, as this three week window (from when operations staff were given details of the development to the first scheduled production run) did not allow sufficient time for them to have taken place. There was also some bloody-mindedness on the part of the product development technician, who felt aggrieved that operations staff had been kept effectively out of the loop until such a late stage in the development. Production therefore went ahead without the normal range of pre-manufacturing tests having taken place.

The first production run went ahead on schedule, but immediately ran into technical problems and had to be delayed for a week. When production resumed, a further problem emerged in the handling of the product on the production line. Ideally a first production run would be used as a trial, both in how the product 'handled' and for subsequent testing. With this project, however, the first production run was distributed to retailers, and following distribution several other technical problems emerged, with some of the product then subject to a factory recall.

Problems were also experienced in the labelling of the product. Labels had been designed in-house by Firm E for the client company's product. However, when these

went on sale, it was found that the barcode design could not be read by the client's scanners. This necessitated extra production staff being drafted in to manually relabel product destined for the retailer.

Because of the difference in packaging to any of Firm E's existing products, machinery at the end of the production line used to lift boxes from the line on to pallets was not configured correctly, and so until the machinery could be reprogrammed (necessitating a visit from the supplier), further production staff had to be brought in to do this lifting manually.

4.8.2 Issues Affecting the Progress of the Project

Firm E was in the process of introducing a more formal approach to project management. Whilst procedures for scoring and ranking potential project ideas were in place, they were not in this case employed. The project went ahead primarily on the basis of *who* the customer company was.

BOX 4.31

I suppose the thing here was that we didn't look at it too well on the spec sheet side, we just said oh yeah, [*customer*], we should do it. If you were to relate each one of these - would it fit in to our strategy, would it fit in to the equipment we've got - I think we would probably have said no.

Development Director

I don't think it's something we would have chosen to do, and yes, if it had been somebody quite small saying why don't you do a match for [*product name*] we'd have said no, it's not worth it.

Marketing Manager

The project suffered from a lack of any rigorous planning, and this was reflected in both the length of time it took to bring the project to fruition, and also in the critical comments from several interviewees regarding both the planning and management of the project. Project leadership was suggested by a number of respondents to be ineffectual.

BOX 4.32

One of the things we've suffered from I think is ineffective or absence of project management, when somebody actually takes ownership of the whole thing.

Marketing Manager

People will just do the bit that they have to do, and then there's no follow-up or no-one overseeing it, no-one in charge of the project all the way down.

Production Engineer

Although there is a commitment to including representatives from across the company in the product development management group, in practice, it was suggested, there is little collaboration on development projects, with instead the imposition of targets and activities. Given the number of production problems that emerged late on in the project, it would seem that earlier production and operations involvement could have been beneficial. These production problems and technical difficulties have had a negative impact on any profit the company will be able to make on the project.

BOX 4.33

So if we look at the potential for profit for that product, it doesn't exist, because it's costing us another four people to run the line, we're running at half the speed almost that we should be, so I question the profitability of that product. Sometimes you've got to do that, but it's better to do it in terms of having ironed out all those issues first before they go on line.

Operations Manager

The company was marked by what appeared to be a very divisive split between operations and head office staff, with difficulties in communications between the two groups evident. Production staff in particular felt very aggrieved at having been (as they saw it) ignored, and suggested the existence of a blame culture within the firm. There was thus a general reluctance among them either to take any risks with production equipment to explore what could be achieved on current machinery (which might result in further downtime), or to get involved in the development beyond exactly what was asked of them.

BOX 4.34

I was just annoyed that I didn't get earlier involved ... and that annoyed me because maybe we could have, if we had went about it properly, we might have been able to predict a couple of problems that we had.

Product Development Technician

> But the way we implement it is wrong, because what we do is, it's not seen as everyone's project, so there are defence mechanisms put up there straight away to doing things which we should be able to do fairly easily. Because it hasn't been communicated people will say things like we can't do it because I need that piece of equipment, and when you really question it, we can do it as a try-out ... We should just be saying right we can do that, we can do it adequately by putting resources into it, a little bit more work from people, more responsive attitude from people etc. That goes, because the goodwill goes, because its dictated in terms of right, you're doing that, I've agreed a date of the 16th you're doing that, and that's the communication.
>
> *Operations Manager*

As at Firm C, certain 'common-sense' ways of understanding the motivations of different functional groups were evident.

BOX 4.35

> It seems to me, chatting to production supervisors, that sales just go to customers and give them a blank piece of paper rather than trying to sell what we're good at
>
> *Production Engineer*

> You've got to have someone who's coming from the sales and marketing or buying side [*on a product development team*], whereas from the production side, you'll find they won't be pushing it because they don't want the product, they don't want these daft [*packaging*] variations because it's just going to cause them problems. So you need to come from the commercial side and say look, we need to be in this market, we've got to push this product, we know it's going to cause you problems but it's going to help the company.
>
> *Brand Manager*

4.8.3 Discussion

Firm E was in the process of introducing a more formal approach to its product development management procedures, and thus illustrated a pressure which seemed common to a number of firms across the study: that of becoming 'more professional' (as a number of interviewees characterised it) in management procedures. At the same time however, individuals within Firm E were fearful of becoming 'too formal' in their product development management (and again, in that were typical of interviewees at a number of companies) and so constraining what was felt to be an essentially creative activity.

BOX 4.36

Basically I steer clear from doing that [*having written PD procedures*] because NPD in its own right is, well has to be by its own right very much blue sky, and less rigid that say an operating procedure on the line ... I think personally we're getting too hung up with procedures.

Development Director

The project itself, however, was suggested by interviewees to be ineffectively managed, planned and controlled, and that this had led to both the length of time the development took, but also to specific production difficulties which emerged. It was suggested that hierarchical authority within the company was not by itself adequate for effective project leadership, what was also crucial was the 'respect' that the individual project leader was able to command. This is similar to Brown and Eisenhardt's (1995) notion of the 'power' of a project leader, discussed in Chapter Two, *Section 2.4.1.4.*

BOX 4.37

Unless you've got somebody project managing it then it doesn't go forward in the timescale you would expect, and we've experienced a lot of delays like that.

Marketing Manager

I've got to say nobody does it willingly or wants to get it wrong, we do it because I think there's not enough focus, and I think there is certainly a gap in terms of the leaders of projects, in terms of having the respect from the rest of the group.

Operations Manager

The company was also characterised by significant internal divisions between different functional departments, and this had a negative impact on how it was able to manage its product development processes. The project illustrates difficulties that could arise in what is essentially a process industry when production staff are not involved in development projects until a fairly late stage, when all important production decisions have been taken. It was suggested by production staff that the knowledge which they had accumulated through working in the industry was discounted, and this contributed to their sense of grievance.

BOX 4.38

I've got nineteen years of experience out there, I mean, I'm not an engineer, but I've worked on the lines for nineteen years. I've seen so many things, I mean I could just pop up with something in a meeting that they've never thought of. And [*the production engineer*], twenty one years of experience, his whole life's been here right from school, and he's put all these lines in and everything. And if they'd consulted him right at the beginning... there's so much experience out there and they don't involve people.

Production Supervisor

There's people out there forgotten more about [*the product*] than I'll ever know. There's a wealth of knowledge in this company but it's not utilised enough.

Product Development Technician

At the same time, however, it was suggested that some staff had become entrenched in their ways through being with the company for a number of years, and that this combined with the company's 'blame culture' meant that risks (with potentially beneficial outcomes) were avoided.

BOX 4.39

We've got a guy who's been with the company a long time ... and he's kind of tunnel vision in terms of what we can do, so he always looks back instead of looking forward ... and he probably doesn't question the current equipment in terms of what its capability is, and get outside sources to help in that evaluation ... there's a lot of mistrust with people who've been in the company long periods of time.

Operations Manager

Much greater access was given to production staff at Firm E than at other case study companies, and it is possible that this made more evident the differences between functional groups within the firm. It is suggested that these difficulties may be related to misunderstandings arising from the alternative company 'worldviews' (Schein, 1996; Thomas, 1994) or 'thought worlds' (Dougherty, 1992) apparent between different functions within the company, and this is discussed more fully in Chapter Six (*Section 6.2.2*).

Overall then, Firm E's case study again illustrates a struggle to implement a more formal approach to product development management, characterised by interviewees as 'becoming more professional'. There were also concerns within the firm that such an approach might constrain what was felt to be an essentially creative process. Overall interviewees criticised the ineffectual planning and leadership of the project,

suggesting that the strength of the project manager (in terms of the respect such an individual commanded within the company) is crucial to the ultimate success of a project. Difficulties in production appeared to result from the late involvement of operations staff in the project. Internal divisions within the company were particularly apparent, and seemed to be exacerbated by the absence of any production involvement until quite late in the development, and the subsequent production and technical problems which arose.

4.9 Conclusions

This chapter has presented data from the case study phase of the project, and has made an initial attempt to answer those research questions outlined in Chapter Three, representing RTCN's core concern to understand how SMEs could be assisted, through the identification of 'good practice', to become more efficient and effective in their product development activities. Accordingly the chapter has outlined *what* product development processes were at individual firms, how these were managed, and also those difficulties which firms encountered.

Whilst no single model of 'good practice' has been found, it did seem as though some loose guidelines regarding a 'better' way to manage might be emerging, but that what appeared to be possible to either attempt or achieve in product development management was contingent on individual firm contexts and circumstances. Some of the 'good practice' recommendations identified in the literature (discussed in Chapter Two) seemed to be particularly difficult for firms to put in to practice.

For example, whilst a thorough understanding and assessment of any potential market is suggested to be necessary for any (speculative) product development success (Rothwell *et al*, 1974), as Balachandra and Friar (1997) point out, and as the experiences of Firms A and B would seem to suggest, obtaining such information can prove to be extremely problematic, with, however, potentially risky consequences for the innovating company resulting from its absence.

Similarly, whilst interviewees (and the literature) suggested that a more formal and planned approach to project management and control was expected to be beneficial to project outcomes, Firms A, B and E all struggled with this, whilst Firm C allowed control of its development project to rest with its client company. Firm D, in the contract phase of their development project, were able to meet customer deadlines (albeit with a number of project 'teething problems' remaining which only came to light once units were out in use 'in the field'), although interviewees suggested that in the absence of customer imposed deadlines, projects were much more likely to drift and miss scheduled targets. There was therefore evidence of a distinction at all companies (although to a much lesser degree at Firm D) between how interviewees thought projects *should* be managed and how they were able to put this into practice.

Perhaps then, as Balachandra and Friar (1997) suggest, 'good practice' product development management recommendations must be contingent on individual company circumstances, although interviewees at all companies shared clear ideas regarding how projects *should* be managed which (perhaps not surprisingly) approximated to 'best practice' prescriptions. It may be as well that in addition to identifying appropriate 'good practice', firms must be able to implement this, and there is therefore perhaps the necessity for the company to learn how to manage product development processes in those ways which are most effective for its own particular circumstances (c.f. Bessant *et al*, 1996).

The differences apparent between case study firms suggest therefore that the product development process is less straightforward manage than 'good practice' recommendations might imply – a variety of experiences were apparent amongst the case study companies, in contrast to the single 'route' implied by 'best practice' prescriptions. The following chapter will examine data collected (in single face-to-face interviews) from a further 26 North East manufacturing SMEs in relation to both product development processes and product development organisation, in order to supplement data from the case studies and to further an understanding of how the theories of product development discussed in Chapter Two might equate with firm-level practices.

5

Product Development: Process and Organisation

5.1 Introduction

In the preceding chapter the product development process was described in some detail through data obtained from case studies of five manufacturing firms operating in non-competing industrial sectors. Whilst some ways of managing product development were suggested by case study interviewees to be more effective than others, the degree to which individual companies were able to put these in practice was by no means uniform. What was possible seemed to be contingent on both individual company contexts and circumstances.

In order to supplement case study data, interviews were undertaken at a further 26 manufacturing SMEs. Evidence from this second-phase of data collection, relating to the process and organisation of product development in these firms will be examined in the following chapter.

As in Chapter Four, the research aims to make explicit processes of product development as well as management practices at the firms studied, in order that, in line with preliminary research questions, 'good practice' in product development might be identified. Recommendations identified in the 'success factors' product development management literature (discussed in Chapter Two) are presented alongside *actual* company practices, in order to begin to understand how theory and practice equate, and in the light of evidence presented in Chapter Four suggesting that how firms are able to approach product development may be contingent on their own particular circumstances and characteristics.

5.2 Strategic Position of Product Development within the Firm

An initial consideration is given here to approaches to the role of product development in company strategy, since this itself is influential in determining how product development processes will be organised and managed. The technology

management literature suggests that a strategic approach to product development (where consideration is given to how product development activity can contribute towards the achievement of overall business objectives) will be beneficial to future company growth and development. As with the case study companies, however, there was no uniform approach to how product development as a business process was situated or employed within firms studied. Partly this seemed to be contingent on both the background of the owner-manager/managing director (OM/MD) of the company, but also related to the competitive criteria which the firm was operating under, and which could be industry specific.

The question of whether or how product development was used strategically within the firm can be linked to questions of *why* companies were innovative. In an obvious way, the answer related to maintaining company competitiveness,

BOX 5.1

We have to be proactive in product development, we'd be dead without it, and in a short time as well.

Managing Director (case study Firm B)

[T]he bottom line is you need to make money. Also the market doesn't stand still. One product which we were virtually totally reliant on now probably accounts for only 20% of sales, so we need to have products that will take over.

Managing Director, Engineering Company, ≤ 20 employees

Particularly for smaller firms (but as well as a 'historic hangover' for larger SMEs) the specialisms and background of the company's OM/MD had a bearing on the strategic position of product development within the firm. For example, where the OM/MD had an engineering background, product and technical development was more likely to take a central role in the company's business planning.

BOX 5.2

That's [*product development*] the bit of the job I find enjoyable and interesting, and also as a company we have a bit of a name for that, so people will contact us because they know we do it. We're respected for our product development.

Managing Director, Engineering Company, ≤ 20 employees

Where the OM/MD had a sales and marketing background, both current and future business development (long or short term) tended to be much more focused around securing new markets and sales areas.

BOX 5.3

Our MD is very sales oriented and had discussions with the client. He was running the sales team at the time and the enquiry would have gone straight to him. He makes the decision about whether or not to go ahead on a project.

Development Manager, Electronics Company, 21-50 employees

The dominant competitive criteria of the sector or markets within which a company operated were also significant in influencing how product developments were used. In an industry sector where the predominant competitive criterion was price, product development could be a way of ensuring a low-cost product.

BOX 5.4

We just do what we're asked to. The MD will come in and say someone wants to buy a hundred of these. If we can do it for ten pence less then we might be able to poach the job.

Technical Manager, Engineering Company, 21-50 employees

[*Product development*] is nearly all driven by price, a price issue somewhere, the current one is too expensive, or the one they're buying from someone else is too expensive. There are very few products now where price is not either the main or a significant issue, because people take for granted these days that the technical requirement and the quality will be right, and usually the only thing that's up for discussion is price, wherever you buy it from. If you buy it from another supplier you automatically assume that the product will do what you want it to do and be the right quality.

Senior Engineer, Electronics Company, 101-150 employees

In other industries there was room for competition on the basis of technological superiority, and product development was a way of securing that differentiation (as at Firm D for example).

BOX 5.5

We aren't a low-cost supplier and we had to move back into our more comfortable ground, which is high-tech, high cost and therefore more profit margin.

Senior Project Engineer (case study Firm D)

Technical advancement is one of the key features that distinguishes our products from everybody else's.

Managing Director, Medical Equipment Company, ≤ 20 employees

> We're pre-eminent in [*product*], probably a world leader.
> *Managing Director, Medical Equipment Company, 21-50 employees*

For smaller firms, it was possible to trace how the prevailing management style in the company, (which can be seen to originate with the OM/MD and their own particular approach to management), had a bearing on how devolved product development management was within the firm. Some espoused a more collaborative approach,

> *BOX 5.6*
> I try to get everybody involved in product development, because that's the future of the company and we all have to be part of it.
> *Managing Director, Electronics Company, 21-50 employees*

Whereas in other companies, the OM/MD might take a much tighter control of product development, putting the department responsible for it in a more reactive position,

> *BOX 5.7*
> Strategic planning is down to the sales team and the MD (which is basically the MD). I get asked to contribute on about 10% of occasions, when there's real doubt about our technical capacity to do something.
> *Development Manager, Electronics Company, 21-50 employees*
>
> The sales department will talk to the MD. Both sales and development were under the MD's control before he was MD. Sales will say they think there's a need for this [product] and he will say get me a bit more information, and then he'll come through to design and say we need this.
> *Technical Manager, Engineering Company, 21-50 employees*

There was also a variation between firms in how explicitly product development was recognised as a component of company strategy, and this was related to the degree of formality in management procedures adopted by the company overall. Product development could be a central component of the company's development plans.

> *BOX 5.8*
> When we started eight years ago with no product range, we had a long-term five to six year plan to develop a number of types of machine that we thought would be required by the industry, so we had a strategic idea of what the product range was going to be.
> *MD, Engineering Company, ≤ 20 employees*

> We've got an explicit strategy in terms of its going to be in the research market, research products. We know how to develop them ... and we're doing a forecast of the next five years. We've got pretty clear ideas of the type of product. The [*specific product*], we've got the first five planned and the rest will follow.
>
> *MD, Medical Equipment Company, 21-50 employees*

Alternatively it could be done in a much more informal and less planned way.

BOX 5.9

> There's never really any debate over what we're going to do, because it's just come out as an iterative process in meetings anyway. It's just 'we've finished that one, we're going to move on to this one'.
>
> *MD, Engineering Company, ≤ 20 employees*

> We'll always have a number of ideas that are sitting in the background, that we know there's a market for when we get round to doing them. It's just a question of picking up and running with whatever we think will be the most needed.
>
> *MD, Engineering Company, ≤ 20 employees*

As suggested by the quotes above in *Boxes 5.8* and *5.9* (but also with reference back to case study examples), a more formally strategic position was not associated exclusively with any particular size of firm. Obvious differences between the companies represented in *Boxes 5.8* and *5.9* related to overall business planning, with the firms in *Box 5.8* having a much clearer plan for the future direction of the business, but also, there was a difference in size of technical resource. At the firms in *Box 5.9*, product development was almost exclusively the preserve of the managing director. The firms represented in *Box 5.8* in contrast, had a much higher proportion of technical staff. In the first company quoted (≤ 20 employees), over half the staff were qualified engineers, and in the second company (21-50 employees), a fifth of staff worked exclusively on R&D, with a number of other staff (including the managing director) additionally involved in product development.

As firms grew larger, it seemed to become necessary to adopt a more formal and co-ordinated approach to management. Previous research has suggested that once a firm's employees number in the region of one hundred upwards, a more structured (and therefore 'less personal') approach to management will be necessary and practical (Atkinson and Meager, 1994; Storey, 1994). Whilst some firms had been established originally with quite formal and structured business plans in place, others,

particularly those who had been in an existence for a number of years, when perhaps such a formal approach to management was not quite so common, had to go through what might be termed a 'process of professionalisation', where newer and more formal management practices had to be (it was felt by managers of these firms) understood and incorporated into the firm. So whilst larger firms (over seventy employees) were, by virtue of a larger internal functional structure, more likely to be setting departmental targets contributing to an overall business plan (including targets in terms of product development), some companies managed this more successfully than others. It seemed therefore, that just importing these 'professional' management techniques into the company was insufficient, companies had in fact to *learn* how to manage in a different way.

Although many of the firms interviewed for both stages of the research espoused a cross-functional approach to product development, in practice, it was often equated with the activities of a single department, usually the engineering or technical design department where one existed. In these firms, product development strategy and planning was usually equated with departmental plans and targets for the function seen to be 'responsible'.

5.3 The Product Development Process

Much of the product development 'success factors' literature examines both the process of product development (stages which a project will be expected to pass through) as well as the most effective ways to execute these. The following sections will illustrate how product development projects proceeded and were managed *in practice*. Again, the evidence will illustrate the absence of any single approach, and also the difficulties in trying to make sense of processes without due consideration to the specific contexts within which firms were operating.

5.3.1 The Project 'Front-End'

The technology management literature suggests the initial stages of identifying and selecting ideas for potential projects to be critical for project success (Baxter, 1995; Brown and Eisenhardt, 1995; Hollins and Pugh, 1990; Kmetovicz, 1992; Maffin *et al*,

1997; Martin, 1994; Rothwell, 1992; Twiss, 1992; Ulrich and Eppinger, 1995). As with most areas of the product development process, the main concern in the literature is with speculative or 'off-line' product development projects, rather than contract developments for a specific customer. In both the case studies and second-stage interviews there were observable differences between the front-end processes of contract and speculative developments. As has been suggested by the experiences of Firms A and B, for speculative development projects, this was a part of the process which appeared to be both critical to project outcomes, but also one which was difficult to manage and operationalise.

5.3.1.1 Identifying Potential Project Ideas

If product development is believed to be essential to the survival of the business, then a continuing flow of potential new product ideas or product improvements is of importance in continuing product development (Twiss, 1992). There were several mechanisms by which companies aimed to achieve this, demonstrating a general concern that a source of ideas should not be allowed to dry up.

For companies who were engaged on contract projects, the whole process of initiating projects seemed to be much more straightforward. Initial approaches were usually from customers, and whilst companies had to keep an ear to the ground in terms of identifying potential project opportunities, there was less need to be inventive for its own sake. A contract development could either supply a standard product that the company had made before, or could involve the company in coming up with a more inventive solution, but usually only in relation to a problem which had been identified by their customer.

Only one contract company demonstrated an exception to this, and itself sought to define what its customer's 'problems' might be. This firm had purposefully developed close relationships with its customers[1], and attempted to identify problem

[1] The company was supplying process machinery into a small and specialist industry (with therefore only a very limited number of potential and actual customers - a total of only eight UK firms operating in the industry, and a further forty in the USA), and was consequently able to develop and maintain particularly close customer relationships.

areas in customer production processes, before then approaching the customer company it felt was most likely to be amenable to funding the development, with a potential solution. This solution would then be developed and engineered on a contract project.

BOX 5.10

It's more a case of us being proactive in getting work rather than waiting for approaches to say 'can you do this'. We try to keep in close contact with our customers so that we're aware of what their problems are and what opportunities there might be for us.

MD, Engineering Company, ≤ 20 employees

This issue of 'problem identification' was suggested by interviewees from a number of firms to be key. For most contract projects, this was undertaken by the customer company. However, it was also important for contract firms to keep aware of general market developments in their customer's industries, in order to identify where project opportunities might arise.

BOX 5.11

Really we're following whoever's got the engineering money to spend. We don't just wait for companies to get in touch with us, we go after business as well, and mainly follow projects, so for example the Quayside redevelopment in Newcastle. We keep an eye on that by following what's in the newspapers, magazines, word-of-mouth contacts, consultants, because they're in there first.

Director, Electronics Company, 21-50 employees

There are people who monitor that kind of activity. We find out mainly through our customers I think, or our customer's customers. Keeping track of all the worldwide activity is quite difficult. What we tend to monitor is new ships, if we know who's building ship then that gives us an indication of who's looking for equipment.

Engineering Director (case study Firm D)

Existing contract customers (particularly of volume producers, illustrating the competitive criteria which such firms were operating under) could also force redesign as a way of bringing down their costs, so for example demand that a company take a percentage out of the cost of a component under the threat that business would be transferred to a competitor.

BOX 5.12

That's got to be the principle driver, the development work we do is all based around that. Obviously we do new products for new customers, and for existing customers who've got a new project coming along, but very often, behind that is cost.

Senior Engineer, Electronics Company, 101-150 employees

Customers were in fact a primary source of potential project ideas for all companies interviewed. This could come via a direct approach from a customer (as with the majority of contract projects), or could result from a more general observation made by a company's sales staff, who were presumed to have the greatest opportunity to interact with customers and thus identify or anticipate their needs. Close customer contact was felt to facilitate the problem identification which was suggested to be crucial for a product with market potential. It seemed that if the right 'problem' could be identified (which customers needed to be 'solved'), then the firm would have come up with a product which (it was expected) would sell. As was suggested by interviewees from Firms A and C, problem identification was, however, potentially an area of some difficulty (see *Box 4.6* and *4.21*).

BOX 5.13

[*The sales department's*] where most of the drivers for development come from.

Technical Director, Specialist Process Company, 101-150 employees

We don't know how well informed sales are, but that's where the information starts, and then that goes to the MD who'll make some kind of judgement on that, and that'll come through to us as a design project.

Technical Manager, Engineering Company, 21-50 employees

Sales and marketing are the ones that have to sell the product. They tell us what they want, because we see ourselves as a bit blinkered, not having as much customer contact... the R&D department is here to please.

R&D Manager, Engineering Company, 21-50 employees

Depending on how tightly regulated the industrial sector that a company operated in was, changes in legislation could have an effect on existing products and would sometimes be the starting off point for a new product, and it was therefore important to in some way monitor any amendments or new directives. Industry associations could be used as a current awareness service to flag up any relevant legislative developments. This was evident at case study Firms A, B and E, but was also a tactic used by a minority of second-stage interview companies.

BOX 5.14

[*We keep up with it*] generally through trade association, we have the [*association name*], they tend to communicate round the type of changes.

Development Director (case study Firm E)

We put ourselves about as this type of manufacturer and we expect to be contacted about things like that, but we also look out for pieces of legislation and regulations. We have to source them and make sure we're working to them. Its the job of the QA manager to keep his eye on that, plus worldwide standards.

Director, Engineering Company, 21-50 employees

We're very much driven by legislation. [*The MD*] and I are involved in trade associations, which our competitors are involved with as well, and it gives you an opportunity to keep in touch with BSI and other standards bodies, so we get copies of draft standards before they actually become mandatory.

Engineering Manager (case study Firm B)

Trade association membership was for several firms a mechanism by which they were able to gain advance notice of what was discussed at BSI standards committee meetings, but one company, as one of only two UK companies operating in its industry, was invited to participate in the drafting of future standards.

BOX 5.15

We have a quality assurance manager whose job it is to keep account of the latest [*industry*] standards ... This year, BSI informed us they were having another look at the standard as they were modifying international standards, and the QA manager has been attending those meetings.

Director, Engineering Company, 21-50 employees

Aside from customers, ideas for new or improved products most often originated from one or two individuals within the firm, although in company procedures, there might be a commitment to encouraging ideas from across the business. This was the case at Firms A and B (see *Box 4.6* for example), where some concerns were expressed at the potential limitations of this. Several companies used brainstorming techniques as a way of encouraging wider participation in the generation of ideas for product improvement, and at a number of engineering firms, this was combined with a peer review process by company engineers of rival suggestions.

A number of possible starting-off points were suggested by interviewees as specific reasons why a company had felt it necessary to come up with a new project. Some of

these were more reactive than others. For example, matching a competitor's new development with a 'me-too' product was a common experience.

BOX 5.16

The project came from two different directions. A competitor produced something similar. He used to work for us, although I never met him, and we think he may have been developing it while he was still working here. Also, the unique bit of technology in the product is something I'd been thinking about, which I thought was possible. It was always something we planned to do, but we were spurred on to doing it by our competitor launching [*their*] product.

Technical Manager, Electronics Company, ≤ 20 employees

Really we wanted to design a switch that the customer could use in place of our competitors. So in this case the specification was very well defined, because it had to be a reproduction of another one. Which isn't good, because it has no particular selling point other than maybe a couple of quid a unit.

Technical Manager, Engineering Company, 21-50 employees

Ten per cent of what we do are basically rip-offs, the competition bring something out, it's brilliant ... But they do it to us as well. If you don't protect what you're making you can guarantee the competition will put something on the market.

Product & Design Manager, Medical Equipment Company, 101-150 employees

A product which was felt to be underperforming in the marketplace could be redesigned to make it more appealing aesthetically (as at Firm B) or technically (Firm D) in an attempt to rekindle customer interest, or as a way of reducing costs and thus making the product more competitive.

BOX 5.17

We already had a product that wasn't as successful as it might have been, and sales and marketing information suggested that the main reason for that was that its price was uncompetitive, hence the need for a new version. If we wanted to stay in that business we needed to have a more competitive product.

Technical Manager, Engineering Company, 51-70 employees

Historically these are big ugly clunky things, and go in big unattractive boxes that look like a suitcase, but the general perception was that it's just a [*product*], it doesn't have to look nice, people aren't bothered as long as it does the job. But people are affected by the aesthetics, so if your product's as good as everyone else's, functionality, same price, everything else, but it just looks better, then it gives it a little edge.

Engineering Manager (case study Firm B)

Aesthetic design was particularly important for consumer products it seemed, when it became a relatively inexpensive way of differentiating a product.

BOX 5.18

The innovation in packaging scope is limitless, because you can do anything with it. Product is... there's less opportunity to be innovative in product, because someone's always done it somewhere before.

Development Director (case study Firm E)

People get bored with stuff as well, we're selling the same stuff to the same people, its hard to sell the same stuff over and over again. Changing the colour or something can make a difference.

Managing Director, Engineering Company, ≤20 employees

A further impetus from redesign could come with the obsolescence of a particular component used in an existing product. Dealing in small numbers (as many of these companies did), they had very little influence on suppliers, and so were forced to design around what was available.

BOX 5.19

Life-cycles on electronic components are becoming much shorter these days ... so that's another reason why we do product redesign, some of it is forced by the fact that we're taking components and we don't know the life-cycle of those components. Because of our smallness we're at the mercy of suppliers and manufacturers.

Managing Director, Engineering Company, ⊘20 employees

Von Hippel (1988) has described 'lead users' who may need particular solutions and products in advance of the rest of the market, and so can supply an indication of what future market directions might be. Cultivating a relationship with such customers as a source of ideas for future developments was a strategy which had been adopted by a minority of firms, for some of whom it could perhaps be seen as a necessary response to the way the markets they were in operated.

BOX 5.20

One of the characteristics of our market is that it is largely led by opinion leaders of the market, and these people will both define the direction and the nature of the research over the coming years. We stay in close contact with the labs or the individuals who are recognised as market leaders within the market. Not only are these people going to drive us much harder than anybody else would in terms of their needs and requirements, but they're also telling us what the market will require, or what the researchers in the market will be looking to do over the coming three to five years.

Managing Director, Medical Equipment Company, ≤20 employees

> I still prefer to go to the top six suppliers to an industry, identify the top guy... whoever it is, and get it from them and go and talk to them.
> *Managing Director, Electronics Company, 21-50 employees*

A minority of companies had identified core technologies and were now actively seeking out new markets to which these technologies could be applied in a way that was either new to the company or to the marketplace.

BOX 5.21

What we did around 7 years ago was to pick 5 or 6 sectors ... and started off the project by doing some market assessments and saying what potential work is there, and then saying this is the technology that we have at the moment, what do we have to do to that to make it fit into one of these sectors. By a process of elimination that left the steel and oil industry as the two key contenders, so that's where we focused our efforts.

Managing Director, Specialist Process Company51-70 employees

So what we've done is we've identified some materials technology which we believe is innovative, and we've taken it forward and taken out a patent application... and from that we then say well, 'what if', and then we say is there a marketplace out there. So we've conjured up a potential product opportunity, and we've then had a quick look to say is there a market out there, and in doing that we've actually identified some very significant market opportunities where they have a need, but they don't have a product, but our know-how and this new innovation will allow us to satisfy that market need.

Managing Director, Electronics Company, 21-50 employees

5.3.1.2 Assessing Potential Project Ideas

Cooper (1979: 93) suggests that a major impetus for research into those factors which determine new product success or failure is the wish to identify 'empirical' new product screening models, which might separate "winning" and "losing" new product ideas. Most companies interviewed, however, did not attempt to evaluate potential project ideas in any formal way, but rather made an assessment based on 'experience' or 'gut-feeling' as to whether or not an idea should be progressed or abandoned. Implicitly, projects seemed to be selected on the basis of how closely they fitted in to the company's existing technical capabilities, and this was observed for both contract and non-contract projects. For companies working predominantly or exclusively on contract projects however, and especially those where the element of novel design was minimal, the notion of technical synergies was taken for granted. It was not expected that the company would ever be approached to do something outside its

technical capabilities, and so the idea of assessing whether or not to go ahead with a project was largely absent from the company's procedures.

BOX 5.22

I'll read it [*the customer request*] and then try and make the decision ... We know ourselves, you can get a feeling whether people are just testing you or whether they're really interested ... Last year people had to ring us up and say can you manage it, not how much does it cost.

Technical Director, Engineering Company, 21-50 employees

The project then (in this instance) is expected to be always something the company can *do*, the question for consideration is whether the customer is serious in their approach, or whether the company themselves have the spare capacity to do it. For most companies working on contract projects, the position was one of quoting for any potential customer orders, so their strategy, in terms of both product development and individual potential project assessment, was therefore to attempt to say yes to every job that was offered, since they never expected to be offered anything which was not something that they as a company 'did'.

BOX 5.23

The estimating manager makes a decision about whether the company is capable of building it, he'll acknowledge receipt to whoever sent the enquiry in ... We would very rarely knock anything back, unless it was huge and past our commercial viability, but normally we'd quote everything.

Director, Electronics Company, 21-50 employees

It wasn't such a big project ... we thought that we could do it.

Director, Engineering Company, 21-50 employees

For companies engaged in more speculative developments, an assessment was usually made on the basis of both marketing (or sales) and technical considerations, and where a company was large enough, was often a joint decision made by managers from both departments, although perhaps with the weight of the decision resting more on one function than the other. Although technical considerations were important – making the product, after all, had to be within the company's technical capabilities – primacy was usually given to the question of whether or not a product would sell and this was the guiding criteria for idea assessment in the majority of second-stage interview companies undertaking speculative developments. Project opportunities

under consideration (in the firms studied) were always quite close to the company's existing capabilities and so provided they were technically *possible*, what then remained was the question of whether the finished product would sell. This could be based on a 'feeling' of 'knowing' that something was right, or could be based on a more formal assessment of expected development costs versus projected sales figures.

BOX 5.24

We end up with an estimated cost for the whole project, including the cost to the company in terms of R&D. I take all this information to the sales and marketing team to say this is what the project will cost you, and they would either approve it or not.

R&D Manager, Engineering Company, 21-50 employees

Normally the sales department would come along and say can we do this, and we'd set it up and go away and try it, and then review it and say that's what we think would be involved in doing it, is it worth taking it forward. That's what the likely costs are going to be, can we justify that or is it a one-off?

Technical Director, Specialist Process Company, 101-150 employees

Sometimes a product opportunity seemed too good to miss, and so a company might forge ahead with a project without any consideration of likely costs (see for example case study Firm A's experience, *Box 4.1* and *4.7*). Like Firm A, one of the second stage companies interviewed had been in a position of needing a big increase in sales turnover, and when a project idea had been suggested which seemed to promise that, did not examine it too closely but instead went ahead with sinking time and money into the project and accepting the idea of 'big sales' at face value.

BOX 5.25

The concept behind the design was that it would be a control unit which would fit on to any kind of [*product*] equipment. This meant that elderly equipment, which couldn't be used with modern control units, could be put back in to service. We felt it was apparent that such a design would have massive sales potential... We were in trouble at the time and this was going to be our salvation.

Technical Director, Engineering Company, 21-50 employees

Once initial ideas had been suggested, customers were used by a minority of companies as sounding boards to gauge how much interest in a potential product there might be. Ideas which had either originated from customers, or which were then subsequently approved by them were felt to have some kind of market potential in terms of future sales. So the assumption was made that if one or two potential

customers showed enthusiasm for a product idea, this could be taken to be representative of a wider interest in the marketplace for such a product.

Two companies interviewed (case study Firms A and E) had introduced a much more formal mechanism for scoring projects and assessing whether or not to progress them. However, in both instances, the project studied had not undergone the formal scoring process, and had been progressed regardless. For Firm A, as was earlier suggested above, the project was felt to be too good an opportunity to ignore. Firm E was at an early stage in introducing product development management procedures, and at the time of interviewing, had yet to run a full project through its new systems.

As discussed in Chapter Four, Firm E went ahead with the development because of *who* the client company was, and their importance to them as an existing customer, even though initially, they did not have the internal capabilities to proceed with the project. The importance they attached to their customer persuaded them not only to go ahead with a project, but also to make a significant capital expenditure to enable them to do so.

Even where a company has instituted a more formal scoring system, Kleinschmidt and Cooper (1995) suggest that how well such a system operates will depend on the criteria which management have chosen to rank as 'success determinants', and that these themselves are largely based upon the 'good feelings' that management has for what makes a project successful. They further speculate that these criteria will be based on a fairly limited sample of projects or anecdotal evidence, and may in any case be biased by the most recent project that management have worked on.

5.3.2 Project Planning

It is recommended in the product development literature that some level of planning in product development is essential if projects are to achieve objectives in a timely manner (Baxter, 1995; Kmetovicz, 1992; McGrath *et al*, 1992; Maffin *et al*, 1997; Rothwell, 1992; Tidd *et al*, 2001; Ulrich and Eppinger, 1995), although different levels of planning may be suitable for different types of project (generally related to

the degree of uncertainty or novelty in the project to the company). So for example, Brown and Eisenhardt (1995) suggest less rigid planning (but with iterative loops and review milestones built in) to be more appropriate for projects where there is a higher degree of uncertainty. A higher level of uncertainty in a project (i.e. a greater level of innovation for the company) will constrain the level of planning possible (Maffin *et al*, 1997). It is also suggested in the literature that such is the value of effective project planning that its absence may in itself present a significant opportunity for improvement in how the company manages its product development processes (*ibid.*).

From interviews it did appear that those projects with a high degree of planning *and* control (so planning by itself was not sufficient) were more successful in achieving targets than those without. Interviewees from some companies, however, again felt resource constraints more acutely than others, and drew attention to the difficulties of planning developments (and subsequently working with those plans) in an environment where there were so many competing demands on their time, and attention had to be given to 'everyday crises' which had (within the business) a higher level of priority than development projects.

5.3.2.1 Written Procedures for Product Development

It is suggested both by ISO 9001 and in the product development literature that a company should develop general formal definitions of their product development procedures (Maffin *et al*, 1997), in other words, a generic outline of the stages a development project is expected to pass through. Assuming a company has found a satisfactory way of managing product development, documenting this as a generic set of procedures will make it both repeatable and traceable, as well as ensuring that all stages are covered or at least considered. Generic procedures may also facilitate learning in the company, as points which might benefit from modification become apparent through repetition (McGrath *et al*, 1992). Of the thirty companies included in the analysis, seventeen had been accredited with ISO 9001 (with a further two working towards it), and as such could be expected to have produced a formal set of development procedures. Of the remaining eleven, five had written procedures describing their routine product development processes. The existence of a set of

procedures, however, did not guarantee that they would be followed (see for example *Box 4.7* and *4.14* for the experiences of Firms A and B). In the projects discussed, procedures had sometimes been perceived as adding an unnecessary layer of bureaucracy to product development which caused delays[2].

If different levels of planning are held to be appropriate for different types of project (i.e. according to the degree of novelty in the project to the developing firm), then it follows that procedures for development projects should also embody an element of flexibility. It is then important that there must be a clear understanding of what 'type' of project it is which the firm is undertaking, and particularly the degree of novelty and innovation involved. Whilst a company may have a generic set of procedures, not every stage of those procedures may be relevant for every development project undertaken. This could be explicitly acknowledged by a company,

BOX 5.26

Not all the steps in the procedures will be relevant to every project, but the booklet asks us a series of questions so as we go through the project we don't forget anything.

R&D Manager, Engineering Company, 21-50 employees

More usually, particularly for firms working predominantly on contract projects, and especially where there was a high degree of repetition between one project and the next, those stages of procedures which were felt not to be relevant (because the firm felt secure in 'knowing what it was doing'), were missed out.

BOX 5.27

This project maybe isn't a very good example, because as far as ISO 9001 is concerned it cut a lot of corners.

Director, Engineering Company, ≤ 20 employees

Staff in one R&D department had developed a very elaborate set of procedures, and this seemed to be a safety net designed to compensate for what they perceived to be their own inexperience and inadequacies as designers.

[2] However, in some projects where procedures were *not* followed, this was raised by some interviewees as a failing which had in fact added development time to the project rather than reduced it (see for example the case study describing Firm A's experience).

BOX 5.28

None of us had any R&D experience, so we've set it all up ... it's taken us about three years to develop the procedures to where they are now, which is almost the Mark I version ... We've got a checklist to make sure we don't miss any nuts and bolts, fitting instructions, rough bill of materials with costs, production costs ... and a job-list of any jobs we have to do within the quote, more as a tracking device than anything.

R&D Manager, Engineering Company, 21-50 employees

In companies with a more informal approach, there was some evidence of a fear that procedures could constrain what was effectively felt to be a creative activity (as for example at Firm E, see *Box 4.36*).

BOX 5.29

I think our bosses don't want us to be too formal, because they see that as a barrier to producing new products quickly.

Technical Manager, Electronics Company, ≤ 20 employees

The notion of formality and informality in product development management has emerged as an apparently important theme of the research project, with concerns voiced by a number of interviewees regarding the way they felt product development 'should' (according to both best practice recommendations and 'official' company procedures) be managed and the ways in which they felt able to do this in practice. Introducing a more formal approach to managing product development (in line with best practice recommendations) appeared to be a goal that companies were trying to attain, or at the least felt that they *should* be moving towards, and as at Firm E, a number of interviewees characterised this in terms of becoming 'more professional'.

5.3.2.2 Specification and Project Objectives

The designation of clear project objectives and the formulation of a well-defined specification have been identified in the product development literature as having a significant impact on project success (Baxter, 1995; Hollins and Pugh, 1990; Kleinschmidt and Cooper, 1995; Kmetovicz, 1992; Maffin *et al*, 1997; Twiss, 1992).

Designing a contract project for a client, with its implied higher levels of individual customer contact, seemed to be easier, in that the specification and brief provided by

the client facilitated design. (As at Firm C (see *Box 4.20*), the client had identified 'the problem' which made it more straightforward for the engineers to develop a solution).

On speculative projects, specification writing was often an opportunity for the company's marketing department (where it was large enough to have one) to get involved in product development. Since sales and marketing staff were presumed to have the largest amount of customer contact, they were therefore thought best placed to know what customers wanted, and to pass back the information about possible customer requirements to technical or engineering departments. Ideas which originated from customers had a validity that an idea generated internally did not.

Any alteration to the specification once the project was underway could have a detrimental effect on the progress of the project, if this was not taken into account with a parallel accommodation in project planning (as was the case at Firm B, see *Box 4.9*)

BOX 5.30

The specification was written by me, but then was changed about halfway through the project, and that caused subsequent problems ... one of our customers decided they'd like to use the unit in a different mode of operation which I hadn't considered. I looked into it and decided it could be done, so the spec was changed to achieve this extra output and hopefully secure sales ... We should have spent more time ensuring the original spec was adequate and correct, and not allowed it to be changed.

Technical Director, Engineering Company, 21-50 employees

In some instances, designers were asked to work to quite vague specifications, for example, when doing a 'me-too' product, the specification could be as simple as 'one like that', resulting in a brief which could be widely interpreted.

BOX 5.31

One of the things that came back was that the competitor product had more [*of a particular component*], so the marketing guy said he wanted more, because he needs something to be able to go into a customer so he can say ours is better because its got this. So that was all I had, the other thing was to get it to work.

Technical Manager, Electronics Company, ≤ 20 employees

How successful that can be probably depends on the complexity of the product being 'copied' as well as how good an understanding the company's technical people have of the technologies involved. Whilst it could be assumed that a potential market existed for a 'me-too' product, relying on technical assumptions embodied in a competitor product, or the making of incorrect assumptions in the reverse engineering of that product added an extra element of technical risk.

BOX 5.32

You do look at your competitors products and assume that that product is right, and do a version based on that ... It's a bit like Chinese whispers in terms of knowledge getting passed through the marketplace.

Technical Manager, Engineering Company, 51-70 employees

In terms of what they were doing for the States I'm sure it was pretty much correct. But then it depends on whether our interpretation was right ... You can't sort of piggy-back on someone else's information, otherwise you just compound errors all the way.

Technical Director (case study Firm A)

5.3.2.3 Project Plans

A majority of interviewees expressed a concern with bringing projects to a conclusion in a timely manner and without excess use of resources. Project plans were used in almost all companies as a way of achieving this, and success (in terms of achieving project objectives) appeared to be related not only to project planning, but to how those plans (and the project overall) were managed and monitored.

On contract projects, planning was (in the main) a routine activity, with the threat of financial penalties for late delivery perhaps ensuring that projects did not drift on independently of scheduled plans. This was, however, not uniformly the case with, for some contract companies, the degree of planning varying in accordance with the demands and requirements of the particular customer involved.

BOX 5.33

The only time we put a plan in place is when we're involved with someone like British Aerospace who would ask to see a production plan ... The bigger ones would demand something like that ... a build programme, drawings, calculations, approvals, bill of materials, a general sort of plan.

Director, Engineering Company, 21-50 employees

> Sometimes we put it on a chart or something like that, depends who it is. If it's a big project, a blue-chip corporation, we'd set it up on some sort of flow-chart and we'd keep an eye on the progress of the project. Other projects, we'd just cover it through product development meetings ... Otherwise if you're not careful you get involved in a Gantt chart exercise, which we would for the big companies, and that's ok, it looks good for the big companies, but if you do it, it's quite a bit of administration work just doing that.
>
> *Director, Electronics Company, 21-50 employees*

Where there was minimal technical or design novelty inherent in the project, when for example a company was repeating a project it had done previously, the need for planning was sometimes felt to be reduced.

> *BOX 5.34*
>
> No we don't plan, we're just using experience ... We set delivery dates, but then internally we have set hours. The estimating manager has to 'guesstimate' how many hours for CAD, test, production etc., and then we analyse it when it comes back, where the hours have gone. If it's way out of scale then we'll break down why.
>
> *Director, Electronics Company, 21-50 employees*

For some contract project companies and almost all speculative project companies, estimating development times was an area fraught with difficulties, and as has been found in earlier studies (Maylor, 2001), over-running on projects was considered to be the norm (see Firm B's experience, *Box 4.10*).

Some smaller companies (with < 50 employees), and particularly those with only one or two individuals working on development projects, felt that conflicting demands on their time made planning almost redundant.

> *BOX 5.35*
>
> I always try to guess how long it will take, because you always get asked, but it's not really formally planned ... things are so liquid in the way that we do things that there isn't any point, but we prioritise each month.
>
> *Technical Manager, Electronics Company, ≤ 20 employees*
>
> We won't have bothered writing out a time plan ... Possibly if you just spent all the time doing development it wouldn't be so bad, but things are quite bitty as they stand with our current resource.
>
> *Managing Director, Engineering Company, ≤ 20 employees*

> I do a schedule that lists the activities. The intention is that we map out on this chart the length of time that each of these activities are going to take, which means that we'll be able to gear in marketing for the right time when the product is going to be launched. We put together this list of activities and then start off, but because we're only a small outfit, crises come along which aren't related to design and we get diverted and the project falls to pieces ... So after the first few activities on the plan, what tends to happen is we start making it up as we go along, and then we could either abandon the project and let it stagnate, or else things just get increasingly drawn out.
>
> *Technical Manager, Engineering Company, 21-50 employees*

Another interviewee, however, suggested that coping with these difficulties was part of the skill of project management.

> *BOX 5.36*
>
> There's always the kind of day-to-day problems with any engineering project, there's always some sort of difficulties, or supplier difficulties, or one particular piece of hardware is out of circulation and there isn't something that directly replaces it. And that tends to throw in a whole set of different variables, but that's largely part of the technical know-how of running a project.
>
> *Managing Director, Medical Equipment Company, ≤ 20 employees*

Goldratt (1997, cited by Maylor, 2001) suggests that planning both requires and infers a high degree of certainty in time estimates not actually compatible with the realities of project management. In predicting and trying to work to timescales, companies could therefore be setting themselves up to fail, something which may be detrimental to workforce morale, as was suggested at Firm B.

> *BOX 5.37*
>
> It's demoralising for the design team, because if they're always underachieving, they see every project as a failure... almost blaming themselves.
>
> *Engineering Manager (case study Firm B)*

Projects which had not been planned and which had gone badly could be a catalyst which instigated a move towards a more formal approach to project management (as had happened at case study Firm A).

> *BOX 5.38*
>
> This was our first attempt at being really innovative, and that fell in our laps basically, somebody else came up with the idea ... and to be honest it was a brilliant idea, and people still say it was, but it failed abysmally, and I think it was from that realisation that it failed and why – ... that we've tried to put some structure into it.
>
> *Development Director (case study Firm E)*

> The electro-mechanical design of the unit was complex, so it was difficult to produce and repair, the average repair time for a unit is six hours. I'd estimate we've had one engineer working for the last year almost exclusively on warranty work ... In the future we'll be approaching the design of new products in a different way, we'll be using consultancy a lot more, we don't have procedures currently but we're working on them.
>
> *Technical Director, Engineering Company, 21-50 employees*

Introducing a more formal way of managing product developments, with more explicit planning and control, was therefore seen by these firms as a desirable goal. It was believed that the existence of a project plan *could* (though of course, that by itself was not sufficient) facilitate the stricter management and control of developments, both in preventing a project from drifting with no real progress made, but also in making visible the level of resources that were being invested.

The question of ensuring visibility (Maylor, 2001) was also raised with regard to both actual plans as well as any progress which was made. Firm C was somewhat exceptional in suggesting an occasionally secretive approach to planning.

> *BOX 5.39*
>
> On some occasions we don't actually publish what that project plan is going to be, so it's very difficult to see whether you're on schedule or not.
>
> *Sales and Marketing Director (case study Firm C)*

But other interviewees suggested that a visible record of progress was important, both in communicating what current developments were, but also in fostering a sense of involvement in the project throughout the company.

> *BOX 5.40*
>
> We also have a big whiteboard in the office which has the rough progress of all current R&D projects, colour coded and prioritised for each member of R&D staff's input. It's useful for us in R&D to see where things are up to, but also for people from other parts of the company to look at. When a task is completed then the member of staff concerned marks that on the whiteboard.
>
> *R&D Manager, Engineering Company, 21-50 employees*
>
> There wasn't any visibility in its project management because it was all done on email. On [*a previous project*] we used wall charts and post-it notes to show deadlines and progress etc.
>
> *Director of Logistics (case study Firm A)*

> All these things, we put them on the notice-board, we have a notice-board out on the shopfloor when these teams are running, and we update the information so that the people, particularly on the cell where you're making this, they can see what's happening and how much progress is being made ... [*The plan*] is a working document really ... we have them on the office wall so people can see them if they wanted.
>
> *Senior Engineer, Electronics Company, 101-150 employees*

5.3.2.4 Targets and Measurement

Targets were used by a majority of companies to gauge both the success of individual projects as well as the products that came out of them. Project targets were set mainly in terms of conformance to predicted timescale and budget, whilst product performance was judged in terms of conformance to specification, and also, for speculative projects, with regard to sales achieved against those predicted.

Those companies who imposed targets in project management did so because it was felt without them, projects were liable to drift.

> *BOX 5.41*
>
> We put target dates for each stage, we find if we don't, things tend to slip.
>
> *Technical Director, Specialist Process Company, 101-150 employees*
>
> We put targets in internal projects as well [*as contract*], because otherwise the project drifts.
>
> *Product Development Manager, Engineering Company, 151-200 employees*

There was also a feeling, however, again from smaller companies (< 50 employees) with only one or two individuals doing development work, that there was no point in setting targets which would invariably not be met.

> *BOX 5.42*
>
> We try to put targets in, but they generally don't work because we're doing other things as well with a limited set of resources ... So we don't then have the information to review our progress against the original targets, because there are just too many different jobs to do.
>
> *Managing Director, Engineering Company, ≤ 20 employees*

Targets could be related more specifically to project objectives, so for example where the development was part of a cost-cutting programme, a specific amount of cost might have to be designed out of an existing product.

BOX 5.43

We had a brainstorm at the beginning ... because the overall project was to reduce the cost of this by 10%, and we came up with something like thirty ideas that were worthy of further investigation.

Senior Engineer, Electronics Company, 101-150 employees

Targets and deadlines were sometimes imposed in order to meet an external requirement, and with varying input from technical staff as to whether such an imposition was viable or not, reflecting perhaps the status of the technical department within the company.

BOX 5.44

The sales team define costs and timescales and then I'm told what I have to achieve and by when. Its imposed rather than managed ... The media launch of the product had already been booked [*by the client company*] even before we got the approach, so that meant there were eight weeks to do the development. It wasn't feasible, but I did it by working weekends and sometimes through the night. Four or five months would have been a reasonable amount of time.

Development Manager, Electronics Company, 21-50 employees

There are conferences during the year for set disciplines ... so we knew there was a new conference coming up in a set period of time, and to jump on the bandwagon with published papers for that conference meant we could launch into it like that, so we had a set time or target date, so we had to backtrack before that to see could we do what needed to be done within that period of time.

Product & Design Manager, Medical Equipment Company, 101-150 employees

5.3.3 Development Phase

To a degree, the development process can be viewed as a problem solving phase, through which the original concept or idea is taken through the iterations necessary to develop it into an actual product. One issue which needs to be considered, then, is how much of a leap in development terms the project is in relation to what the company currently does, and how much learning and problem solving is therefore required to bring it to a successful outcome. A company may have the capabilities to resolve a development issue internally through the stock of knowledge accumulated, both in what individual employees 'know', and in the knowledge which resides in the company's routines and systems (Harris, 1997). Alternatively, a firm could look externally to resolve development issues, and a number of ways of doing this are explored more fully in Chapter Six.

Also of interest here is the question of when the development phase actually ends (if it does), with products being committed to market often at a point when those working on them felt they were still unfinished.

5.3.3.1 Technical Synergies

It has been argued that synergies between new and existing products allow a firm to make the greatest use of its own unique skills and knowledge base, and thus have a better chance of bringing a development project to a successful conclusion (Rothwell, 1992). In discussing the ways in which potential project ideas were selected and assessed (*Section 5.3.1.2*), it was suggested that this technical synergy was the guiding criteria in a majority of firms interviewed, although often this was not explicitly recognised by the firm in question.

Some interviewees *believed* that they were developing projects which were close to existing products in terms of technology, but ultimately found out that they had underestimated the complexity of what was involved, illustrating a disparity between what a project was *thought* to be about and what it *actually* involved.

BOX 5.45

I don't think we potentially quantified exactly how much work was involved ... I think probably because we saw it as near our core technology, and probably because we were foolish, we hadn't really stopped and thought about how much angst there is in getting one or two new assemblies on to the system, never mind 400.

Technical Director (case study Firm A)

It was a product that we did already, so you might expect it was technology that we fully understand. The previous range that we did had been 'me-too' products, so produced from competitor products without doing all the research, although they involved a certain amount of testing to make sure they did what they were supposed to do ... Prototypes were built and a test programme started, and everyone expected it to work first time because the parameters weren't a million miles away from the current product, but it was a complete failure.

Technical Manager, Engineering Company, 51-70 employees

Technological uncertainty in development projects could, it was suggested by some interviewees, lead to difficulties in planning projects, which in turn could result in a

loss of control of the project. It was important therefore that the degree of novelty embodied in a project (to the developing firm) was recognised.

BOX 5.46

You don't know where you're going with a new design. There's another thing we do ... which is kind of modular, and while customers might want to get different functions out of it, we feel that we're on firm ground with it, and we know that we can put it together and control it as a design project. But when its something new that you've not tackled before, you don't really know where you're going to end up.

Technical Manager, Engineering Company, 21-50 employees

The same company was working within particular financial constraints, and this in itself could enforce a level of synergy in a development project.

BOX 5.47

[*Engineer*] Its a question of the MD coming along and saying we want this instrument and we want it at this cost. So we do a prototype to see if we can make it work, bearing the cost in mind as we go along, and then refining it to see where we can get the cost down, and turn our one-off prototype into a reality or production thing that will meet the cost.

[*Technical Manager*] Without any spend on production facilities or equipment. Generally when we're designing a prototype it must be made on our existing equipment and using existing components and it must be technology we're familiar with.

Engineering Company, 21-50 employees

5.3.3.2 Design for Manufacture

The interface between the design (or development) and production functions within the company can be of critical importance in the product development process (Brown and Eisenhardt, 1995; Ernst, 2002; Kleinschmidt and Cooper, 1995; Shenhar *et al*, 2002). Effective functional integration throughout product development (Rothwell, 1992) will ensure that a product is designed which is 'build-able', thus keeping production costs to a minimum. A variety of mechanisms were employed or had developed to ensure a level of integration at a majority of companies interviewed, ranging from the formal inclusion of a member of production staff on the development team to more informal and *ad hoc* methods.

In a majority of companies, effective integration was reliant upon individuals themselves, and the channels of communication which had developed between them.

Contacts between design and production staff could not be said to be managed, instead they just seemed to 'happen', by virtue perhaps of proximity within the firm, or through a shared employment history where designers had previously worked on the shopfloor, and therefore understood the company's production capabilities and had long-standing relationships with existing production staff, as at Firm C (see *Box 4.23*).

BOX 5.48

When I'm designing I have to design to make it as easy for production to make as possible, that's part of my brief ... Because we're quite a small company, there's talk, the production manager will come up and chat, we're more informal than formal ... I discuss things in an informal way, I eat my sandwiches downstairs with the lads and we talk about things then, and out of those talks will come things that I'll keep in mind.

Technical Manager, Electronics Firm, ≤ 20 employees

[*Technical Manager*] Because we're a small company we do have daily contact with the machine shop and the assembly area, so we're not entirely ignorant or isolated from them, when we design components we know pretty much what their capabilities are. Machinery and people don't change very much out there, so we know what they can do.

[*Engineer*] I spent considerable time working in the machine shop so I know pretty well what they can and can't do, and both me and *[the technical manager]* will consult with production and ask them what they think of designs, ask if it will cause a problem in machining or assembly.

Engineering Company, 21-50 employees

More formally, production staff could be included on a development team. At most companies who followed this strategy, this seemed like the 'obvious' thing to do.

BOX 5.49

At any time we can bring any of the production people in for any sort of meetings or whatever. Any particular changes in anything like this, which directly affect the lives of certain people out there, because you're changing something they're doing ... management are very much behind us on this, because it's product improvement, it's company improvement, it involves the people, so any people we want to involve in anything, we can get them released from production ... The company's prepared to look at it, and you can look at the savings you make compared with the investment in time you put in, you get to the end and it speaks for itself.

Senior Engineer, Electronics Company, 101-150 employees

We put a team together to address it, who's involved in that depends on what the content of the project is. Obviously there'd be people from the technical department, but a lot of the development is full-scale on the production line, so you need to involve production people.

Technical Director, Specialist Process Company, 101-150 employees

Production involvement, however, was not always so central to a project, as was the case at Firm E, where although production representatives were included on the generic product development team, there was some suggestion that operations staff were there not to give any input, but rather to be instructed as to what there role would be.

BOX 5.50

Basically what it is, you're told about it, its coming through, you're doing it sort of thing, that's what you're using. So really its not consultative, you're just told that's what you're doing.

Production Supervisor (case study Firm E)

Both Firm E and a second firm (interviewed for the second-stage of the research) who had failed to include production staff sufficiently early in the development process had suffered problems when their new product had finally gone into manufacture, having both developed a product which was not in its existing state, sufficiently 'make-able' to be building any profit for the company (see *Box 4.33*).

BOX 5.51

It wasn't production engineered and when it went into its initial production run the build times on the unit were horrendous, about nine hours a unit. When the boxes went through their initial tests there was 100% failure rate on production errors ... The wiring was no better than a rat's nest ... If I'd had longer to work on them then I guess it could have been tidied up.

Development Manager, Electronics Company, 21-50 employees

There was, however, no consensus on the 'right' time to involve production staff in a development project – in large part it seemed to vary according to the company's production processes. Where there were significant production implications, it seemed to work best when production staff were involved from as early in the project as possible. When issues were just related to assembly however, it was suggested that a later involvement was more appropriate.

BOX 5.52

Once we've done the design and parts have been ordered we issue a full set of drawings to production who do the assembly. Any modifications are marked up on these drawings. At the end of the project, the drawings come back to design and we have a meeting with the workshop manager and engineers who worked on the project to make sure all changes have been made and to discuss the project. We've attempted before to involve the workshop guys earlier than that, but we found it didn't work very well. They find it easier to have an input once they've got a physical part in their hands rather than just looking at drawings. Assembly is when they come up with good ideas or find things that aren't quite right.

Managing Director, Engineering Company, ≤20 employees

But at another company where *in theory* at least production had an involvement in product development, the practice was less straightforward, reflecting perhaps a more traditional attitude to the role of production staff in the product development process.

BOX 5.53

The first machine that comes off the production line, we [*R&D*] build in our workshop, which brings to light mistakes which have emerged. Better that we do that here than in production, because they're not paid to think about the products, that's our job, they're paid to put things together.

R&D Manager, Engineering Company, 21-50 employees

5.3.3.3 Testing and Prototyping

Product testing and prototyping was an important stage in the development process, presenting, as it did, an opportunity to ensure that a product was functioning both correctly and safely, with test results highlighting product areas requiring redesign or further development. In some cases, meeting particular test criteria was a legal requirement. Tests could be carried out internally by the company, or could be contracted out to an independent test centre. They could be witnessed by customers (common on contract projects), or could involve field-trials with selected customers using a prototype version of the product for a limited period of time in order to give the company of how it performed and was received 'in the field'.

Testing could have a significant impact on product performance, with one company, following a prototype failure of a product replacement to an existing range (and which was therefore expected to sail through testing), discovering the test procedures it had used for several years to be inadequate.

BOX 5.54

It didn't allow us to understand what was going on in the unit, we weren't measuring enough parameters. We were measuring inputs and outputs, but the unit was like a black box, we didn't really know what was going on inside.

Technical Manager, Engineering Company, 51-70 employees

Following the redesign of the company's test procedures, however,

BOX 5.55

It was like a revelation, because everybody had thought they knew what was going on, but what was actually going on was very different. It took us up a whole new level. We also tested some competitor products in the same way, and found that some of the things they were claiming about their products weren't true. And some of the things we were saying about our products also weren't true, because we didn't understand what was going on inside them.

Technical Manager, Engineering Company, 51-70 employees

Although customer field-trials were a popular concept for speculative product developments, in practice, results from them seemed often to disappoint, with customers perceived as not using test products in the way that they would an actual unit which they had purchased, or with information from field test sites not getting back to the relevant individuals.

BOX 5.56

It's difficult to find reliable field-test sites that you can get quantitative information back over a short period of time. Because if you get someone to test it for four weeks, it's usually a week before they get it out of the box, and then they have a look at it, and that's another week, and then they'll use it for a while and then put it down, and then we'll get it back again ... So we made up a test regime that was there to simulate almost customer abuse.

Engineering Manager (case study Firm B)

Field data gets a bit lost as well, there are hundreds of these [*units*] floating about ... so you end up with odds and sods, and we didn't quite get the results.

Managing Director, Specialist Process Company, 51-70 employees

5.3.3.4 Product Launch

A common theme which emerged regarding the launch of a new product, evident from both contract and speculative development projects, was a concern from design and development staff that a product had been launched too soon, before it was really ready for market, necessitating a degree of development to continue 'in public'.

BOX 5.57

Everyone was very very nervous having so many going through ... It was one of those things where if we'd built one, had six months of it in the field, rectified everything at one go, then the others would have been alright. At the moment, the things that are going wrong, we might have to go back to all five and change things, which will be costly, a lot of time, and its public.

Project Engineer (case study Firm D)

See that's something, whenever we put a new product on like this, to me, if we do a new product we should be storing that product for two to three months on site to see if there's any problems... We should keep a pallet, put it on site, you send them out, the next thing you know you're bringing them all back because of these problems ... So mistakes are there for everybody to see.

Production Supervisor (case study Firm E)

It was evident at a number of companies that both senior managers and sales staff were keen to start making money on new products, and as well as an additional source of pressure, this seemed to be in conflict with the concerns of technical staff to ensure that products were 'ready' for the market.

BOX 5.58

We've recently joined up with a Canadian company and we've got a new philosophy from that, which is that if a product is more than 85% finished then you've spent too long on it.

Technical Manager, Electronics Company, ≤ 20 employees

There are still ones in the range that we've not done yet, so when a customer asks for one of those, no doubt there'll be some kind of crisis and everyone will get back involved with it. We're so short of time, we really drop design projects at the earliest possible time. We don't really complete them. I wouldn't draw a line under it.

Technical Manager, Engineering Company, 21-50 employees

[*We're doing more testing now*]. This does delay things, which can be a problem for sales people, because they want to get products in to the market. Although we've tried to explain to them why we're doing it.

Technical Manager, Engineering Company, 51-70 employees

We're [*the R&D department*] under pressure from sales staff, as in this project, because they're keen to put something out on the market even if its not quite ready for it.

Technical Director, Engineering Company, 21-50 employees

5.4 Project Organisation and Management

The following sections relate to the management and execution of projects, including the ways in which they were controlled and organised. Although a variety of

approaches were in use, a difference between formal and informal styles was again evident with some firms feeling the constraints of their size much more acutely than others. Such firms stressed that they felt unable to manage development projects in the way that management and best practice literature told them they were 'supposed' to, and clearly had an idea of what project management 'should' be, but felt that this ideal was beyond their reach.

5.4.1 Project Leadership

The need for effective project leadership is identified in the literature as crucial for project success, with the project leader or manager fulfilling several important roles, including managing the project team, ensuring the successful and timely progression of the project (particularly in relation to the project plan, which, like the project team, is presumed to exist), negotiating resources for the project throughout its duration, and often acting as the principle communications link between senior management and the project team (Brown and Eisenhardt, 1995; Kleinschmidt and Cooper, 1995; Rothwell, 1992; Twiss, 1992). A majority of interviewees also highlighted the project manager role as a significant factor affecting the progression of projects. Where strong or effective project management was felt by interviewees to have been absent on a project, this was usually presented as a contributory factor to project failings.

The way in which the project manager role is discussed in the literature makes certain assumptions about the resources which a firm is expected to have at its disposal, particularly with regard to the number of staff who are available within the company to become involved in development work. It appeared from the interviews that companies had two different approaches to project management, one of which more closely approximated to the product development literature approach to project leadership than the other.

Almost all of the companies interviewed put in place someone as project leader or manager (with the exception of case study Firm C who relied on their contract customer to manage the development project studied). For the majority of second-stage interview companies, however, this title meant only that they were the named

individual responsible for the project (and would probably be carrying out most of the work involved), but not that they had a project team to manage in the sense that is more usually intended in the literature. These project leaders (rather than the literature version project team managers), were associated with routine projects, particularly on contract developments where there was a high degree of repetition based on previous projects and involving a low degree of technical novelty to the company, but were also prevalent in those smaller companies with only one or two individuals available to make a contribution to development projects.

BOX 5.59

The person in charge of the project is the person who picks up the telephone call and takes the initial enquiry.

Director, Engineering Company, 21-50 employees

It depends on who gets the enquiry, who writes the quote, who talks to the customer.

Technical Director, Engineering Company, 21-50 employees

As shown in the case studies, in firms which could be characterised as taking a 'project management approach', where a project manager (as described in the literature) had been appointed[3], it appeared that they were best able to fulfil their role when they held a position of sufficient seniority within the company which allowed them to 'get things done'. Appointing someone to the position of project manager did not in itself confer the necessary authority. Several interviewees suggested that a more senior company manager was necessary for the role, and thus hierarchical authority was required as well in order to manage and direct individuals from several functional areas of the business, who would usually be expected to continue in their day-to-day work in addition to their project team role (see for example, Firm B *Box 4.12*).

However, as Firm E's experience showed (see *Box 4.37*) seniority by itself did not appear to be sufficient to ensure effective project leadership, there was also the issue of the *respect* that the individual commanded, both within the project team that they managed and throughout the company as a whole, since this again was crucial to their

[3] Who was managing not only the project but also a product development team.

ability to 'get things done'. This is similar to Brown and Eisenhardt's concept of the *power* of the project leader within the organisation. A powerful project leader holds a high hierarchical position within the company, has significant decision-making responsibility and organisation-wide authority, and is thus in a position to lobby effectively for resources (in terms of personnel and budget) for the project, as well as manage and defend the project team from outside influence (1995: 370).

5.4.2 Cross-functional Involvement

Both this section (examining *who* is involved in product development) and the following one on project organisation (*how* that involvement is managed) are closely linked. Both concepts represent an ideal which firms are encouraged by best practice literatures to live up to (see for example Takeuchi and Nonaka, 1986; Wheelwright and Clark, 1992: chapter 7, and Rothwell, 1992:224, who notes that "interdisciplinary teams with the maximum sharing of information across functions" are associated with 'successful innovators'), but not all firms felt able to manage development projects in such a way, or felt that it was appropriate to their own circumstances.

It is recommended in the literature that development projects are viewed as a corporate-wide task to which members of several internal company functions can make a valuable contribution (Ernst, 2002; Kleinschmidt and Cooper, 1995; Maffin *et al*, 1997). By increasing the amount of variety and information available to the development team, overall product design will be more robust (Brown and Eisenhardt, 1995), customer needs will remain the primary focus of product development activity, and products will be designed that can be easily manufactured (Rothwell, 1992), with any manufacturing problems or market mismatches merging early on in the project, when they are smaller and less costly to put right (Brown and Eisenhardt, 1995). However, from the interviews it is suggested that the size of a company will have a bearing on the extent to which such an approach is practical, and the degree to which it can be organised in any formal way.

Those companies who had sought to formally organise cross-functional involvement in product development were predominantly the larger companies (over 70

employees). Bringing together employees from different functional backgrounds was felt to confer benefits. As well as technical or engineering departments (who were still largely seen as 'responsible' for development projects, even where a company had made a formal commitment to cross-functional product development), inputs were most commonly sought from sales and marketing, production, purchasing and sometimes quality.

Whilst interviewees from smaller companies also spoke about the necessities of involving individuals from different parts of the company in development projects, contacts between departments at these firms tended to be much more informal and less based around structured attempts to manage cross-functional involvement. Projects tended to be managed or run out of the technical department, with other inputs coming particularly from sales, marketing and production.

BOX 5.60

I'll talk around developments with the marketing people, but we don't have formal meetings.

Technical Manager, Electronics Company, ≤ 20 employees

Sales are always asking us questions, how are you getting on. They don't just walk out the door and let us get on with it. So we don't have any official meetings, but there's a lot of contact.

R&D Manager, Engineering Company, 21-50 employees

5.4.3 Project Organisation

For some smaller firms (those with a smaller technical staff resource), development projects were managed and driven by one or two individuals within the company, and the idea of a 'project team' was not felt (by interviewees from such firms) to be relevant.

BOX 5.61

There are twenty people working for the company. In terms of the physical development of new products, it's just myself and the engineer who are involved.

Managing Director, Engineering Company, ≤ 20 employees

Often other individuals within the company would make a contribution to the project, but this was not formally managed.

BOX 5.62

The guy who set the original specification, which was the MD, myself and [*the production engineer*] as engineers, so just the engineering team really [*are involved*], there's no input from other departments at that stage ... We talked to production, probably about the time when we were getting to the pre-production prototype level, when we start talking to the machine-shop – can they produce these particular components – and the assembly area.

Technical Manager, Engineering Company, 21-50 employees

In other companies, development projects would be managed and run by a formal team of selected individuals, and this could be a fairly constant team who addressed all developments, or could be project specific. The size of companies was suggested to make a difference to how teams could be resourced, making certain 'heavyweight team' approaches suggested by Wheelwright and Clark (for example, where the project team co-locates) simply not possible (1992: 194-195).

Managing and running development projects through a fairly constant team of individuals could be seen as a response to such constraints. If effectively the same individuals were going to work on all projects anyway, then this could be formally recognised by having a 'product development team' responsible for all developments and with a regular meeting time, thus avoiding a scenario where the same individuals were required to attend several separate project meetings.

BOX 5.63

Within the new product arrangement, we meet every three weeks, we'll sit down, and that's *a* formation of a team, where we can brainstorm and we can discuss problems that have occurred.

Product and Design Manager, Medical Equipment Company, 101-150 employees

We also have weekly meetings about development projects in general, where each specific project might not be mentioned, but the opportunity for discussion is there.

Product Development Manager, Engineering Company, 151-200 employees

In some companies, whilst project specific teams were appointed for each development, in practice they were not felt to function 'as a team', with the bulk of the work instead falling on one or two individuals, as had been suggested by Firm B.

BOX 5.64

The idea is, with a project team, everybody pulls their weight. If you've got a number of engineers, an electronics engineer, myself, there's two people that the bulk of the work goes to, and everybody sits down at the meeting, takes notes, but there's only one or two names at the end ... as far as helping out and working as a team, it's the one thing we fall down on. Its usually left to the engineering department members to move the project along.

Production Engineer (case study Firm B)

There were two people working on the project from our side, me and a draughtsman, but with the bulk of it falling to me. Although on the original contract review lots of names appeared, but doing the work was just really down to me.

Development Manager, Electronics Company, 21-50 employees

One company interviewed made a practice of always including a customer representative on project teams for contract developments.

BOX 5.65

[*On the team would be*] design engineering, usually somebody from manufacture, somebody from development, and if its for an external customer, then a representative from them so that they can have an input.

Product Development Manager, Engineering Company, 151-200 employees

Co-location of the project team to a separate physical area was a strategy used by case study Firm D, and was felt to facilitate informal communications on the project as well as increasing the focus of the project team and fostering a sense of team spirit. In a further two companies, the lead engineer on a project worked exclusively on the development, with other members of staff involved in the project continuing with day-to-day tasks or other project work as well.

BOX 5.66

The electronics guys have the easy side because they work on one project, they might get pulled back when there's problems on past projects, but effectively they've got one project they work on.

Production Engineer (case study Firm B)

The only person who's solely dedicated to it is the project manager. That's his life!

Quality Manager, Engineering Company, 21-50 employees

For other staff at these companies, and for staff at companies where no member of staff worked solely on one project and nothing else, there was a tension evident

between trying to juggle project and 'other' responsibilities, with priority setting stressed as key.

BOX 5.67

Because of our size, all of us wear lots of hats, so the design people are dealing with other things as well. It's really that with a limited resource you have to prioritise.

Deputy Chief Executive, Specialist Equipment Company, 21-50 employees

However, most were not members of the project team throughout the entire duration of the project, instead membership of the team changed according to the stage that the project had reached, and this was another way of managing staffing constraints.

BOX 5.68

The team evolves depending on the nature of the project. So at the start of the project you may have only a couple of key individuals doing the research, and then it'll be opened up to the rest of the team ... after that, people will come to the team and come off the team depending on what the need is at the time.

Technical Director (case study Firm A)

We had about twenty one [*on the team*] throughout the whole project, but sometimes there might have been only five people or two people, depending on what stage of the project they were on. Bearing in mind we had four other projects on at the same time, so one person might be working on more than one project.

Quality Manager, Engineering Company, 21-50 employees

5.4.4 Project Documentation

A degree of paperwork was generated by all projects, including, for example, minutes of meetings, details of supplier and customer contacts, technical drawings, test results, and so on. Maintaining such records, for example in a project file (either paper or electronic), was a way of keeping track of the progress of a development, but could also be used to enable the organisation to learn from past projects in identifying both successful actions to be repeated as well as mistakes to be avoided on future projects. One company for example, (*Engineering Company, 21-50 employees*), had constructed a database in which to record all project non-conformances (good and bad).

BOX 5.69

It's any issue relating to anything we think is either an improvement or a good idea, so we have a log of all these issues which has proved very useful ... generally because we only make one or two-offs, it's basically prototyping all the time, so you've only got one real shot of getting it right, and any mistakes that you have in there, you'll continue on to re-correct, redesign and put right and obviously add a lot of cost to the job ... so if we can learn by our previous history then we won't have these problems next time.

Quality Manager, Engineering Company, 21-50 employees

We hang on to all that project documentation, including projects that come to a dead-end, or the need for it disappears ... It's so that in three or four years time we don't reinvent the wheel with something we've already tried.

Technical Director, Specialist Process Company, 130-150 employees

For engineers, project documentation seemed to have a further role, in that it was a way of 'covering their backs'. Having a record of decisions and choices made was a way of making decisions accountable and traceable. Engineers appeared to be (in some cases) reluctant to make decisions themselves, but then needed documentary proof of who *had* taken a decision or the reasoning behind a particular choice (for example on a supplier's recommendation).

BOX 5.70

We make no decisions. We basically just document everything and put it in to management ... It's all documented ... It's covering our backs really.

Lead Design Engineer (case study Firm B)

These are basically all the design notes for each project, so notes, discussion notes, drawings, quotes. So if we ever have to think why we made a particular decision, then all the information is there in one file.

R&D Manager, Engineering Company, 21-50 employees

5.4.5 Project Meetings and Reviews

Particularly for smaller firms (with fewer than 50 employees), but to a degree on a majority of all projects discussed, a significant number of communications and project meetings were of an unplanned and informal nature, and were often facilitated by the proximity of individuals within the firm.

BOX 5.71

We don't have any official meetings while all this is going on ... If anything comes up in the design process we'll call in sales to have a look at it ... so we don't have any official meetings, but there's a lot of contact.

R&D Manager, Engineering Company, 21-50 employees

> There are [*formal*] design meetings, but there are lots of *ad hoc* meetings. In a company this size a meeting can occur in a corner of a room.
>
> *Deputy Chief Executive, Specialist Equipment Company, 21-50 employees*

For those companies who were trying to 'project manage' their development projects, design and project reviews were usually scheduled into a project plan. On contract projects, these would normally be attended by the contract customer.

It had been suggested by Firms A and B that there was sometimes a tendency (on projects where there was no external attendee) for planned meetings and review to lapse when it appeared there was nothing to report on a project.

BOX 5.72

> There's no point in having a weekly meeting if there's nothing to report, so there were certain points in the project where there was no pace, nothing was happening, so why call a meeting ... then people said, well if we're not going to have to report, it's not so vital and urgent.
>
> *Technical Director (case study Firm A)*

This (and the tendency to sometimes see reviews as something that had to be done as a requirement of ISO rather than 'value-adding') was perceived by some companies as a problem, and various strategies were put in place to try and overcome it. Ensuring that regular meetings went ahead meant that a situation where the project was allowed to drift or where problems were not spotted was avoided.

BOX 5.73

> The weekly review tend not to show up a great deal in terms of success or lack of it, because it's really a small enough period of time to keep people's minds focused on the fact that we're working to a plan.
>
> *Managing Director, Medical Equipment Company, ≤20 employees*
>
> The team met on that one every week, and that's been crucial to it happening in a good, timely manner, because if you're doing it every week, as soon as you start to get any slippage for whatever reason, you're no more than three or four days behind when you pick up on the fact it hasn't happened, so you can get it back on line.
>
> *Senior Engineer, Electronics Company, 101-150 employees*

Holding a regular scheduled meeting was therefore one way of getting over the problem of non-attendance.

BOX 5.74

They're held at the same time every week on a Tuesday, so everyone who should be there knows that it will always be going on.

Product Development Manager, Engineering Company, 151-200 employees

Where a company had put in place a set of product development procedures, there was often a requirement for an end of project review, but a number of interviewees suggested that whilst they '*should*' review, in practice they struggled to find the time. Resource constraints and the demands made on individuals meant that the next job in the pipeline was always the most pressing task to be dealt with. Projects might only be reviewed where something out of the ordinary had happened, particularly where the project was felt to have 'gone wrong' a *post mortem* was likely to be held.

BOX 5.75

We wouldn't formally review, probably if things had gone badly wrong. If things have gone well then nobody asks any questions. We only have a *post mortem* if things go wrong and we haven't hit targets in some way, either timescales or costs, and then we'll look at lessons to be learned, and what can be done in the future to make sure it doesn't happen again.

Technical manager, Engineering Company, 51-70 employees

We'd usually only review if a job's poor, when we're assessing it financially, if it's a particularly bad job we'll sit down and analyse it, and if it's a particularly good job as well we might. But if it runs true to form and the profit margin is what it started out at, then we'll assume it was a proper job.

Director, Electronics Company, 21-50 employees

The majority of end of project reviews that did take place were concerned with the commercial side of the project, for example, whether it had conformed to predicted budget and timescales, as well as the sales performance of those products which were to go on general sale. A minority of companies specifically reviewed how the project had been managed, and this was viewed as a learning opportunity for the company.

BOX 5.76

Basically we go through and pat ourselves on the back and say what a good job we've done, and we start looking at what were the main problems or the main issues during the project, and if there are any issues we feel we need to integrate into new projects, or technology we should leave out of new projects ... That's the sort of thing we'll look at, what we can do better next time, or what we shouldn't do next time. And we look at client perception, we look at the overall team performance, whether we did it on time, how many days we spent on it, and the wash-out generally throws out a project management report which the project manager does.

Quality Manager, Engineering Company, 21-50 employees

Again, the very smallest companies (with the smallest technical resource) struggled with the idea of introducing any formality into the management of their development projects.

BOX 5.77

No we probably don't review the project and the stages that we went through, though we will review it to make sure its manufacturable. We don't want to know how badly it went!

Managing Director, Engineering Company, ≤ 20 employees

5.5 Conclusions

This chapter has presented data relating to the product development process, the organisation and management of that process, and the strategic position within and contribution to company competitiveness, in relation second-stage interviews conducted for the research project.

A variety of approaches have been illustrated, and a number of 'contingencies' identified which affect (possible) product development processes and management for *particular* firms. These contingencies relate, for example, to the industry sector or markets within which a firm operates, the background and specialisms of the company owner or managing director, particular project-specific characteristics relating to the degree of novelty present in the project for the developing firm, and the number of technical staff employed in the firm relative to the company's overall number of employees.

Therefore whilst some factors have (for some firms) been associated with more positive effects in managing the product development process, there do not appear to be any hard and fast rules, since company-specific circumstances (both internal and external) also appear to play an important part in how a company is able to approach and manage the product development process.

Whilst it appeared that a more structured and controlled approach to project management (including repeatable product development procedures and individual

project planning and monitoring) was beneficial in achieving project objectives and targets, the degree to which companies felt able to implement such an approach varied considerably, with some companies seeming to feel the constraints of their smaller size much more acutely than others. A common factor in such companies was the extent to which technical staff were engaged in everyday 'fire-fighting' at the expense of product development activity, and this was often related to the relative size of the firm's technical resource. So for example, those firms where only one or two individuals (often including the managing director/owner-manager) were responsible for product development activity appeared to feel the constraints of their size (and limited resources) more severely. But larger firms with a relatively small technical resource (in terms of development staff) who had additional responsibilities, for example in dealing with day-to-day production engineering problems, also appeared to suffer.

There were therefore differences in the degree to which companies felt able to manage product development projects in a more formally planned and structured way. Also, however, for those companies who *had* attempted to institute a more formal approach to product development, frequently differences were evident between what interviewees suggested *should* be done in terms of product development management and procedures, and what was actually done *in practice*.

All of these suggest product development to be a highly idiosyncratic and complex process, and one which is therefore likely to present difficulties in how it can best be supported. It is unlikely, for example, that a 'best practice' approach as a standard support intervention will be particularly helpful.

The following chapter will examine further evidence from both empirical stages of the research project, and will also attempt to supplement the theoretical and conceptual framework with which the research project began (set out in Chapter Two) with additional insights from the literature in order to better explain and understand data collected during the empirical stages of the project.

6

Product Development and SMEs

6.1 Introduction

As has been stated throughout the thesis, as the collection of empirical data progressed, the original conceptual framework, whereby product development was understood as a process which could be broken down into a series of steps, for each of which it would be possible to identify appropriate management tools and techniques, began to feel increasingly inadequate.

Data emerged which suggested contradictory findings to this relatively 'rational' original approach, and which suggested difficulties in RTCN's concern to identify ways in which firms could be assisted in managing product development more effectively through the identification and diffusion of a series of 'good practice' options. Whilst some factors were emerging (in both company understandings and practices) which appeared to be beneficial in more successfully progressing projects, the degree to which companies could effect these was clearly not uniform.

Whilst Chapters Four and Five have discussed product development processes and organisation in some detail, this chapter will discuss the research findings in relation both to those literatures discussed in Chapter Two (and which comprised the original theoretical framework informing the research), but also in relation to additional literatures, which will be introduced and discussed in an attempt to resolve some of the inadequacies of this initial conceptual framework. Whilst originally the research set out to provide answers to RTCN's main question – how can SMEs be supported to be 'better' at product development – as the project has progressed, the framework informing such a concern has been found to be inadequate. It is suggested that the original approach in the thesis – identifying 'good practice' in product development management – is, by itself, an inadequate approach, since many aspects of the product development process appear to be potentially problematic and are not amenable to simply 'better management'. By itself a 'good practice' approach significantly

underestimates the complexity of the product development process itself, as well as the variety of contexts within which firms operate and the multiple choices of action which are open to them.

Discussions of research findings will be grouped around three broad areas. Firstly in relation to those characteristics and behaviours which are widely presumed in the literature to be 'SME-typical', for example in terms of the advantages and disadvantages which such firms are presumed to possess with regard to product development processes, particularly in relation to larger firms, and which therefore inform conceptions of the types of policy intervention believed to be appropriate. Secondly, in relation to the ways in which inputs to the product development process are sourced by such firms (from both internal and external sources). This will therefore include reference to organisational learning literatures, as well as to those inputs which were found by firms studied to be critical and important for their product development projects. Finally, findings will be discussed in relation to product development management – both with regard to 'best practice' notions, but also in relation to the ways in which firms come to manage in the ways that they do.

The chapter will therefore attempt to shed some further light on those areas with which RTCN had a principle concern, relating to how best to support SMEs in becoming 'better' product development managers. What has emerged through the course of the project, however, is a sense that this may not be the best way to frame concerns regarding the support of SMEs in product development or innovative activities, since to concentrate on a 'best practice' management approach (how world-class firms manage their product development processes, and how this can be disseminated to other less well-performing firms) ignores a significant amount of context and behaviour which appears to have a bearing on outcomes.

6.2 SME Characteristics

As discussed in Chapter Two, small and medium sized companies are largely assumed to possess particular characteristics which affect how they are able to approach product development activities (Karlsson and Olsson, 1998; Tödtling and Kaufmann,

2001; Vossen, 1998; White *et al*, 1988), and an array of policy initiatives targeted at SMEs have been introduced as a response to these (Hoffman *et al*, 1998). Broadly speaking, larger firms are assumed to enjoy resource advantages over SMEs, whereas smaller firms are believed to operate with certain behavioural advantages regarding their speed of operation, flexibility and lack of internal bureaucracy (Karlsson and Olsson, 1998; Vossen, 1998; White *et al*, 1988). Furthermore, SMEs are presumed to have to concentrate their limited resources on fewer development projects, and are thus operating at an increased risk in relying on those one or two projects coming successfully to fruition (Acs and Audretsch, 1993; Karlsson and Olsson, 1998; Vossen, 1998). Constraints identified in the literature are therefore largely normative, and appear to be resolvable through the provision of extra resource. Advantages which SMEs are presumed to enjoy in relation to the product development process are guided by the assumption that all individuals within the firm are working towards a common good, with the role of personal and group motivations and ambitions neglected (Cabral-Cardoso, 1996: 47, 49).

This section will discuss the research findings in relation to these assumptions regarding 'typical' SME characteristics. Whilst a number of firms did exhibit such characteristics, this was by no means uniform, again suggesting the heterogeneity of the SME population. It also became apparent that some types of difficulties which firms encountered throughout their product development processes were much more likely to be explicitly recognised than others. Where problems related to resource or technical difficulties, it seemed more likely that a solution would be sought. Where difficulties related to less concrete problems, for example to communications difficulties within the firm, or to apparent political manoeuvrings by participants in the product development process, they were less likely to be identified as requiring an intervention on the part of the firm, perhaps because by nature they were more difficult to resolve[1].

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[1] It should be recognised that the types of constraints which were 'uncovered' by interviews varied to a degree on the stage of research. The case studies, using a more intensive approach with several accounts of one project collected from within the same firm, tended to bring to light instances of 'softer' constraints, and this also varied according to the degree of access given to different functional groups within the same firm. So for example, at Firm E, where the greatest access to production and operations staff was given, in addition to interviews with senior and middle managers from other areas

6.2.1 Resource Considerations

It is suggested in the literature that small and medium sized firms face particular resource constraints relating to the product development process (although across a number of other business areas additionally) which are not shared to the same extent by larger firms (see for example Freel, 2000b; Rothwell and Dodgson, 1994; Smallbone *et al*, 2000; Vossen, 1998). A number of interviewees identified limited resources (in terms of staff time and finance) as particular limitations on their product development activities. However, in comparing firms of a similar size interviewed for the research project, some seemed to feel these constraints much more acutely than others, and it appeared that this *could* be related to the relative size of the firm's technical resource (in terms of the number of technical staff employed in relation to the total number of staff in the firm). It seemed therefore that staffing and financial constraints primarily related to a lack of spare capacity in the firm, capacity which would allow the pursuit of product development activity separate from everyday 'fire-fighting'. Where such capacity was absent, day-to-day unplanned for crises would (not surprisingly) be given a higher priority over product development.

Financial limitations on product development projects were discussed as a problem only by stage-two interviewees, with firms who were engaged in more incremental developments to existing products suggesting they were the most restricted in funding projects, since access to external funding for such projects was not felt to be available.

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of the company, the greatest number of internal divisions was also apparent (though differences between internal functional groups were also evident at other case study companies, although to an apparently lesser degree). In the majority of survey interviews, the account given was that of an individual respondent, and so any instance of tension or difference between departments had to be understood as the opinion of only one individual. Survey interviewees, on the whole, spoke about successful projects, which were presented as having run relatively smoothly. Problems which were raised were sometimes project specific and mainly related to technical issues, although occasionally to project management, but often interviewees spoke as well of constraints in more general terms, raising what they felt were recurring obstacles to the company achieving its product development objectives. Four of the five case study firms, however, selected projects which had been in some way problematic for the company (significantly so for Firms A, B and E), and with regard to these, the case study method allowed the emergence of points of difference in project narratives. Problems which were identified were in the main project specific (relating to the project under discussion), and concerned both technical and market issues, as well as difficulties in project planning and management.

6.2.1.1 Financial Considerations

The financing of innovation projects is frequently suggested as a particular constraint faced by SMEs in the product development process (Isaksen *et al*, 2000; Garofoli and Musyck, 2001; Rothwell and Dodgson, 1991; Vossen, 1998). In the case study component of the research, companies were asked to speak specifically about projects which were either completed or close to completion. No major issues regarding project finance were raised, perhaps because the decision to pursue the project had already been made. None of the case study companies experienced difficulties in financing the specific projects that they spoke about, although demonstrated different approaches to the overall financing of product development (ranging from allocating an annual budget to financing developments on a project by project basis).

Financing development projects was raised more as a concern (in accordance with those studies referenced above), by companies interviewed during the second phase of data collection and perhaps reflects the fact that whilst companies were again asked to speak about a specific project, some questions were often answered in more general terms.

Again a difference in approach between firms working on contract and non-contract (or more speculative) development projects was evident. On contract projects, contract milestones agreed with clients would normally also mark stages in a payment plan, with the customer paying an agreed percentage of the overall project cost on the successful completion of each milestone. This staging of payments allowed companies to manage their cash-flows more efficiently, but could also mean that customers effectively financed the more experimental development work that companies undertook, since the majority of such work could be carried out on project, rather than off-line and with no particular customer in mind.

BOX 6.1

I think most of the development goes on as part of a project, so we try and introduce new technologies on every project, and hopefully the client pays for that technology for us to develop it as we go along on the project, rather than spending our resource.

Quality Manager, Engineering Company, 21-50 employees

> We can't afford to fund the entire development project, so we ask for a purchase order from the customer which would cover the commercial cost at which the machine will be marketed, but which won't cover the cost of building the first machine ... So by the time it gets to the end of the project we'll have recovered all of the design costs, but we'll probably have made a loss of around 10-20% of the project's value, which we would hope to recover fairly quickly on the next one or two machines built. Generally speaking, once we've sold three machines of a particular design, we're making profit.
>
> *Managing Director, Engineering Company, ≤ 20 employees*

Where companies did have a specific budget set aside for product development, this was most likely to be equated with the departmental budget of whichever department was seen within the company as 'responsible' for technical matters, so for example, the engineering or design department, as for example at case study Firm B.

The majority of firms did not have a specific product development budget, but instead the cost of development to the company was more hidden. The greatest cost associated with product development was usually identified as labour, which was treated as an overhead, and with other expenditures accounted for (and justified) on a project-by-project basis.

BOX 6.2

> We calculate the R&D spend, the majority of the spend is in labour, so it's permanent staff anyway, the majority of spend is there. It's hard to budget really, I mean you've just got your staff really.
>
> *Marketing Manager, Electronics Company, 21-50 employees*
>
> We do put something in the budget for development, but it tends to be treated as an overhead. Anything that we buy for development purposes is coded to 'development', but the biggest component is staff time, and that's an overhead.
>
> *Managing Director, Engineering Company, ≤ 20 employees*

Some companies attempted to source capital from outside the firm. External funding was believed to be available for 'extraordinary' projects involving new technology (and new not just to the firm concerned, but also with novelty outside the firm as well), but was not perceived to be available for the 'everyday' improvements with which most companies were engaged, even where such an improvement might require a technological leap for the firm involved. If development projects had no technological novelty beyond the boundaries of the firm, then external funding was difficult to come by. All successful bids for external R&D funding had been achieved

through DTI SMART awards (four companies had received SMART awards and a further two were in the process of putting together applications).

BOX 6.3

The SMART award has been a godsend, because it's given us 40% of the development costs, it would have killed us otherwise.

Managing Director, Engineering Company, ≤ 20 employees

Actually it has [*been adequate*] to be realistic. You can always say you could use more money, additional resources are always useful on a longer-term project, in that sense more would be nicer. But the assistance that we had made the difference between going ahead with projects or not.

Managing Director, Medical Equipment Company, ≤ 20 employees

Several companies had investigated the possibility of acquiring European Union funding through the Framework Programmes, but none had gone forward with an application, suggesting that the bureaucracy involved was off-putting.

BOX 6.4

I went on an awareness day organised by RTC. There was a guy from [*company name*] there who was saying its a minefield, don't bother with it, and the whole thing was presented as though unless you were ICI or something.

Engineering Manager (case study Firm B)

Venture capital was not mentioned by the majority of firms interviewed. Only one company had received any venture capital funding (*Medical Equipment Company, 21-50 employees*), and only one other firm (also in the medical equipment sector) made reference to venture capital, identifying it as a potential source of funding for their particular products.

BOX 6.5

You'll always find venture capitalists willing to fund if they can see a product or a concept that is demonstrable.

Managing Director, Medical Equipment Company, ≤ 20 employees

Therefore whilst financing product development was a concern for the majority of firms interviewed, this was not the case across the board. Finding finance for product development was more of an issue for those firms who tended to do more incremental

development work. For those firms, whatever their size, whose products could be characterised as 'novel', sourcing development finance was much less of a problem.

6.2.1.2 Staffing Considerations

Resource constraints were also felt by a number of companies in terms of staff time available to work on development projects. For companies who worked exclusively on contract projects, there was often a struggle to balance time between several concurrent projects which all had to be completed on schedule. At firms where off-line (speculative) developments were the norm, interviewees suggested that there was a conflict between allocating sufficient time to development projects whilst at the same time carrying on with 'everyday' work, with project work generally seen as an additional responsibility, and this perhaps relates to the notion of 'spare capacity' suggested earlier.

All companies interviewed employed staff whose responsibilities included development work (and often development work was equated with the work of a particular functional department, most often engineering or technical design), but those companies with staff whose *sole* responsibility was development work were very much in the minority.

For the majority of companies, development staff also had everyday responsibilities in addition to product development work. In smaller companies (especially where only one or two people worked on product development), but also in larger more process driven companies, there was a large element of 'fire-fighting' in the work of development staff, where crises which occurred were (usually) felt to take precedence over development work and which therefore intensified the conflict between 'everyday' and development work. Where R&D or product development work was less formally organised, this situation of competing priorities became much more difficult to avoid.

BOX 6.6

We were late with the design, but if you clocked up the hours, we probably did alright. Being given a deadline like June 2000 is a bit crazy because it doesn't take into account any of the other work we have to do. It probably came in within the hours, but in terms of calendar days, we were late, and then we get stick for that from the rest of the company.

Technical Manager, Engineering Company, 21-50 employees

I think in a small company it's hard to have plans in development, because you haven't got someone who just sits there blinkered without looking at anything else. Some other machine will break down so we'll have to take someone off development work to do some other issue in general production or something that needs doing.

Managing Director, Engineering Company, ≤ 20 employees

Temporary contract staff were employed by some firms to alleviate resource constraints, most commonly in production or more routine design work where their use was felt to be more feasible. Concerns were raised by several interviewees regarding the effort that had to be put in to bringing an external person 'up-to-speed' with the company's procedures and ways of working as well as other company specific knowledge, only for that experience to then leave the company as the contract period of employment ended.

BOX 6.7

We don't particularly want to use contract design staff, because protecting our intellectual property becomes difficult, we've got to give them access to our systems and so much information, and you've got a learning curve, especially on [*products*]. There aren't many people who design them. You can learn to design them, but there's a learning curve time and you haven't got that, so it is a big problem for us.

Group Technical Manager (case study Firm C).

We have had a few issues where someone comes in and they're just getting into the swing of things and then they're offered another job somewhere. But that's a thing you have to put up with rather than employing them full-time, which has other problems.

Quality Manager, Engineering Company, 21-50 employees

Another option for solving more specialist resource constraints was to bring in a student placement or to make use of the Teaching Companies Scheme. This was a route used by five of the companies interviewed, and to mixed effect. Interviewees seemed to have quite high initial expectations of what could be achieved by such placements, and sometimes were dissatisfied when the reality failed to live up to their requirements.

BOX 6.8

I was worried about the technical side of the development and the quality of work of the TCS, who we felt just went his own way, regardless of what was said in meetings ... The calibre of the TCS engineer wasn't up to scratch, and we wouldn't get involved in a scheme like that again ... I thought there was an ivory tower problem.

Technical Director, Engineering Company, 21-50 employees

At the time we had a student on secondment from [*university*] which turned out to be a bit of a disaster. We were led to believe that somebody from the university would mentor him, and this didn't happen, neither me nor the student could get in touch with his mentors, and this went on for nine or ten months. We were paying the university for this, but the support wasn't there. That really added to our costs but we didn't get anything out of it.

Managing Director, Engineering Company, ≤ 20 employees

As well as these constraints on existing staff, some companies felt hampered by difficulties in recruiting new staff. This could relate to specific skill shortages,

BOX 6.9

It's very difficult to get what we regard is the right skills or calibre of engineer ... I think it's more to do with our expectations in our engineers I suspect, I think we're less inclined to take less able engineers.

Technical Director (case study Firm D)

For some companies, particularly the very smallest firms interviewed (20 or fewer employees), there was felt to be a huge risk involved in recruiting someone to a key post, with a danger that the 'wrong' person might be employed.

BOX 6.10

It's not difficult to get staff, it's more a case of if I was brave enough I'd do it today! On the sales and design side it is a problem, you've got to have the right kind of person. It's less of a problem on the shopfloor because you can always manipulate or do something about that. But if you get the wrong person in a more senior role it can cause big problems. It's something I know I have to do but I keep putting it off.

Managing Director, Engineering Company, ≤ 20 employees

While resource constraints of either a financial or staffing nature were highlighted by a majority of interviewees, as suggested in Chapter Five, they were evidently felt much more acutely at some companies than others. Some smaller companies felt unaffected by their size.

BOX 6.11

When I see those headings in business questionnaires they don't seem to apply. We're highly profitable for a small company, so we're not looking for any venture capital or any of that kind of stuff, recruiting personnel isn't a problem - we have a problem getting good sales people, but the whole industry does - our facilities are big enough, we've got spare capacity, we've got good relations with the universities and we can go and find the expertise we need or the clinical environment we need.

Managing Director, Medical Equipment Company, 21-50 employees

However, others seemed to feel themselves much more limited by their lack of resources.

BOX 6.12

Because we have limited human resources, development doesn't take such an important part as it ought to do ... We're too small a company to have single skill posts.

Managing Director, Engineering Company, ≤ 20 employees

If we'd been free to work on the project exclusively then we'd have been done well in time. There are other things done through the design office that must be done. We've lost an engineer this year ... development work is a relatively small proportion of what we do.

Engineer, Engineering Company, 21-50 employees

It appeared to be largely the size of a company's technical resource which was instrumental in affecting how deeply a lack of (overall) resource was felt. In firms with a greater proportion of design, engineering or R&D staff, resource constraints were felt to be less of a problem. More might have been nice, but was not immediately essential for the continued well-being of the firm. These firms also appeared more able to manage their product development processes in a more 'best practice' way, with planning and reviewing featuring heavily in projects. Firms who suggested they felt their resource position more acutely tended to be operating with a lower proportion of technical or design staff (perhaps for example, only the owner-manager or managing director, and/or one or two other members of staff who had a dual role as service or production engineers), and managed their product development processes in a more informal or *ad hoc* way. Resource constraints for these individuals, with their dual roles and the demands made on their time by the everyday crises which kept on coming in the chaotic environment in which they operated were an everyday reality.

6.2.2 Behavioural Considerations

SMEs, however, are also presumed to possess particular advantages with regard to product development (in relation to larger firms), and primarily these related to what can be classed as 'behavioural' factors (Vossen, 1998). SMEs, for example, are presumed by virtue of their smaller size and lack of internal bureaucracy, to enjoy greater flexibility and speed of operation, with more efficient and effective internal communication (Karlsson and Olsson, 1998; Vossen, 1998; White *et al*, 1998).

Whilst this was true for some of the firms interviewed, it was not the case across the board. The experience of some firms was somewhat less rose-tinted in this respect than is suggested to be typical.

The perceived wisdom regarding small firm communication is that they have an inherent advantage over large in as much as their size will facilitate "rapid and effective internal communication" (Vossen, 1998: 90). Whilst this was often the case in the companies interviewed it was not uniformly so. In some firms it seemed that communications channels had just 'evolved', for example, where individuals had previously worked alongside each other and were now based in different departments, a communications route had been able to develop through the continuation of existing relationships, or the fact of proximity within the firm (sharing lunch etc) meant that relationships between individuals from different areas of the company were established. In other firms, this had not happened, and it had been recognised that something needed to be done in order to kick-start a particular line of communication between different functional departments.

BOX 6.13

We're trying to involve production more in product development and are getting more conscious of design for manufacture. At the moment we don't really have much feedback from the service department to R&D, and we need to change that.

Technical Director, Engineering Company, 21-50 employees

We do [*have input from sales and marketing*], but not nearly as much as we should, that's another thing that's going to change.

Managing Director, Medical Equipment Company, 21-50 employees

Largely those companies interviewed did feel that their size was beneficial in facilitating communication.

BOX 6.14

[*It's*] much simpler when you're a smaller organisation, everyone can talk to everyone else on an almost hourly basis.

Managing Director, Medical Equipment Company, ≤ 20 employees

Most people are within earshot of everybody anyway... I think the communication is where we score, because we're a very flat organisation. Although we've got quite a few people, they've all grown up together, some of the lads served their time together and there's no protectionism like 'this is my department'.

Director, Electronics Company, 21-50 employees

From the case studies, however, it became apparent that good internal communications could not be taken for granted. At Firm B, for example, a senior member of staff (who subsequently was 'let go') was in theory in overall charge of a project, but was effectively kept out of the communications loop by engineering staff who failed to report to him.

BOX 6.15

He's meant to be head of the engineering department as director. So theoretically he's in charge over [*the engineering manager*], so we should report to him. We don't, but we should.

Design Engineer (case study Firm B)

Poor communications were also identified by interviewees at Firms A and E as a failing on their project (see *Box 4.34*).

BOX 6.16

The big team, splitting it down, ok, we thought we'd done a good job of that. The problem was communications, the top, the management team did not manage the project.

Marketing Director (case study Firm A)

Lots of sub-groups went off to do their own little bit, what was supposed to happen was that they should report back to the main team, a lot of that information was lost.

Logistics Director (case study Firm A)

Such difficulties could be explained in terms of poor internal communications systems, or perhaps in terms of interpersonal differences between individuals who

simply didn't get on. What did seem to be visible, however, were differences and misunderstandings between internal functional groups at several companies, and these varied in how divisive they appeared to be to internal company cohesion. Dougherty (1992) has suggested that such differences cannot be explained in terms of individual personality clashes or conflicts over departmental goals. Rather such conflicts are the manifestations of internal cultural differences between different functions within the firm, called varyingly departmental 'thought worlds' (*ibid.*) and 'worldviews' (Schein, 1996, Thomas, 1994). Different occupational groups develop idiosyncratic outlooks and ways of thinking, and will thus tend to have more in common with members of the same occupational group from outside the firm than with staff from other functional areas of their own company (Schein, *op. cit.*). The concept is therefore similar to the idea of boundary-spanning communities-of-practice which have been identified as a source of learning and occupational knowledge (Amin, 2000; Brown and Duguid, 1991; Wenger, 1998). It is suggested, however, that such differences in outlook can also be a source of internal conflict and miscommunication. Each occupational group will develop their own distinctive language through which different assumptions will be made about what is important in the day-today running of the firm (Schein, *op. cit.*), and each of these systems of meaning will affect how each departmental thought world interprets the same information and ultimately produces a different understanding of the same process, including the process of product development (Dougherty, *op. cit.*: 195).

As suggested in Chapter Four, such differences were recognised by some interviewees in a 'common-sense' way as 'how things were' (see *Boxes 4.25* and *4.35*).

BOX 6.17

Everyone who's involved has got different priorities, so what's really important to one person who's working on this project might not be that important to somebody else.

Marketing Manager (case study Firm E)

Differences were most evident at Firm E, where there appeared to be a large gulf between marketing and strategic product development staff (based at the company's head office site) and operations staff (including a senior manager) and operational product development staff (based at a separate production facility). Both 'sides'

appeared to share a common goal of both business and product development success, but suspected the other of trying to undermine this. From the head office perspective, production staff did not want the business to move forwards, and instead wanted to limit production to only those products which were easy to handle on the production line. Operational staff *were* concerned with the efficiency of the production line (and not surprisingly, as they were required to work to production targets), but they also spoke about trying to meet overall company objectives, and particularly the company's product development strategy of bringing out niche (and difficult to imitate) products as a way of strengthening the company's competitive position.

BOX 6.18

When we've said to management that some products won't run efficiently on the line, what comes back is 'the needs of the business' and 'you can't stop the development of the business, we need to work'. We want to work as well. Management are looking for work to see us through the winter, and we'd like to see a better spread of business all year round.

Production Engineer (case study Firm E)

The likes of [*Director*] and the rest of them, everything's kept close to the chest and I don't know why, it's all for the company, so if they'd just involve you at an earlier stage ... I've never known anything like it the last couple of years, especially when they've turned around and said we're bringing two new products a year out, or two new concepts. Fair enough, it's the way the company wants to move forward, that's great for everybody if the company's looking to move forward, I just wish they'd get them meetings right and involve people at an earlier stage.

Production Supervisor (case study Firm E)

Production staff suggested there was a 'blame culture' within the company, where if they *did* take risks (albeit those which had been sanctioned by management) which subsequently did not 'pay off', they would be publicly blamed. Consequently there was a reluctance to be anything other than conservative in estimating the capabilities of current production equipment.

BOX 6.19

I think the company had a blame culture years ago and that seems to be coming back. It's not that you want to point the finger at anyone, it's wanting to do it right.

Production Engineer (case study Firm E)

> [*Production staff*] kind of limit the implementation because they're looking after their own interests ... they're trying to protect their interests because I'm putting the people out there under pressure in terms of getting the performance right because that costs us money, and then along comes a new product which say performance is going to go down to 50% or less, so I put them under additional pressure and say yes but, we need to get that done in that period of time. So they're coming up front and saying no we can't do that, instead of saying yes we can do it, but we need to do [*this*] to do it right ... And I've got to say this is probably part of the culture of the company, which is changing and needs to continue to change, in terms of finger-pointing and blame-culture sometimes, and that's still around to a degree. It's better since IIP but it's still there.
>
> *Operations Manager (case study Firm E)*

Schein (*op. cit.*) identifies three distinct worldviews relating to the cultures of executive managers, engineers and operators, which have their own communication styles through which different and competing assumptions will be made regarding what is felt to be important in the day-to-day operation of the firm. He suggests that these three cultures persistently (though unwittingly) misunderstand each other and often work at cross-purposes, and this lack of alignment can ultimately lead to failures in organisational learning (*ibid.*: 9), which can then impact negatively upon product development. Similarly, Dougherty (1992) suggests that function-related interpretive schemes within the organisation, used to make sense of product development, can in fact inhibit the progress of innovation-related learning, acting as interpretive barriers between functions. Functions or departments within the firm have their own 'thought worlds' relating to styles of organising and thinking about innovation, each focusing on (and therefore privileging) different aspects of the technology-market knowledge necessary for product development (*ibid.*: 179). Each functional thought world ultimately shares the same goal – the successful development of the product – although each may have a different interpretation of this goal, and so bring different concerns to the fore. For example, while both technical and marketing people may be concerned with customers, technical people may have more of a concern for finalising a general design, whereas marketing people may be focused on meeting individual customer requirements in a design, whilst additionally manufacturing people may have specific fears that neither technical nor marketing people understand the limitations of the company's production capabilities, and so may be uncooperative unless this is dealt with openly (*ibid.*: 196).

Whereas both Schein and Dougherty suggest that these different ways of seeing and thinking will typically cause conflict within the organisation at the expense of learning and product development outcomes, Brown and Duguid (1991: 54), argue that the frictions that arise between competing practices are in fact necessary in generating the "improvisational sparks" that can generate innovative thinking. Although they are not alone in suggesting that internal organisational politics can be beneficial to the organisation (see for example, Buchanan and Badham, 1999), more usually, politicking is suggested to be "detrimental to effective management" (Jones and Stevens, 1999).

6.3 Building Assets for Product Development

As was suggested in Chapter Two, innovation rests on learning (Smith, 2000) – how the firm can acquire and generate knowledge and inputs to the product development process from both internal and external sources. With their R&D Quest project, RTCN had also recognised that how firms were able to access and use external inputs to product development in particular might be critical to the outcomes of projects. This section will examine evidence relating to both where firms sourced inputs to the product development process, as well as how such inputs were used to build a 'technological base' for the firm, which would enable it to be innovative and active in product development.

The ability of a firm to develop new products depends, at least in part, on its potential to acquire (and to continue to acquire) a stock of knowledge, regarding for example its markets, production techniques, existing products and the management of the product development process itself. The firm must be able to recognise and access what is already 'known' (for example, in existing company routines, but also in the knowledge of individuals within the firm, which could themselves be combined to form new 'knowledges'), but must also be able to access external inputs to the process (which can come in a variety of forms) and assimilate these into its own technological base.

'Assets' for product development include all those potential inputs to the process, and relates to both inputs which can be bought or are readily available, and those which are firm specific and must be built up over time. It is suggested by Christensen (1996: 115) that technological assets are the combined result of internal learning and 'absorptive learning' (or the capacity a firm has to absorb or take on and understand inputs) from external sources. Thus a firm's 'absorptive capacity' relates to the prior (related) knowledge it has been able to accumulate, and which will enable it to recognise the value of new information, assimilate this and apply it to commercial ends (Cohen and Levinthal, 1990: 128). Product development, therefore, can be seen as an information intensive activity, requiring both knowledge and learning. Inputs to the process are expected to be derived both from the firm's existing internal stock of knowledge, and also through the acquisition of external knowledge (and thus requiring an ability to learn, or a level of 'absorptive capacity').

6.3.1 Internal Inputs to Product Development

Knowledge and inputs sourced from within the company can come from what is already 'known' within the firm (and such knowledge could be held by individual employees, or reside in existing company routines), but also the individual 'knowledges' of employees can be combined to form new knowledge. Individual knowledge, or a combination of that, can become embedded in a company's routines (Nelson and Winter, 1982), and thus become part of the knowledge repertoire that is available for future problem solving and innovation. Routines - encompassing rules, conventions, formal procedures, belief structures and cultures that guide behaviour within the firm (Levitt and March, 1988) - can be altered over time in response to changes in the firm's external environment (McLoughlin, 1999). Whilst this learning is dependent upon the actions of individuals, at the same time, it is more than simply the cumulative outcome of individual learning. Individual actors may join or leave the firm, but organisational routines continue to exist independently of such movements (Dodgson, 1993). Organisational routines can therefore be seen to be independent of the individual actors who execute them (Levitt and March, 1988: 320).

Therefore both individuals within the firm and the firm itself can be presumed to 'learn'. A third level at which learning takes place within the firm (but also drawing on sources external to the firm) is that of 'the group', where knowledge creation and learning is suggested to occur primarily through conversations and interactions between individuals (Easterby-Smith *et al*, 2000: 787), and can be described as "everyday practices of learning in micro-communities within and between firms" (Amin, 2000: 1). Such 'communities-of-practice' (Brown and Duguid, 1991; Lave and Wenger, 1991) exist within organisations, but, as with 'thought worlds' (Dougherty, 1992) and worldviews (Schein, 1996), are not bound by organisational affiliations and can span organisational hierarchies and boundaries (Wenger, 1998a: 2-3). Whilst communities-of-practice can be argued to be present in all areas of life (Wenger, 1998b), in an organisational context, they can be associated with particular occupational groups, although this is not necessarily the case (Brown and Duguid, 1991). The key to 'membership' is participation in a shared practice - members of a community are informally bound by what they do together (Wenger, 1998a: 2). The boundaries of the community are flexible, members are those who participate in and contribute to the practice, but they can participate in different ways and to different degrees (Wenger, 1998a: 3). Learning is suggested to take place through the interactions of these communities-of-practice, and is therefore dependent in part on the interactions of these groups through networks (Bougrain and Haudeville, 2002). New knowledges are constructed through collaborative interactions with other members of the group, who, since they are not limited (necessarily) by the boundaries of the firm, can be inside or outside the company (Brown and Duguid, 1991).

6.3.1.1 Learning in Practice

Amongst the firms studied, a minority had introduced more formal mechanisms to ensure that knowledge and learning relevant to the product development process was captured. Most often this was based around project documentation. Project files were archived to provide a record of the company's previous activities, with the assumption that they would be referred to when a similar project came along in the future, potentially saving the company time and money.

BOX 6.20

Because we're starting to build up a bank of information about past development projects, if we've done something similar in the past, we can look at that.

R&D Manager, Engineering Company, 21-50 employees

We have a design file which we'll maintain, everything that's been happening is kept in there, and that's maintained for years to come in case we do something similar.

Deputy Chief Executive, Specialist Equipment Company, 21-50 employees

We have a 'live' file and a 'completed' file ... We learn from what's been done before, but also people leave who might have that knowledge, so rather than relying on people's memories and their own individual notebooks, at least there'll be an outline of what they've done.

Technical Director, Specialist Process Company, 101-150 employees

At a number of companies design files were paper copies filed in chronological order, and were not catalogued in any other way, and so individual memory *was* relied on to access the data from past projects. Someone had to *remember* that a similar project had been done in the past in order for the system to work, and in practice this was not always the case.

BOX 6.21

I suppose we just concentrated on other things ... nobody had written it down when it happened the last time, so we didn't go back and say 'oh, remember last time'. We all knew it, but we all held it up here, the old tacit knowledge ... we all knew it was there, but it didn't prompt a discussion at all.

Development Director (case study Firm E)

Learning therefore could be problematic. It was another 'best practice' activity which was felt by interviewees to be desirable, but around which there was there was a degree of mystification as to exactly *how* it should be done.

BOX 6.22

If we've made mistakes we try not to do it twice, but people tend to make the same mistakes over and over.

Technical Director, Engineering Company, 21-50 employees

The sales team and the service technicians ... there are a lot of people out in the marketplace, people have lots of intelligence and sometimes they realise it, sometimes they don't. We've not got a formal system for gathering all that and we need that.

Sales & Marketing Director (case study Firm C)

> Knowledge handling and knowledge distribution within the company, we've got the means, we're PC linked, we've got the internet. What tends to happen though, every department tends to be a bit specific on what they release through ... I think that's certainly something we need to concentrate on doing, how do we get the knowledge that we currently have ... into a central area so it can be utilised.
>
> *Development Director (case study Firm E)*

Individuals within the firm were recognised as major sources of knowledge, and this meant that what was 'known' could easily be lost.

BOX 6.23

> Moving the business up from the south west was difficult because we lost a lot of the knowledge and attitudes of people who'd been with us a number of years, but who didn't make the move.
>
> *Managing Director, Engineering Company, ≤20 employees*
>
> Our production engineer has got thirty years of experience [*of this industry*], so he probably knows as much as people at the suppliers ... We don't let him cross roads by himself!
>
> *Managing Director, Specialist Process Company, 51-70 employees*

Employee movement between firms was suggested as a way in which knowledge could migrate between companies operating in those industries which were suggested by interviewees to be relatively 'closed' in terms of employment (relevant industry knowledge was very specific and did not transfer readily to other industrial sectors). In one industry, for example, a number of whose major European players are located in the North East region, knowledge was portable and moved between regional companies via both informal interactions between employees at rival firms, but also through employee transfer from one company to another.

BOX 6.24

> All of the key players in our business are located within a twenty mile radius, including the number one in the world ... There is informal contact, including the movement of employees.
>
> *Technical Manager, Engineering Company, 51-70 employees*
>
> I don't know what happens when they [*current staff with several years experience*] leave. .. Our main global competitor are making a lot of redundancies at the moment, so everyone's got their eyes on who they're letting go.
>
> *Managing Director, Specialist Process Company, 51-70 employees*

'Learning-by-doing' (Arrow, 1962) was evident in those firms working predominantly on contract projects with a minimum degree of novelty, and enabled reductions in both design and production time as company staff grew more familiar with the 'routine' of the project.

BOX 6.25

It all went well, because we're used to building these types of machines we don't tend to have that many problems on them now, we know what we're doing ... What has changed on repeat orders is that the engineer won't be in charge [*as project leader*] because there isn't really any need for any engineering involvement once we know what we're doing on a machine.

Managing Director, Engineering Company, ≤ 20 employees

This familiarity meant that planning a project was sometimes felt to be less important, because employees 'knew what they were doing'.

BOX 6.26

On a project like this, our through-put of materials is very quick, the basic [*product*] takes two days to produce, on our bread and butter line it would only take a maximum of five days, so we only have a weekly programme, it's pointless putting out charts for every project we do.

Director, Engineering Company, 21-50 employees

As was suggested in Chapter Four, informal interactions within the company appeared to be a source of knowledge-generation and learning on development projects, and this was particularly evident amongst engineering staff. This was explicitly recognised and exploited at Firms B and D, where at the former project teams were co-located in order to facilitate such interactions, and at the latter, whilst co-location was not felt to be feasible, the physical space in which the engineers worked was reorganised into 'project spaces' in order to try and replicate co-location benefits (see *Boxes 4.15* and *4.30*).

Overall then, internal organisational learning and knowledge capture was seen as desirable, and several firms had introduced more formal mechanisms to try and achieve this. In practice, however, it was somewhat problematic for a number of companies, with knowledge from previous projects sometimes lost because it was not recorded or because of the way it was recorded.

6.3.2 External Inputs to Product Development.

Firms, of course, do not operate as standalone entities, they are "one point in a social economic constellation of points comprising other enterprises and agents" (Taylor, 1995: 102). As such, if they are unable to resolve a product development issue internally, a number of external sources of inputs and assistance are *potentially* available to them, although not all companies will make equal use of such external sources. How a firm is able to make use of external sources of inputs will, as suggested earlier, rest on its 'absorptive capacity', in other words its ability to recognise the value of new information, assimilate it and apply it to commercial ends (Cohen and Levinthal, 1990: 128). In order to assimilate and use new knowledge, the firm requires a certain level of prior related knowledge (*ibid.*: 129), and hence new learning will be (by necessity) in some way related to what the firm already 'knows'. Rothwell (1992) has also suggested that an openness to external ideas and assistance is one characteristic which distinguishes successful from unsuccessful firms in the product development process.

Possible sources of external inputs include customers, for example as sources of potential new product ideas, but suppliers can also be critical, and may be called on to resolve specific problems seen to be outside the expertise of the firm. Assistance can be sought from external 'experts' (for example, consultants, universities), and knowledge thus acquired can then become part of the firm's own stock of knowledge. An individual could be employed by the firm for specific skills which can then be said to be internalised by the firm, (and to become part of the firm's own internal capabilities). A technical solution could be acquired through the firm buying new machinery in which that solution or technology is embodied. On a larger scale, a company might buy out an existing firm or plant in order to acquire the technology, knowledge or competencies of that firm.

The majority of external relationships maintained in relation to the product development process by companies studied were vertical in nature (i.e. up or down the supply-chain), with either customers or suppliers. There was a suggestion from some

companies of a preference for local suppliers, since this was felt to facilitate the management of the relationship, which could otherwise sometimes be problematic. There was no concomitant suggestion, however, that companies questioned who were themselves suppliers, had to be located close to their customers, who were not predominantly local. Customers were located nationally and often internationally, with only one company (case study Firm E) citing local (North East) markets as particularly important, and this was explained (by interviewees) as a hangover of the way that production and markets had historically been organised in their industry. In practice it seemed that local suppliers were preferred for standard (widely available) inputs. Where a 'specialist' input was required, location was less important. For these key supplier inputs, companies would deal with whoever was felt to be the best supplier (although all other things being equal, a local supplier was preferred *if available*).

The following sections discuss the nature of external relationships which companies interviewed had entered into, with customers, suppliers and a broad group of 'other' external contacts who could provide support, assistance and inputs.

6.3.2.1 Customers

A number of companies in the study had cultivated relationships with customers which particularly benefited their product development processes. The use of 'lead-users' (von Hippel, 1988) as possible sources of advance information on future market requirements has been discussed in *Section 5.3.1.1.* Rothwell (1992: 226) has described 'leading-edge customers' who are willing to take risks in the early adoption of innovations and are a primary source of post-launch improvements. Two companies (one case study and one second-stage interview) sought specifically to involve such customers in their projects, making explicit the connection between the customer's trust in the firm, and the freedom this gave them to develop novel technologies within the financial security of a contract project (see also *Box 4.28*).

BOX 6.27

What we try and do is work with the customer who we think is most likely to buy that type of machine and be willing to put some money in to developing it... If we can get the customer interested in the concept, then we would try and get them to place an order. Some customers are more prepared to take the risk than others. Its easier to do this now than it was in the earlier days of the company, because relationships have been built up. Initially there were only two customers willing to do it, and that was because I'd done work for them in previous employment. We're now in a position where all of the UK companies and several of the overseas ones will trust us in this way.

Managing Director, Engineering Company, ≤ 20 employees

Customers were also valuable as a source of post-launch information which could be used to modify a design to bring it more closely into line (it was hoped) with market requirements. Such information was usually routed back into the design department via the sales force.

BOX 6.28

If you want negative information back about a product and its failings, sales people are quite a good mechanism, because they see that as a barrier to selling it. So they're quite vociferous about why they can't sell it, not the good bits.

Engineering Manager (case study Firm B)

At the first three and six months that's reviewed – is it selling as we perceived, is it being well received for price and performance – these are all marketing feedbacks.

Product and Design Manager, Medical Equipment Company, 101-150 employees

Whilst design departments particularly were dependent on sales staff as a means of accessing customer opinion, interviewees at one firm made the point that they had no idea how accurate this information was, it was all taken in good faith (see also *Box 5.13*)

BOX 6.29

Sales are the conduit for that information, but we've no idea where that's gathered.

Engineering Company, 21-50 employees

A minority of companies were affected by unequal power relations in their dealings with customers, all to the detriment of the projects discussed. A development project was effectively killed off by the internal political wrangling within a company's client firm. The company (*Engineering Company, ≤ 20 employees*) had produced a prototype product following discussions with contacts at their client company, but a

more senior member of staff at the customer meanwhile sourced a rival product and championed this instead. Without such senior backing they were unable to compete.

BOX 6.30

The other product had a higher performance, which we felt wasn't necessary, but because we were competing with it we felt we had to match it. We achieved that, but we were on a hiding to nothing really because we couldn't compete with the senior [*customer company*] engineer. So we put work into a product which had major problems and there were major costs associated with that, but to no avail.

Managing Director, Engineering Company, ≤ 20 employees

As shown in *Box 5.30*, one firm (*Engineering Company, 21-50 employees*) was persuaded by an important customer of theirs to change the specification on a development project, and this subsequently caused problems. Finally, a third company felt forced to offering additional testing when this was demanded by their contract customer.

BOX 6.31

At the end of the job, the customer asked us to do a lot more testing before acceptance than was planned, not because it was out of spec, because it wasn't. If we'd been a harder company we'd have drawn a line and said if you want more done then you pay, and we didn't, we just kept going.

Technical Director, Engineering Company, 21-50 employees

6.3.2.2 Suppliers

Whilst a substantial number of supplier contacts were routine in nature, where an element of a development was novel to a company, suppliers could be called on to problem solve or advise on a course of action. Suppliers could potentially, therefore, be a critical source of inputs to the development process. Developing and maintaining close supplier relationships was felt to facilitate this (see also *Box 4.13*).

BOX 6.32

You don't find things out unless you've got a good relationship with your suppliers, and we spend a lot of time finding out what their problems are, because you can put something on a drawing which has implications to somebody else which are ridiculous. So you're always best to talk to the person who's doing the work and get an understanding of why it is like it is and what the problems are.

Senior Engineer, Electronics Company, 101-150 employees

> We work very closely with our main suppliers because they're so critical ... They come back a lot of the time and say it's going to cost you more money if you do it like that, why don't you do it like this. So there's a lot of interaction between us, there's some good partnerships there.
>
> *Quality Manager, Engineering Company, 21-50 employees*

As has been suggested in *Section 5.4.4* on *Project Documentation*, a primary concern of engineering staff appeared to be with accountability in product design, and acting on the advice of suppliers was a further way of 'covering their backs' and ensuring that all decisions were traceable. Suppliers as a source of expert advice were almost an insurance policy, and it therefore became important to document all supplier contacts.

BOX 6.33

It's pointless me making mistakes that they [*suppliers*] know about, and if that bit of the product subsequently goes wrong, then you've got somebody to go back to.

Technical Director, Engineering Company, 21-50 employees

We've got the [*suppliers*] involved in tri-partite discussions with the architects to overcome a particular design issue. Getting them involved is a bit of a guarantee for us, because if the [*product*] we use starts to discolour at the edges where it's open to the elements, at least some of the liability is transferred on.

Technical Director, Specialist Process Company, 130-150 employees

Suppliers were 'the experts', and bringing in their opinion could save a lot of time as well as prevent the 'wrong' choice being made, and was potentially an opportunity for the company to further expand their knowledge base. This again made it important to cultivate close supplier relationships.

BOX 6.34

Materials suppliers [are] the experts in that narrow field, we're the jack-of-all-trades, so we use their expertise to get that material, that process, and then that's all obviously recorded and logged.

Product and Design Manager, Medical Equipment Company, 101-150 employees

We can't be expected to know everything, so we ask our suppliers. But then once a supplier has answered a question, then that means we've learnt a bit more as well.

R&D Manager, Engineering Company, 21-50 employees

Our lads are getting better at it as they're watching the experts do it.

Director, Engineering Company, 21-50 employees

Some interviewees raised the concerns about the confidentiality of dealing with suppliers. Firm D, for example, had suggested suppliers as a potential source of competitor information.

BOX 6.35

You can get a lot of information from machinery suppliers, raw materials suppliers. Surprising what will suddenly drop in - they don't think they're giving a lot away, but you can learn an awful lot. You can put two and two together and come up with the right answers, so you try and get as much information as you can, because they're the ones that get shown round. But similarly you've got to be careful what you tell them. Or sometimes you can tell them what you want other people to know.

Development Director (case study Firm E)

Another firm was more concerned with themselves being compromised by suppliers, with confidential information passed on (unwittingly or not) to competitors.

BOX 6.36

I have a problem with suppliers in general in terms of the confidentiality of the projects. My experience is that they're not confidential very long, and because of that we have to be very careful because we've signed a confidentiality agreement [*with our customers*]. We do get suppliers to sign a non-disclosure agreement as well, but the problem I have is that a lot of these sales guys are mainly concerned about their commission.

Managing Director, Electronics Company, 21-50 employees

6.3.2.3 Other External Inputs to the Product Development Process

In addition to inputs from customers and suppliers, the majority of companies (although not all it should be noted), were open to the idea of using external assistance which was expected to be of benefit in the product development process. Sources used included universities, trade and industry associations, public sector support organisations, patent attorneys, consultants, industry experts and standards institutions and committees. Information sought included market research and information, supplier listings, assistance in identifying market and technological opportunities and technical information relating to specific development problems. Using external sources was felt by those who championed them to be a way of alleviating some of the stresses on already constrained resources, as well as accessing knowledge not readily available within the firm itself.

BOX 6.37

Even with the best will in the world, you're going to get some engineers who are good at one aspect of a job and some that are good at another, and you can't expect the design department to be gurus in all fields of electronic development.

Engineering Manager (case study Firm B)

Obviously, the number of diverse expertise that would need to contribute to the types of project we handle here, it would be beyond the resources of the business to handle everything here, so we rely on outside contractors for [*some things*] … Some of these may be university resources rather than commercial businesses.

Managing Director, Medical Equipment Company, ≤ 20 employees

Involving external experts allowed individuals within the company to pick up extra knowledge (thus expanding the knowledge base of the firm), and such relationships developed over a period of time.

BOX 6.38

We brought him in, he made some recommendations, the engineer concerned has picked up expertise on the last few projects. That's the other benefit as well, we've got this chap in who's supposedly the UK's leading expert on EMC, but now he's on first name terms with the engineers here, so we've got this relationship with him now.

Engineering Manager (Firm B)

We work with quite a few university, not formally consultants, but advisers, which is one of the things we've set up over the years and probably goes back to my own scientific career in universities.

Managing Director, Medical Equipment Company, 21-50 employees

Several factors limited the use of external assistance. A number of companies had no experience of accessing such services or contacts, and did not know exactly how to use them.

BOX 6.39

No, I think its because of our history, because we've never used them before. If somebody was to come along and say why don't you try this, then we probably would, but until someone comes along and shows you what they can do, you just do it the way you do it.

Director, Electronics Company, 21-50 employees

Not in design, I wouldn't know what use to make of them. When we do a design project it would never enter my head to include in the preliminary investigation 'consult local universities or consultancies'.

Technical Manager, Engineering Company, 21-50 employees

Company culture might limit the use of external assistance in a further way - for example, Firm D (as was discussed in Chapter Four) preferred to internalise a technological input rather than seek assistance on a one-off basis, although external inputs would be used if that was felt to be their best or only option (see *Box 4.29*).

Concerns were also raised regarding confidentiality issues in bringing in someone from 'outside' the firm to look at a commercially sensitive development. It was also suggested that there were costs involved in bringing an external person up to speed, and related to this was a concern regarding the quality of assistance that might be forthcoming.

BOX 6.40

I still don't see what they bring to the party. They may be a consultant in a specialist field, but they don't know enough about your product or the marketplace in general, they may have the contacts in the marketplace, but I think if you're going to be in any marketplace you have to know it yourself.

Managing Director, Electronics Company, 21-50 employees

We invited so-called industry experts in to advise us, and we found they didn't necessarily know what they were talking about.

Technical Manager, Engineering Company, 51-70 employees

Within both stage two and case study groups of companies, as might be expected, attitudes towards the use of external inputs to the firm's internal processes were not uniform, however, the majority of companies did enter into some form of external relations (usually with customers or suppliers at a minimum) which then had a degree of input to the development project discussed. Beyond that, particularly for external services that might have to be paid for, there were constraints, either in terms of available resource or the company's culture, which could mitigate against the use of such sources of assistance.

Informal horizontal links between companies were facilitated through, for example, Chambers of Commerce and networking events organised by support services such as One North East and RTC North. These (as they were intended to) provided an opportunity to meet representatives from other companies (not necessarily direct competitors), in a more social setting, where information might be exchanged or

contacts made which could be of future benefit, though not specifically limited to the area of product development.

Such events were intended as a means of creating and reinforcing informal regional networks between firms, but they could also be exploited in a more formal way by companies who saw them as offering particular benefits. So, for example, case study Firm C had carved up responsibility for attending these events and sitting on both regional and national committees of trade and industry organisations between its technical and marketing staff, in order to ensure that no opportunities or information were missed.

Those interviewees who suggested that external links were particularly important to the company usually took full advantage of the range of regional services available but were equally as likely to look outside the region for similarly useful contacts, and did not see their networks as being limited by geography.

BOX 6.41

We're in the DTI mentoring scheme ... We've got [*local university*] links ... the North East Innovation Centre ... We're members of [*trade association*], the Energy Industry Council

Group Technical Manager (case study Firm C)

We have a database of potential support organisations including PIRA, Business Link, RTC, IMECHE, the Welding Institute, [*national trade associations*].

Technical Director (case study Firm A)

Regarding contacts with universities, industry experts and research centres, as with key supplier inputs, there was little suggestion that those consulted had to be local to the firm. For what could be described as more generalist services, such as industrial design for example, companies did tend to source such inputs locally. Therefore again as with supplier relationships, all other things being equal, a local contact was preferred as a way of facilitating the management of the relationship.

Where specialist inputs were required which could not be sourced locally, companies were prepared to go wherever they had to in order to find them. In such cases, the content of the contact was what was important rather than the location, and often this

contact had been cultivated by the company concerned and had developed over time. Such contacts could have been sought out by a company in response to a particular problem which they were trying to solve on a development project, or could be based on the existing contacts of a key member of staff (see also *Box 6.38*).

6.4 Managing Product Development

Particular tools and techniques which have been used by firms in their management of product development projects have been discussed in Chapters Four and Five, and it was these which RTCN were hoping to develop into a 'good practice' product development management toolkit, (and which also represented the initial conceptual position of the research). However, as the project progressed, it became apparent that firms were not able to straightforwardly implement good practice recommendations, even where it was their expressed aim to do so, and this aspect of the research is discussed in the following section.

A basic tension which became apparent from the research was between how interviewees felt they *ought to* approach the management of the product development process, and how it was managed *in practice*. In one way this related to the gap between 'official' company procedures and actual practice, and this can perhaps be understood in terms of Brown and Duguid's (1991) distinction between an organisation's formal descriptions of work and work process (which based on Orr (1987 and 1990) they term canonical practices) and the actual work practices undertaken by members of the organisation (non-canonical practices). Formal descriptions, or canonical practices, inevitably omit the details of work, and are abstracted from actual practice (*ibid.*: 40), and reflect the assumption that complex tasks can be mapped on to a series of Taylorist canonical steps which can be followed without significant understanding or insight (*ibid.*: 42). However, it was also symptomatic of the pressures which companies felt themselves to be under to conform to 'best practice' management processes, and the difficulties which some companies had in adopting or assimilating these.

Following DiMaggio and Powell's (1983) theory of institutional isomorphism, a drift towards a more homogenous approach to the management of the product development process amongst corporate actors is to be expected. Firms which operate within the same organisational field (described as "those organisations that, in the aggregate, constitute a recognised area of institutional life: key suppliers, resource and product consumers, regulatory agencies and other organisations that produce similar services or products", [ibid. : 148]) it is suggested, will be subject to pressures towards homogenisation. This homogenisation or 'institutional isomorphism' can come about through three processes in particular, termed coercive, mimetic and normative isomorphism. Coercive isomorphism relates to the political (formal and informal), cultural and legal pressures which companies are operating under. Mimetic isomorphism emerges in an environment of uncertainty, when organisations model themselves on others who appear to have developed successful strategies for coping with this insecurity. This can be done unknowingly, for example through the movement of employees between firms, or can be the result of more intentional actions, for example through the encouragement of consultants and trade associations to follow 'best practice' examples. Carrying out these changes in a formal way can itself reinforce their legitimacy, since they carry with them the message that the organisation is becoming more 'business-minded' (ibid.: 152). Finally, normative isomorphism arises principally from the process of 'professionalisation' of workgroups, defined as "the collective struggle of members of an occupation to define the conditions and methods of their work ... to establish a cognitive base and legitimation for their occupational autonomy" (ibid: 152). Professions are themselves subject to the same coercive and mimetic pressures that organisations are operating under, and whilst separate groups of professionals within an organisation may exhibit many differences, at the same time, they will have a great deal in common with their professional counterparts in other organisations (ibid.: 152). In terms of how organisations 'learn' to manage their product development processes, a process of mimetic isomorphism is suggested to have most resonance, given the preponderance of 'best practice' advice offered to companies from a range of sources, including policymakers, trade and industry associations and consultants, and in adopting these changes, there is a sense from companies that they are becoming 'more professional'

in their approaches, with a 'professional' approach increasing the legitimacy and enhancing the reputation of the firm to other organisations (ibid.: 153).

Firms are subject to a battery of advice regarding the 'right' or 'best' way of managing product development from a variety of sources, including policymakers, trade and industry associations and consultants, based on what "winning" companies (DTI, 1997, 1998a) are themselves doing. 'Benchmarking' is encouraged, with a comparison of current performance against that of companies identified as successes, and the adoption of management practices of such successful companies identified as a route to increased competitiveness (Prabhu *et al*, 2000). Both the proliferation of the 'quality management' approach and the growth in the number of support organisations has increased the opportunities for private and public sector consultants. Companies are given encouragement to achieve quality accreditation (for example BS EN ISO 9000), both from advisory sources such as those identified above, but also as an entry level requirement to some markets, where for example, such accreditation is demanded by certain companies of their suppliers. There is also a pressure to keep up with or get ahead of competitors, where accreditation is perceived as offering a competitive advantage, for example as a marketing tool to help secure sales.

BOX 6.42

It's nice to have it. At the time our competitors were very active, our main competitor ... was going for it, and we thought if they got it when we hadn't then we'd be at a disadvantage to them.

Director, Engineering Company, 21-50 employees

They're meaningful in a number of ways. ISO 9001 is essentially a certification system for your quality management system. They're essential often to be on the bid list for a project, but they also give you someone coming in and verifying that your system is robust and stable, so the auditing side I find as much value as the marketing side, but the marketing side can't be understated.

Group Technical Manager (case study Firm C)

Both ISO 9001 and 9002 are of course about achieving *quality systems* rather than necessarily *quality products*, and accreditation was criticised by a number of interviewees as sometimes merely a paper exercise.

BOX 6.43

ISO 9000 ... you write it down on a piece of paper but you don't necessarily do it. I'd far rather see it being done than it just being written down on a piece of paper to show someone you're interested in that. But ultimately we are in a situation whereby in most cases it's written down, that's it, it's kosher, it's quite happy. Nobody looks for the practical side.

Development Director (case study Firm E)

My scepticism is that because people can say 'we've got this' that means that they're a quality company, and that isn't the case. If you've got ISO 9000 it means you do what you say you do, what you actually do could be rubbish. When you have the quality audits, it's just a paperwork trail, and it's possible just to pay lip-service to it and not achieve anything from it. It's too much of a paperwork trail rather than ensuring that the product you put out of the door is good quality.

Managing Director, Engineering Company, ≤ 20 employees

Other interviewees suggested that ISO accreditation had not changed the way that they managed product development, but had rather added a formality to it.

BOX 6.44

It didn't really make a difference to what we did in the design office ... It means that we have traceability, and it means that we formalised what we do, so everyone does things in the same way rather than going off at a tangent. We use it in sales literature. It's stabilised the way we do things in the design office and it impresses our customers.

Technical Manager, Engineering Company, 21-50 employees

When I was head of R&D it was very informal, and we had to formalise it and put it down on paper for the ISO systems, so that was quite formative, though it worked before.

Managing Director, Medical Equipment Company, 21-50 employees

It didn't really make a difference to how we do things, but it has just formalised it.

Deputy Chief Executive, Specialist Equipment Company, 21-50 employees

A recurring concern was the loss of control of a project, since this was expected to increase development time and costs. A more structured and procedural approach to management (in line with 'best practice' recommendations) was seen by a majority of interviewees as a way of maintaining control of the design processes. It could therefore be expected that companies be moving towards adopting similar approaches in their management of the product development process (as suggested by DiMaggio and Powell's (1983) institutional isomorphism). However, from the evidence of the case studies and the survey, it appeared that for a significant number of companies, this homogenisation was occurring more in thought than in deed. There was,

therefore, perhaps evidence of isomorphism in the way that interviewees *thought* that the product development process should be managed, but this was not matched in practice. Interviewees had an awareness of a way of managing the product development process which they suggested they *should* be adopting (relating to more formal and structured management procedures). Whilst a number of companies had, it seemed, adopted such approaches quite successfully[2], other respondents either operated without any formal framework for managing the product development process, or else had attempted to introduce a more formal and procedure-led approach, but in practice managed product development in ways distinct from official company procedures. There were no rigid divisions between 'adopters' and 'non-adopters' of more formal processes, but instead there appeared to be a 'continuum of formality' along which companies were ranged. The argument here is not that a formal and 'best practice' approach really *is* the best for all companies, but rather that this is how it was *perceived* by the majority of interviewees, as a goal to which their companies should ultimately be progressing, or as the 'proper' way to successfully manage product development, even if they felt unable to actually achieve it. By introducing a more structured approach, interviewees suggested they would become 'more professional'.

At one end of the continuum were those firms who were managed in a more formal way *overall*, and who were the most likely to have a product development strategy in place, to both create and *work with* a project plan, and to manage individual projects along cross-functional lines. These companies typically had a large technical department (in terms of the number of development staff) in relation to the overall number of company employees (for example, over a third in three of the companies, and just over a fifth in another)[3]. Often these firms were recently established, and it is perhaps the case that the way they were managed is evidence of a more formal approach required to secure start-up funding. This was in contrast, for example, to the

[2] Projects were planned and monitored in accordance with best practice procedures and were perceived by interviewees to have hit targets and met objectives.

[3] Although it should be noted that other companies had similarly large technical departments, but did not adopt such formal approaches to product development management, and some companies had managed to work with relatively formal procedures whilst operating with a smaller technical resource.

managing director of a company managed in a much more informal way, who was able to say

> *BOX 6.45*
> In a company this size I don't have to justify budgets to anyone else, or have to think about timescales or what it's going to cost.
> *Managing Director, Engineering Company, ≤ 20 employees*

Perhaps also then the aspirations of the managing director or owner-manager are of relevance for how the company is managed. For a company aiming to achieve growth, and needing to attract external finance in order to achieve that growth, a more formal management approach may be necessary in order to satisfy potential creditors. Where the aim was to keep a company ticking over (perhaps as a future pension fund) rather than go for growth, managers could be less formal, or only pay lip-service to a more standard approach.

> *BOX 6.46*
> We have to do [*a business plan*] for the bank ... it's pure guesswork.
> *Technical Director, Engineering Company, 21-50 employees*
>
> We had to do a plan five years ago to get a loan to purchase this property we're in now. We produced that for the benefit of the bank, we don't do it on a regular basis ... The company is as big as we want it to get, we think we can guarantee employment for everyone as long as we need to. Neither of us have any successors on the horizon ... we think we'd like to sell up, that would just require a tweaking of that business plan because circumstances haven't really changed since then, we're not expanding but we're not retracting either, we just want to keep everybody busy.
> *Director, Engineering Company, 21-50 employees*

The group of adopting companies who had instituted a more formal approach to management, and where procedures and practice were fairly congruent, did not, however, take on board 'best practice' principles wholesale. There was a sense that they had adapted existing and recommended techniques to suit their own circumstances, and seemed to be confident in their approach to managing product development, whilst at the same time, not complacent about it. One interviewee said in relation to the way that development projects were planned within his company,

BOX 6.47

Doing it that way is born out of experience, some of it bitter experience, because it's a formula that works, whether it's theoretically viable or not.

Managing Director, Medical Equipment Company, ≤ 20 employees

Further along the continuum, but still ranged towards the 'formal' end, were companies who had gone some way to introducing product development procedures and a more structured approach to project planning and management, but who experienced difficulties in the application of this. These companies had the greatest difference between 'official' product development procedures and actual project management practice. Company growth was important to these firms, and product development was part of a strategy to achieve that.

BOX 6.48

It's not as though the systems have just been constructed to get us through ISO 9000 and that's it, it is developing with the company. But when it comes to design, it's not controlling the design process, the design process has a life of its own.

Technical Manager, Engineering Company, 21-50 employees

Case study Firms A and B both exemplified companies who had introduced a more procedure led and formal approach to product development management, but who nevertheless experienced difficulties in executing those procedures. Planning on both projects was apparently flawed, and whilst each company had adopted a cross-functional project team approach to project management, both experienced difficulties in how this worked in practice, with attention drawn in interviews to points where each project had departed from company procedures (see *Boxes 4.7* and *4.14*).

Moving further along the continuum to more informal (less planned and controlled) approaches were companies (some of whom had attempted to introduce an element of structure to their product development management, although were less likely to have a detailed set of formal procedures or work practices) who overall were resistant to formality in product development, with interviewees suggesting they were fearful of over-rigid planning or control in the development process, believing that this could be too constraining and perhaps stifling to what was essentially felt to be a creative activity (see *Box 4.36*).

BOX 6.49

They were all standard steps, but I didn't have any defined procedure for doing it ... I'd like more structure in it if it means there's better organisation, but I don't want to get bogged down in paper. Our projects range from product changes with a very small amount of work to full-blown NP, and a lot of things, you don't know how they're going to develop. I'm concerned that project procedures could be too rigid, I know we'd need different sets of procedures for different types of product, but I'm not sure how this would work ... I don't feel too formal approach is appropriate to our company.

Technical Manager, Electronics Company, ≤ 20 employees

Finally, there were those companies in the sample for whom taking a formal approach to managing product development was felt to be an irrelevance, and these were typically companies with very small technical departments, perhaps with only one or two engineering or design staff who usually doubled up in at least one other role, for example as production or service engineer, or as the firm managing director. Resource constraints were felt very acutely, and there was a prevailing feeling that attempting to plan product developments was very much swimming against the tide and would be met with failure.

BOX 6.50

I'm not saying that we shouldn't do some of the 9001 type things in-house, we probably should do more than we do, particularly in documentation, but that's just a time thing. Why spend a lot of time writing it all down when you could be doing something else! ... we'll have said we think we can do this in *x* weeks, but we won't bother formalising it because we know we're not going to meet it, because something else will happen in the intervening period. It feels like we're already overloaded as it is anyway, if we spent time trying to keep time records of how much time we spent on what, you'd almost spend as much time filling those forms out as anything else.

Managing Director, Engineering Company, ≤ 20 employees

One company had been accredited with ISO 9001, but still struggled with the formality required by such a structure.

BOX 6.51

It's very difficult to plan something like a design project in an environment where nothing seems to be planned. We get things fed into us all the time, crises come up, and when you're dealing with those you can't do the design stuff. So you create a plan in an environment of chaos, and it just falls to pieces because we can't isolate ourselves at all.

Technical Manager, Engineering Company, 21-50 employees

Whilst this company nominally worked within the ISO framework and maintained records to satisfy auditors and keep its accreditation, the structure imposed by ISO requirements did not seem to work, and the company instead continued to manage its product development in an informal way, although retrospectively recording this as though it had happened formally.

BOX 6.52

Another thing we do is we tend to record it retrospectively, because we get audited, so we go through the design process and then think we'd better write it up. We write up design review meetings, we talk about these things continuously and we do discuss things and come up with decisions and know what we've been through - but I'll then record that as a design review meeting. So the design file that we put together, it has a lot of interesting information in it and all the information that we've put together to design the project, but the formal part of it is very much fiction really.

Technical Manager, Engineering Company, 21-50 employees

So whilst ISO was used by the company as a marketing tool, and was suggested by the engineers interviewed from the company to have imposed some standardisation on procedures and to have been instrumental in raising product quality, the way that they were required to 'prove' that they had worked within their systems was not compatible with how they actually worked. Although companies are responsible for writing their own quality systems and procedures, and so might be expected to include in procedures only those processes which actually take place, it is difficult to see how they would be able to record an informal action (or set of actions) in such a way as to satisfy formal auditing requirements. The company technical staff therefore found themselves in a position of having to pretend a degree of formality which simply was not present in their work practices, and were not the only company to deviate from what they were 'supposed' to do.

BOX 6.53

There is a team, and they have the little meetings that they're supposed to have and these get minuted, but with it being a small company, privately owned, it works better with one person working on the project, even though that's not how it's supposed to work!

Technical Director, Engineering Company, 21-50 employees

In summary, there was evidence of a common approach in how interviewees *thought* the product development process should be managed, and this approximated to 'best

practice' prescriptions. However, in practice a range of approaches were apparent with regard to how companies *actually* managed product development projects. There appeared to be a gulf not only between the 'correct' approach suggested by interviewees (what they *should* be doing) and what they were able to do, but often also between 'official' company procedures and *actual* company practices. Those companies who managed their processes more formally and where actual practice and 'official' procedures conformed most closely to each other (and these companies were in a minority in the sample), appeared to have *adapted* best practice prescriptions, and so were following a company-specific model which approximated *overall* to these best practice recommendations, but which in its detail had been adapted to suit the company's individual circumstances.

If managing product development is itself a key capability which can confer competitive advantage, then it too cannot simply be acquired by the firm, but must be *learnt* over time (Bessant *et al*, 1996; Bessant and Francis, 1997; Tidd *et al*, 2001), and this perhaps will involve the *adaptation* of best practice prescriptions which may otherwise be unsuitable. McAdam (2002) found that SMEs, in applying best practice concepts of 'reengineering' which had originated in a large firm context, had been able to develop their own versions of what was involved in applying the concept, as it had become apparent to the SMEs he studied that large firm definitions and methods were not appropriate to a small firm context. Firms therefore do not only need to be able to make sense of inputs to particular innovation projects, but also must learn *how to manage* the product development process, perhaps through adapting externally developed management mechanisms to their specific circumstances. Dodgson (1992) distinguishes between 'tactical' and 'strategic' learning in relation to the innovation process. Tactical learning is of an immediate problem-solving nature, and so can be seen to relate largely to the learning required for specific product development projects. Strategic learning, on the other hand, has a scope beyond immediate issues, and involves the development of managerial and technical competencies which can provide the basis for future (as yet unknown) development projects (*ibid.*: 147). Whilst tactical inputs will be necessary for the progression of individual product

development projects, strategic learning will be required if a company is to develop competencies in product development management.

6.5 Discussion

What emerges from this data analysis therefore relates to two principle areas. Firstly the heterogeneity of SMEs is clearly important. Even within a 'manufacturing sector' there is evidence of a variety of behaviours and possibilities open to firms, many of which, however, will be either more or less achievable depending upon specific firm characteristics and the environment and circumstances in which the company operates. So for example, in the context of the research, whilst some ways of managing product development processes appear to be more effective than others, not all firms are equally able to put these in practice.

Secondly, undertaking product development is, for the firm, at least in part, an essay in accumulation, necessitating the building of a range of assets (including but not limited to, technical and managerial competencies). The resource or competence-based perspective is one route by which both this heterogeneity and necessary asset-building can be understood.

The resource-based perspective shares with evolutionary economic perspectives (discussed in Chapter Two) a concern with firm-specific differences as a source of competitive advantage. What is important is not the market (or markets) in which the firm operates, but rather the internal assets (resources, competencies and capabilities) which the firm possesses (Christensen, 1996), and which make up its unique asset profile. Although in the short-term competitiveness may depend on the price and market performance of current products, in the long-term it is dependent upon the core competencies and collective learning of the organisation (Prahalad and Hamel, 1990). Resources are suggested to be tangible and always tradable at factor markets and therefore can be accessed by all firms, whereas capabilities and competencies must be accumulated in-house over time, and are therefore firm specific (Christensen, 1996). Since competencies cannot be readily acquired and put together through markets, they are not easily imitable, and it is here that a firm's competitive advantage

will reside. They are analogous to the concept of 'organisational routines' and must be built up within the firm over time (Grant, 1991). Competencies are not easily transferred (Leonard-Barton, 1995), it is not possible to simply copy the strategies of a successful firm and expect the same results, thus replication of best practice may be illusive (Teece *et al*, 1997). Capabilities and competencies reside in routines which are intangible, and which originate from activities undertaken by people within firms (Verona, 1999), as such they must be understood in terms of the organisational structures and management processes which support productive activity (Teece *et al*, 1997). They represent the capacity of the firm to structure resources for productive purposes, and are the combined result of internal learning and 'absorptive' learning or import (Christensen, 1996). As with the evolutionary perspective therefore, learning is crucial to the competitiveness of the firm. Teece *et al* (1997) have labelled as 'dynamic capabilities' those which enable the firm to create new products or processes and to respond to changing market circumstances. Both firm and technological development will be path-dependent, and any opportunities for learning will by necessity be 'close in' to previous activities (Teece *et al*, 1997).

In order to understand specifically those assets which enable the firm to be innovative, Christensen (1996) attempts to employ a synthesis of ideas from the resource or competence-based perspective with literature from the evolutionary approach concerning innovation and technical change. The resulting "technology base of the firm" (Christensen, 1996: 111) is not just a matter of technical competence (Adler and Shenhar, 1990), and thus to solely concentrate on scientific research inputs (measured as R&D inputs) to the innovation process is to severely underestimate the range of assets required by companies to 'be innovative' (Christensen, 1995). Further consideration should be given to assets (both physical and organisational) relating to a firm's production capabilities, to its engineering and development capabilities (which include the ability to search for and evaluate technological opportunities throughout the innovation process, with such activities resulting in experienced-based and firm specific knowledge which can then be drawn on for future innovative activity), and also to aesthetic design assets (Christensen, 1995). Similarly, Adler and Shenhar (1990) suggest that the technological base of the firm is made up not just of

technological assets (which can more or less be replicated by other firms), but also of organisational assets, (which include the skills of employees and managers, the organisational structure and culture of the firm and the strategies which guide action), external assets (which constitute the relations the firm has established with external actors, including customers, competitors, suppliers, political actors and local communities), and finally projects (which are the means by which assets are both deployed and transformed), constituting a *modus operandi* not dissimilar to the evolutionary concept of those routines which guide firm behaviour (Adler and Shenhar, 1990: 26). This notion of the "technology base of the firm" therefore suggests a way of understanding the methods by which a company seeks to source inputs to the innovation process. Technical competence and technical inputs will, by themselves, be insufficient. Organisational, managerial and external assets (or competencies) will also be required, and it would seem that these are all *firm-specific assets* which must be built over time.

The concept of the technology base of the firm then is a useful way of assembling a picture of the *range* of assets which contribute towards innovation. It should be remembered, however, that the firm does not operate in a cultural or political vacuum. Conflict and political action are a potential fact of life, both within the firm and in its external relations. Members of the firm will not necessarily share an agenda, or be working together towards some 'common good'. The roles and motives of individual actors are obviously critical in understanding firm-level product development processes. To understand product development only as a 'rational' process which, when it is failing, simply needs to be 'better' managed (a conceptual position held at the outset of the thesis, and one which is evident in a 'best practice' management approach), significantly underestimates the complexity of both the product development process itself and the circumstances in which companies and the individuals within them operate.

6.6 Conclusions

This chapter has discussed empirical data in relation to broader themes than were represented in the original conceptual framework employed in the thesis. The

heterogeneity of SMEs, even amongst a group of firms who might be presumed, as a consequence of sector membership, to have much in common, has been emphasised. The ways in which a range of assets must be built by a firm in order for it to be innovative has been highlighted, including, but not limited to, technical and managerial competencies. The resource-based perspective has been suggested as a way in which both firm heterogeneity and asset building can be understood. It appears to offer a theoretical understanding of firm-level practices which have been observed during the research project. It is also suggested, however, that cultural and political considerations should be recognised in any firm-level study of product development processes. Whilst the literature (discussed in Chapter Two) often seeks to describe (and recommend) the management of product development as a rational process (Jones *et al*, 1994; Jones and Stevens, 1999; Thomas, 1996), this substantially underestimates significant parts of the process which do not seem to be amenable to a 'rational' approach.

The following chapter will draw together research findings and conclusions, and discuss issues arising from the project in relation to the study's original research questions. Implications of the research findings for a policy audience will be explored and the contribution of findings to academic debate reflected on. Finally, directions in which the existing analysis could fruitfully be expanded and developed through future research projects will be suggested.

7

Conclusions

7.1 Introduction

The overall purpose of this research has been to examine the processes through which manufacturing SMEs (operating in the North East of England) seek to introduce and improve new and existing products. Whilst innovative manufacturing SMEs are suggested to be essential to continuing economic growth (DTI, 2002) and in spite of the specific policy assistance targeted at such firms in the areas of research and technological development, in practice there is only a limited understanding of how these companies undertake product development activity in practice (Hoffman *et al*, 1998). RTCN, as part sponsors of the research, also had particular concerns which they wished the project to address. The core research problem posed by RTCN was the identification of ways in which SMEs could be supported and assisted (by organisations like RTCN) to become more efficient and effective in their product development activities, specifically through identifying a set of good practice recommendations in product development management which could then be disseminated amongst a wider number of firms.

In the light of this, an initial series of research questions were negotiated with RTCN. These were:

- What is the process of product development in manufacturing SMEs in the North East region?
- How is the process of product development managed by such firms?
- How do such firms generate inputs to the product development process, both internally and externally?
- What factors constrain product development activity in such firms?

The answers to these questions were intended to provide RTCN with a 'toolkit' of 'good practice' management options, which could then be presented to firms as ways of improving their product development management processes. Understanding how

product development processes and organisation were managed in practice would (it was hoped) allow the identification of propositions regarding the most effective ways of achieving product development success. Examining how firms generated inputs to the product development process was also an opportunity to identify 'good practice', but additionally would give RTCN information on the types of product development inputs required by firms, and which RTCN might be in a position to provide. Similarly, identifying factors which constrained firms in their product development activities would allow RTCN to establish those points in the product development process where support interventions could usefully and appropriately be made.

The initial conceptual framework employed in the thesis (and outlined in Chapter Two) has understood the concept of a *process* of product development utilising ideas from within evolutionary economics, suggesting that innovation is primarily an incremental activity, and that both the previous history of the company as well as its ability to transform external inputs and internally accumulated knowledge into inputs to the product development process (the firm's 'learning ability') are crucial. The technology management literature was used in order to identify ways of organising and managing product development which were suggested to be common to successful innovators and/or innovation projects, and which therefore approximated to 'best practice' recommendations.

Empirical data have been collected through an intensive qualitative research design (Sayer and Morgan, 1985) comprising case studies of specific product development projects at five manufacturing SMEs, and semi-structured one-off interviews at a further twenty five firms. Data were initially analysed using methodological techniques suggested by Miles and Huberman (1984). As empirical data were collected, however, the conceptual framework with which the research began (primarily relating to the usefulness of identifying 'good practice' recommendations for product development organisation and management)was found to be increasingly inadequate and less straightforward than it had initially appeared. Whilst some ways of managing product development were suggested by interviewees to be more effective than others, there were clear difficulties in the degree to which firms were

able to implement 'good practice', and not all of this could be put down to poor management. In depth data relating to the process and organisation of product development at firms studied have been presented in Chapters Four and Five. Chapter Six, however, has discussed empirical findings in relation to the original conceptual framework, but also with regard to the range of assets which firms require in order to be innovative, as well as the heterogeneity of the firms studied, suggesting a standard approach to the support of product development in SMEs is unlikely to be successful. Additional theoretical perspectives are identified which seek to understand how firms can build a 'technology base', but also which recognise both product development and the firm itself as a potentially political arena, where competing agendas may be aired and fought over.

This chapter will provide an overview of data which have emerged throughout the thesis. Implications of the research findings for a policy audience (with particular reference to the circumstances of the CASE partner sponsoring the research, RTC North Ltd), including the inadequacy of the original conceptual framework, will be explored. The contribution of the research to academic debates, will then be examined. Finally, both the boundaries of the project will be highlighted, and directions in which the analysis could be expanded and developed through future research projects suggested.

7.2 The Research Findings.

7.2.1 Processes of Product Development in Manufacturing SMEs.

Processes did appear to have a degree of commonality between firms, although the detail of each stage and how it was undertaken varied considerably. This *variety* of approaches suggests that blanket best practice recommendations have limited utility for firms seeking to try and improve their product development processes. Even *within* a firm there is a need to recognise that not all projects are the same and may require differing management approaches. In particular, the degree of novelty in the project (to the firm) will affect the ways in which it can be managed (Wheelwright and Clark, 1992), and it is therefore important that individuals within the firm can recognise the 'type' of development that they are engaged in.

The question of whether or not the company predominantly worked on contract development projects for a named customer (in contrast to more speculative or 'off-line' projects) appeared to have a bearing on the progression of projects within the company, with contract developments seemingly more likely to be completed within an agreed timescale to meet the customer's delivery date. It has been suggested in the literature that contract developments are often associated with a more sequential process, with a lower degree of interaction between functional departments, particularly where the project holds a minimum degree of design novelty for the developing company, and is essentially repeating (perhaps with a small amount of variation) a project which has been done before (Alderman *et al*, 2001). It may be the case that this lower degree of novelty was what enabled the stricter management of contract projects and their increased likelihood of meeting target dates. More speculative projects, running only to internal deadlines were more likely to drift. This could reflect the fact that they embodied a higher degree of novelty for the developing company, making them more difficult to plan, but also perhaps that an external customer (with associated penalty clauses for late delivery), can impose an extra discipline on project management - dates are met because they *must* be. The 'front-end' of the product development process (so for example idea generation, market assessment and project selection), seemed to be particularly problematic for firms working on speculative development projects. This relates back to the innovation management 'success factors' literature (discussed in Chapter Two), which suggests that the 'front-end' of a development is critical to the project's ultimate success (Biemans, 1992; Brown and Eisenhardt, 1995; Cooper, 1979; Maffin *et al*, 1997; Rothwell, 1992; Twiss, 1992). On contract developments, this stage of the process was to an extent resolved, since the development area or problem which the firm was to work on had already been identified by the contract client. Contract projects were then associated with clear and specific project objectives, and this was suggested by interviewees to facilitate design. Where project objectives were less clearly defined, as was the case with a number of the speculative developments discussed by interviewees, this may have contributed to uncertainties in the design process. Finally, companies who largely do more speculative developments are at the same

time engaged in 'everyday' production. Companies who work exclusively (or predominantly so) on contract developments do not have these other 'bread and butter' distractions, it is the contract itself which is their everyday work, and so they can be more focused on its project management, and perhaps become more practised through its repeated execution of similar projects (although may face difficulties where the degree of novelty in a new project is unrecognised and 'routine' management procedures and practices are relied upon which may not be suitable to the new development).

There was a difference in the degree to which companies had attempted to make their product development processes repeatable, for example through developing generic product development procedures, and this was related to the overall formality of their approach to product development management. A 'continuum of formality' has been suggested in the thesis to encompass the range of approaches, with at one end, companies who had adopted formally laid down procedures for product development, and who followed these procedures throughout each development project, and at the other those companies who felt unable to introduce any level of formality into their development projects, even though interviewees from these companies suggested that this was something they *should* aspire to. In between these extremes were a number of companies who had attempted to introduce a level of 'procedurisation' and repeatability into product development, but who struggled with the implementation of this. This theme is returned to in the following section, relating to the management of product development.

7.2.2 The Management of Product Development in Manufacturing SMEs.

Whilst more structured and formal approaches to project management did seem to be associated with the achievement of project objectives, firms studied varied in the degree to which they were able to implement such an approach. An important overall theme related to the extent to which the process of product development management was formalised. There was evidence of a difference between the way in which the majority of respondents talked about how they *should* manage projects, and how they suggested they were done *in practice*.

There was a broad consensus amongst interviewees with regard to how product development projects *ought* to be managed, as might be expected given the exposure of companies to a range of actors all offering broadly the same 'best practice' advice (for example consultants, the DTI, local organisations such as RTCN), and following the ideas of DiMaggio and Powell's 'mimetic isomorphism'. However, *in practice*, companies did not adopt a uniform approach to managing projects, and again, a 'continuum of formality' has been suggested to be evident. Therefore, whilst all interviewees talked about how they *should* manage projects, either in line with what was formalised in their company procedures (where these existed) or in relation to those 'best practice' prescriptions which they felt they should adopt, in the majority of cases this was distinct from the way that projects were managed *in practice*. A number of these companies had introduced formal procedures for the management of product development projects (which can be seen to relate to Brown and Duguid's (1991) canonical procedures) but struggled with the practicalities of working with these. Other companies had avoided anything other than an informal approach to product development management, either because of a fear that formalisation would constrain what was suggested to be a creative process (although again there was an awareness expressed of "what we should be doing"), or because they felt themselves to be operating under such constraints and 'fire-fighting' everyday crises to such an extent that there appeared to be no point in trying to formally manage developments. Whatever was planned would inevitably run out of control, because unexpected events would arise requiring immediate action and thus diverting resources away from product development activities.

Thus constraints appeared to be felt much more severely by some firms than by others, and this related not to the *total* size of the firm but appeared to be linked to the number of technical staff in the company in relation to its overall number of employees. Those firms, for example, with only one or two members of staff available to work on technical issues (including product development, but also often additionally day-to-day technical problems in production), seemed to feel much more constrained than firms (of a similar size) operating with a larger number of technical

staff. Such constrained firms were the most likely to struggle to implement any kind of formality to product development management, and also the least likely to see the need for a more structured approach. Given that so many 'crises' were bound to come up in the everyday running of the business, making any kinds of plans around product development (either overall or in relation to individual projects) seemed to be a waste of valuable time and already overstretched resources.

Those companies (and they were a minority) who *did* seem to be able to work effectively within a more structured and formal framework of product development management appeared to have *adapted* best practice prescriptions. Recommendations had not been imported wholesale into the company, but had been adjusted to the point where they were felt (by individuals within the company) to 'work' for the firm. This indicates perhaps that managing product development is itself something which has to be *learnt*. Passing on a set of 'how to' prescriptions will not in itself be sufficient for a company to become proficient in product development management. Internally the company requires the 'absorptive capacity' to take on board these prescriptions and find out what works in practice, in order to acquire what is an additional capability, that of product development management.

Including contributions to product development projects from different functions within the company (as recommended by the technology management literature) seemed to be beneficial, but the degree to which companies felt able to do this varied, with a majority of companies suggesting they had difficulties in putting together cross-functional project teams (in the best practice sense), due to their limited staff numbers. Rather than formally managed cross-functional involvement, informal communications between parts of the business were often relied on to bring what were felt to be the necessary range of viewpoints into a development[1]. The majority of companies relied a great deal on observations made in the marketplace, particularly by sales staff, to indicate demand for new or improved products which could then be expected to have some market potential. The input of production staff to projects

[1] However, despite the accepted wisdom that small firms have certain internal communications advantages relative to large firms (Vossen, 1998), internal communications could not always be relied on to take place, and this point is returned to in *Section 7.2.4*.

appeared to be of particular importance in those companies where product and production processes were closely intertwined, and so where any new or altered product could be expected to have an impact on production techniques.

Whilst some interviewees suggested the importance of having a strong and powerful project leader overseeing the development (the project leader prescribed by the technology management literature), project leaders were not used in the same way at all companies. Whilst within the firm someone would usually 'own' the project, in a number of companies, particularly those working on contract developments, this 'ownership' would imply only the person (usually an engineer) was responsible for overseeing the project and undertaking most of the work on it, but were not 'leading' a project team in any way. This latter type of project 'overseer' was particularly associated with those companies operating with a smaller technical resource or with more routine contract developments.

Therefore, in product development management, as with product development processes, what is particularly evident is the variety of behaviours and approaches amongst the firms studied. This variety, however, took place in the context of an understanding by all interviewees of notions of 'good' or 'best practice' in product development management. Whilst interviewees suggested a knowledge of how product development *ought* to be managed (in accordance with technology management and 'best practice' recommendations, referred to here as a 'formal' approach), but also with regard to a company's 'official' product development procedures where these existed, in *practice* a majority of companies struggled with implementing these prescriptions. There is potentially, therefore, a fundamental mismatch between how SMEs are advised to manage their product development processes, and how, in practice, some are able to do so. Whilst these tensions are implicitly suggested in some of the technology management literature, with a recognition that many of the good practice prescriptions have been formulated on the basis of large firm practice and experience (for example, Hoffman *et al*, 1998), they have previously been largely unexplored.

Although overall a more structured and formal approach to product development management did appear to increase a company's chances of meeting project objectives, there were limitations for some companies in how far they were able to pursue this. Implementing 'good practice' recommendations appeared to be contingent therefore on company specific characteristics and circumstances, including the industrial or market sector within which a firm operated, the background and specialisms of the company owner or managing director, particular project-specific characteristics relating to the degree of novelty present in the project for the developing firm, and also the number of technical staff employed by the company, loosely relative to its total number of employees. Whilst, therefore, managing product development is itself a skill which companies cannot acquire wholesale in the form of best practice prescriptions, but must instead be *learnt*, at the same time, this may be beyond the capabilities of some firms, particularly those with a relatively small number of technical staff.

7.2.3 Sources of Inputs to the Product Development Process.

Generating and acquiring inputs to the product development process is dependent in part on how the firm is able to *learn*. Sources of knowledge may be internal or external to the firm (Malerba, 1992), however the acquisition of an input is not by itself sufficient, a company must also possess the capability or absorptive capacity to recognise the value of new information and also to assimilate this and apply it to commercial ends (Cohen and Levinthal, 1990: 128).

For those companies working predominantly on contract projects with a minimal degree of novelty, 'learning-by-doing' (Arrow, 1962) was an important mechanism which enabled reductions in design and production time, and allowed some firms to minimise the degree of planning undertaken in projects. For firms working on speculative development projects, or contract projects where the degree of novelty to the company was more notable, informal learning which took place through interactions between individual workers were significant, and this seemed particularly to take place through the interactions of technical workers, for example, groups of engineers. Those firms with a smaller technical resource (particularly when that

resource comprises only a single person) may in this respect be operating at a disadvantage, if opportunities for this informal problem solving between peers are absent.

Participating firms entered into a variety of external relationships which were used to source a range of inputs into the product development process. The extent to which firms made use of such external contacts varied, with some firms operating in a more proactive way to source and maintain such contacts, suggesting this as a strategy by which the company could extend its boundaries and enlarge its competencies.

Cultivating close customer relations was largely suggested to be of benefit to participating companies. Customers were a primary source of ideas for new or improved products for a majority of firms interviewed, with a minority of companies seeking out 'leading-edge' customers (Rothwell, 1992) and 'lead-users' (von Hippel, 1988) who would (respectively) be prepared to take a risk on novel technologies and who, through their position as market-leaders, could give an indication of future market trends and requirements. The firm could go down a specific development route as a result of the influence of a particularly important customer - for example, in relation to developing a product that they would not otherwise have undertaken, or in altering a product specification to suit an individual customer need. Some customers therefore were in a powerful position to influence the future direction of supplier firms.

Suppliers could provide critical inputs to development projects, particularly in terms of providing a solution to a specific problem which was outside the capabilities of the developing firm. Whilst a significant amount of supplier contacts were for routine inputs, where a project included elements which were not within the developing company's core area of expertise, suppliers were often called upon to advise on the most appropriate course of action. Such supplier input could also constitute an 'insurance policy' for the developing firm, since if that part of the project was subsequently to go wrong, liability could be passed back to the supplier. The smallness of some companies and their lack of market power meant that they had little

influence on suppliers and so were vulnerable in relation to the continued supply of particular key components for example.

Other sources of external inputs which were made use of in development projects included consultants, industry experts, universities, trade associations and support bodies. Using external sources was both a way of alleviating resource constraints and also accessing expertise not available within the firm itself. Support agencies were seen primarily as signposting organisations, either to sources of finance or to specific technical assistance. They were perceived as generalists rather than as offering any particular technical expertise. A continuing feature of the North East support service landscape is the proliferation of agencies offering help to SMEs. Many respondents suggested confusion in the face of so many offers of assistance, with little clarity regarding which organisations offered what specific help. This is a long-standing situation in the region, but the fact that it was raised by several interviewees should perhaps give cause for concern.

The majority of linkages which companies maintained in relation to the product development process were vertical in nature, so either up or down the supply-chain with customers or suppliers. A number of interviewees suggested a preference for local suppliers, since this was suggested to make the relationship easier to manage with proximity and face-to-face contacts serving to facilitate the solving of any problems which arose. However, where a specialist or key supplier input was required, location was not suggested to be important. If a local supplier was available, then that was usually the preferred option; if not, companies would go wherever they had to in order to source the input. Customers were usually national and often global, with only one company suggesting the importance of local markets (case study Firm E). Therefore whilst firms interviewed raised the benefits of dealing with suppliers locally, they were not themselves 'local' to their customers.

With regard to contacts with consultancies and universities, for the more general services offered by such bodies, companies again tended to seek such relationships locally, and this seemed to be on the grounds of convenience and ease of managing

and conducting the relationship. Where a more specialist input was required, however, as with suppliers, the location of that input was suggested to be irrelevant. Companies were prepared to go wherever the expertise was that they required, and it was the content of the contact that was suggested to be of importance rather than its location.

Not all firms were equally open to the idea of using external inputs to the product development process, with sometimes a company's internal culture or particular financial constraints preventing their use. However, for those firms that did exploit external contacts, their potential network was national and indeed international. For more general and widely available inputs, a local contact would be used. Where a specialist input was required (which might not be available locally), location was less important, and firms would go to wherever the expertise was that they needed.

Informal contacts between competitor companies were a feature of some industries, and the defining feature of such industries appeared to be that they were relatively closed in employment terms (knowledge was highly specific to the industry and not readily transferable to other industries). Informal contact between technical staff was suggested as one way in which technology moved round the industry, as was the movement of employees between firms.

As has been suggested in relation to customers and suppliers, external networks were not uniformly sources of positive contacts for firms, and the question of unequal power relations between the firm and its external contacts is therefore also of interest (Hudson, 1999b). To assume that those relationships extending beyond the boundaries of the firm are unequivocally beneficial is to underestimate the complexity of the networks in which the firm operates.

7.2.4 Constraints on Product Development Activity.

The identification of those factors which both derailed individual projects and which were suggested overall to be hindering companies in their product development efforts is of particular significance for policymakers and support agencies, who seek

to support firms in the process of product development. Current policies give an indication of where 'bottlenecks' in the process are believed to be (and where therefore firms are presumed to potentially benefit from intervention). In their sponsorship of *this* research project, RTCN were hoping for research outcomes which would identify a range of good practice in product development management, which could then be used as a 'toolkit' to advise other firms on appropriate methods and techniques, and were therefore operating with assumptions that firms were failing in product development because of poor technology management, which could be improved through exposure to 'best practice' methods.

The most common constraints *suggested directly* by interviewees related to limited resources, particularly in terms of finance and staff time. Externally accessed finance was felt to be unavailable for the types of product developments which most firms were engaged in (characterised as incremental rather than radical innovations). Interviewees from companies working on speculative developments suggested there was a conflict of interest between carrying out day-to-day duties and those linked to specific development projects, and it seemed therefore that product development was often seen as an 'extra' rather than a regular activity. As has been highlighted earlier, those firms with a relatively smaller technical resource (in terms of the number of technical staff available to work on development projects) were most likely to raise their size and lack of resource as an issue, and this was seen to impact on how such companies were able to manage development projects as well as resource them. These suggested resource constraints perhaps indicate an absence of 'spare capacity' within the firm to carry out product development activities. SMEs are continually advised that innovation is a route to competitive success, but for a number of companies, product development was an 'extra' activity, over which everyday concerns and 'fire-fighting' took precedence.

Within a number of companies (although particularly evident amongst case study firms, possibly as a function of the more in-depth data which was obtained at this stage of the research), other issues were identified which had a negative effect on the progress of development projects. These issues related to what might be termed

'softer' aspects of the development process, for example, relating to communications and internal company conflicts and disputes. Whilst in the literature it is largely accepted that small firms have particular advantages (over large firms) in terms of more rapid and effective internal communications (Vossen, 1998), in practice, effective internal communication could not be relied on. It has been suggested in the thesis that miscommunications in particular could be related to differences in terms of how separate functional groups within the organisation understand the product development process in accordance with their own idiosyncratic departmental 'worldviews' (Schein, 1996) or 'thought worlds' (Dougherty, 1992). Whilst such differences were recognised in a common-sense way by individuals within the firm as 'how things were', companies did not seek to address or even to confront them. Where conflicts and misunderstandings had been evident on a project, it seemed that managers were more likely to apparently ignore these than to attempt to seek a resolution. This was in contrast to when problems arose which were of a technical nature, when a solution would be sought, either within the firm or from some external source. This situation is reflected amongst innovation support services, (including RTCN), who perceive their role to be to offer technical advice and assistance, rather than help in resolving these 'softer' issues which may nevertheless cause projects to break down.

7.3 Policy Support for Innovating Firms

Whilst the research has not attempted to address policy related issues directly, much of what has been learnt from the data has implications for innovation support agencies, particularly so in the light of the original conceptual framework, which was informed by the position of RTCN and which suggested that examination of processes in product development in SMEs would enable the identification of a range of 'good practice' activities which (if carried out effectively) would help increase the chances of product development project success.

A particular challenge for support organisations such as RTCN is to balance the fact that they have a remit to deliver what will often be relatively standard policy 'solutions' (which will be easier to cost, administer and monitor (Curran, 2000; see

also Christiansen *et al*, 2003) than more targeted approaches) to a heterogeneous population of firms. Even within a small group of manufacturing SMEs, wide variations in behaviour and firm-specific characteristics were evident. Unsurprisingly, there are no easy answers for policymakers with regard to providing effective support to innovating firms, since the technology management process is neither rational nor uncontested within the firm, and there can be no single solution appropriate across a group as diverse as the SME sector. Whilst a set of 'good practice' prescriptions may be an attractive option to policymakers in need of delivering a solution to the perceived problem of low regional levels of innovation, to peddle the line that the product development process can be rationally and simply managed is to underestimate the complexity of the process itself and the contexts in which it takes place. It should be recognised that 'best practices' originating in a large firm context may simply not be appropriate to (and may in fact be beyond the means of) many SMEs. This is not to discount the role of presenting alternative ways of managing product development to firms. If a company is to adapt 'good practice' recommendations to its own circumstances and to be able to *learn* how better to manage product development projects, then illustrating a variety of methods by which this has been done in other companies may well be of benefit[23].

There is perhaps then, rather than a standard 'one-size-fits (almost) all' policy, the need for more targeted initiatives (Nauwelaers and Wintjes, 2003). Questions regarding what policy initiatives are for, and therefore what groups of firms they ought to be aimed at will be paramount in deciding how best to apportion resources, if a stack of *ad hoc* policy programmes is not to pile up, each only as partially successful

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[2] The 'B2B' (Business to Business) best practice company visits programme which RTCN has run for some years now has continuing relevance here. Interviewees during this research project were on the whole fascinated to hear how other companies managed what they themselves were endeavouring to do, and how they measured up to their peers (which perhaps itself reflects the policy emphasis on 'benchmarking' as a route to competitive success).

[3] It should be recognised that the thesis is not intending to suggest that a 'best practice' policy approach is the only or even the predominant model with which support organisations (including RTCN, but also across the wider support network) operate. At the time that the PhD research was undertaken, however, a 'best practice' approach was evident in the thinking of RTCN supervisors. The thesis should therefore be understood as having grown out of a particular set of circumstances at a particular point in time. Policy thinking is continually evolving, although there may be a timelag between policy models being adopted by policy 'makers' and their filtering further down the policy delivery chain.

as the last. Are policies meant to correct market imbalances, for example, or are they intended to offer assistance only to those firms with the most growth potential (Gibb, 2000)? Can policies be designed to be more flexible in relation to the firms they are targeted at, but also to the specific regional contexts in which they are delivered (Nauwelaers and Wintjes, *op. cit.*).

It may be that support organisations could usefully expand their conceptual models of the product development process to more fully appreciate that there is more to product development than either a rational series of technology management 'best practice' steps or support which is largely technical in nature. The areas with which companies interviewed often struggled were related to issues which on the surface had little to do with technology management *per se*, but which nevertheless had the capacity to hold projects up or derail them altogether. As long as support agencies concentrate on herding SMEs down a rationalist 'best practice' route, particularly without any consideration of these 'softer' issues, then they will continue to provide innovating companies with only partial support and assistance, as well as potentially alienating those companies who have previously failed to successfully implement 'best practice'.

As well as a recognition that there is no 'one size fits all' best practice approach appropriate across all firm contexts, it must be appreciated that there is similarly no uniform product development project model or type. The thesis has supported earlier research which identifies particular differences between contract and speculative development projects. The degree of novelty involved in a project (for the developing firm) has also been suggested to be of significance. If there is a necessity for companies to recognise the 'type' of project which they are involved in, then this need to differentiate project types also extends to those services which are seeking to provide support and assistance to innovating companies.

If support organisations are to continue to offer signposting or brokering services, the data on the proximity of external company contacts is of importance here. For lower-level or more routine inputs, local contacts were preferred. For higher-level or key inputs, companies were not limited by geography in procuring contacts, and any

support agency efforts to broker contacts should bear this in mind. For some types of inputs it is the specialist content of the contact rather than its location which is important, and so a search for potentially suitable contacts should not be limited to the company's immediate locality or region, even where the remit of the support organisation is a regional one.

As previously suggested, the North East support service community is characterised by complexity, with confusion amongst interviewees as to the nature of assistance that was on offer. Support services sometimes seem to be in competition with each other, and this perhaps reflects a situation where a number of organisations, in running ERDF or ESF funded projects, collect figures regarding the number of firms assisted as an accepted measure of their successful performance. The current situation, where support agencies are in a continual cycle of bidding for project funds in order to finance their operations overall ensures that competition exists between different services in the region. Grabher (1993) has suggested that a degree of 'redundant capacity' in the regional institutional network is necessary in order to allow a region to have the potential to react to economic and environmental changes, and avoid a situation of 'lock-in' - the region's institutional infrastructure cannot be allowed to become too streamlined and specialised. However, what is also crucial is how these institutions are linked together in order that their individual capacities can combine to form a support infrastructure which is greater than the sum of its parts with a high level of redundancy (*ibid.*, 1993). Whilst the *numbers* of support agencies within the North East region appear to indicate the presence of potential spare capacity, that these agencies and institutions combine to form a coherent network is less clear. While organisations are in competition with each other, continually bidding for limited financial resources, and all trying to prove their status as a 'key' organisation which deserves to flourish (possibly at the expense of others) it is difficult to see how this situation can develop.

With regard to the measurement of 'innovative effort', the research has supported the assertion of Kleinecht (1987) that much of what SMEs do will fail to be captured by official R&D statistics. There is therefore a continuing need for alternative ways to

measure such activities which reflects SME reliance on less formal methods of organising and financing development work. Only a minority of firms studied would have registered in R&D statistics as they are currently collected, and yet all firms interviewed were involved in some form of innovative activity. Even where firms, for example, had an 'official' R&D department (and consequently an 'R&D budget'), in the context of the research project this could be seen as largely a semantic difference (R&D staff rather than engineering or design staff for example). It is not always clear to firms what 'R&D' means, with its association with scientific laboratory-based work (the 'men in white coats'). The inadequacy of current measures are recognised at EC level, where there is a concern to replace 'R&D indicators' with more representative 'innovation' or 'innovative effort indicators' which capture the contribution of a broader spectrum of activities to economic growth. It may be, however, that *some* of what SMEs undertake as part of their innovative activities is simply not amenable to measurement, and that itself presents a further problem in trying to uncover what the bigger 'innovation picture' might be.

7.4 Contribution to Academic Debates

As well as providing original evidence relating to the management and processes of product development in manufacturing SMEs in the North East, the research has sought to contribute to broader academic discussions relating to technology management.

As discussed above, in the measurement of what can be called 'innovative effort', the 'official' measure of R&D employment and expenditure fails to capture much SME activity, which is more typically (though not uniformly) organised along informal lines (without designated R&D staff or budgets) and has been characterised as occurring intermittently and informally (Kleinecht, 1987). What this 'intermittent and informal' activity might be, however, is not well understood (Hoffman *et al*, 1998). This research has sought to explore in some depth the processes which manufacturing SMEs negotiate in order to bring to market new or improved products. Qualitative accounts have been collected from a number of firms, and common processes and themes identified. The research has attempted to understand product development

processes through the accounts of respondents, rather than to steer answers into pre-determined categories in order to facilitate a statistical analysis. Through the use of case studies and multiple interviews from different functions within the same company, fuller and more rounded accounts of product development projects and management have been developed. Where possible, the research has included the views of production staff and non-executive managers in the analysis, and this has given a greater depth to the research than studies which have represented the views only of more senior executives.

Previous small firm product development research has often concentrated on 'high-tech' firms at the expense of the larger SME manufacturing population (Hoffman *et al*, 1998). This research, in contrast, has sought to identify and understand the behaviours of SMEs who, whilst not 'high-tech', are nonetheless innovative, and therefore to make a contribution towards addressing this gap in our understanding of innovative SME behaviour.

Whilst in a review of the literatures (in Chapter Two) it was noted that there is sometimes implicitly suggested to be a tension between how SMEs are advised to manage their product development processes (through prescriptions based on large firm activity) and how they are able to do this in practice, any further exploration of this (in existing literatures) has been largely ignored. This research, in contrast, has found this difference between the *prescribed* and the *actual* methods of managing product development, as well as between *official* company procedures relating to product development management (where these exist) and *actual* practices to be a major theme in SME product development management. The research has supported the position that managing product development can itself be seen as a key company capability which must therefore be developed and *learnt* over time (Bessant *et al*, 1996; Bessant and Francis, 1997; Tidd *et al*, 2001), and this may involve the *adaptation* of best practice recommendations to company specific circumstances[4].

[4] The idea that best practice must be adapted to suit individual company circumstances has also been identified as a research theme in the ESRC's Advanced Institute of Management (AIM) research programme.

Overall, the research has suggested that a *rational* technology management framework is insufficient to understand a process of SME product development management, since this presumes the product development arena within the firm to be largely uncontested and unproblematic. Instead, it is only through the realisation of the political nature of the product development process and the inclusion of this within the analysis that a more complete understanding can be arrived at. Product development projects do not fail only because of poor management. Product development is a means by which individuals or functional groups within the company can seek to advance and consolidate their own position. Understanding and recognising this allows failures or difficulties experienced in product development projects to be understood in a more complete way than when these failings are understood only as representations of 'poor management' in which the company could 'do better'.

Finally, the research has attempted to examine the importance of the region to participating firms with reference to the location and extent of their external connections. Whilst local environments are important for the sourcing of more general inputs, for specialist inputs, the content of the contact rather than its location was important, and there was no sense in which those firms who made use of external inputs were in any way limited by geography when sourcing key or specialist contacts. However, amongst those firms who struggled most overall with product development management (who felt themselves to be operating under significant resource constraints), external sources, either local or non-local, were infrequently used, although again, this was not uniformly the case. This appears to support Rothwell's assertion that an openness to external inputs is associated with greater success (in terms of meeting project objectives) in product development management (1992). However, the political content of any external relationships should not be neglected, since such contacts can be marked by unequal power relations (Hudson, 1999b).

7.5 Constraints and Directions for Future Research

7.5.1 Boundaries of the Research Project

The research project makes no claims to be representative of *all* manufacturing SMEs, either within the region or in a wider context, however, themes which have emerged as significant may well be so for *some* companies beyond the boundaries of the project, and suggest a starting point for any further research in the area.

Whilst semi-structured interviews were felt to be the most appropriate methodology to collect data required to answer the study's research questions, it should be recognised that these interviews provide, in Markusen's terminology, a *snapshot* of a particular point in time. As an object of study, firms are very much a moving target, and data collected is temporally (as well as spatially) bound (Markusen, 1994: 485). Case studies generated rich data through the use of multiple interviews at each site, and if time and resource constraints had allowed, separate supplementary interviews (with different respondents) at second stage interview sites would have added to the robustness of data collected.

Difficulties experienced in constructing a sampling frame in the second stage of the research reflect the fragmented coverage of current business listings. A perception of quality is bound up in listings provided by commercial outlets, primarily because of the premium charges for such services, but the reality is that no single source can be relied on to give adequate coverage. Hence a significant proportion of time during the research project was taken up in constructing a satisfactory sampling frame.

Time and resource constraints have been a further limiting factor for the project. The number of interviews conducted was limited in part by the time available, although the research has also sought to have a satisfactory coverage in terms of the number of firms included in the study.

Whilst political factors have been suggested to be a significant element of the product development process, these emerged primarily through the case studies conducted for the research rather than in the course of the one-off survey interviews. It did seem,

however, that even in the case study context (with multiple informants) such issues had to be allowed to *emerge*, since any direct questioning on political matters tended to produce responses which failed to illuminate. Jones and Stevens (1999) have suggested that the only sure-fire way to get at political issues and agendas within the firm is to be *a part of* that firm for a significant period of time. It is suggested, however, that case studies, allowing for contact with multiple respondents from several functional areas of the firm, can also be used effectively here.

7.5.2 The Research Process

The process of undertaking the research project has itself been an interesting one. The research set off with what might broadly be described as a 'practitioner outlook', whereby identifying 'good practice' in product development (applicable to a variety of manufacturing SMEs) appeared to be both possible and achievable. As the collection of empirical data progressed, however, it became clear that firm-level product development processes were more complex than a concentration on 'good practice' might suggest, and that individual firm characteristics as well as the contexts in which companies operated had a bearing on what could be realistically achieved in terms of approaches to product development management. A 'best practice' management approach then was too simplistic, as was the original conceptual framework of the project, and the research methodologies originally chosen.

With the benefit of hindsight, the case study phase of the research was by far the most effective for uncovering detailed firm-level product development processes. The approach used for second-stage interviews would not be repeated if similar research were to be undertaken seeking the same degree of detail. Reconciling the wishes of the CASE partner with the demands of an academic studentship was felt to be difficult, more so during the first part of the research project where the struggle to make sense of apparently conflicting needs (policy practitioner versus academic) was most apparent, particularly for a 'new' researcher.

7.5.3 Directions for Future Research

A number of themes have been identified in the thesis, some of which are suggestive of future research projects which could usefully be developed to both refine and supplement current findings. Furthermore, additional research projects could be used to confirm the accounts developed here regarding the management and processes of product development in manufacturing SMEs. If (as it would appear) innovative manufacturing SMEs are to remain a policy focus, then there is a need to further expand current knowledge, in order to ensure that appropriate policies are put in place and targeted accordingly.

Expanding the current research beyond the regional boundaries of the North East would seem to be a useful addition. Particularly, it would be interesting to compare the behaviour of North East manufacturing SMEs with similar firms in one or more core regions, but also additional peripheral regions, to see where similarities and differences lie. This would allow further hypotheses to be developed regarding the spatial dimensions of technical change, and the role of the region and regional institutions and actors within this, linking in to current debates surrounding the scope for regional action in the face of globalisation.

Organisational learning has been suggested to be crucial both in acquiring inputs to the product development process (internally and externally to the firm), but also, following Bessant and Francis (1997) in relation to the ways in which organisations become proficient in managing product development and embed new behaviours and cultures, with regard to the management of product development, with this itself suggested as an additional capability which the firm must acquire over time. Particularly when proficiency in product development is seen to be a source of competitive advantage, understanding *how* firms become proficient is expected to be of interest to policymakers. There are also questions regarding the assumptions which underpin policy ideas, for example, how 'best practice' recommendations come to be seen as such, and following Lagendijk and Cornford (2000), how such bundles of knowledge gain the status of received wisdoms within the policy-making community. The theoretical models with which policymakers but also policy *deliverers* are

operating would also be an interesting area for investigation. Whilst particular assumptions inform policy directions that are issued at national or European government level for example, those who are in the frontline of delivering services may be operating with alternative models in mind, and this could have an impact on how programmes are implemented in practice.

In terms of learning *for* product development (rather than how to do it), the role of communities-of-practice as sources of learning can be further investigated. If, as has been suggested, their operation is critical to organisational learning mechanisms (Brown and Duguid, 1991; Wenger, 1998b), then this has implications for our understanding of the spatial dimension of technical change, since such communities are not limited either by organisational or geographical boundaries (Amin, 2000). In terms of communities *within* the firm, particularly related to occupational and functional groupings, they have been suggested to be potential sources of tension and misunderstandings within the firm (Schein, 1996; Dougherty, 1992), possibly leading to negative outcomes with regard to product development. The role of such 'worldviews' and 'thought worlds' is also suggested as an area for further investigation (making it important to involve not just technical staff but also staff from outside the technical function in academic research projects, including production and non-managerial staff), as is the role of the individual as a political actor in processes of technical change. One particular failing of the technology management literature has been suggested to be its neglect of the political dimensions of product development processes, and its assumptions of a uniform community within the firm which strives towards an uncontested common agenda. These political aspects of product development have been suggested in the thesis, and have been identified primarily during the case study stage of the project. A continuation of the exploration of product development processes through the utilisation of in-depth case study methods could allow for the development of further understanding of the political dimensions of product development.

As has been suggested, the measurement of innovative effort, particularly with regard to SME activity, remains unsatisfactory and is an area for further exploration. With

its preliminary investigation of what manufacturing SME innovative effort (for the achievement of product development or improvement) might involve, the research could be developed in the future to contribute towards such a target.

7.6 Conclusions

This thesis has sought to contribute to an understanding of the product development process in manufacturing SMEs, and has found that, overall, a rationalist or normative approach is inadequate for understanding either the process of product development or its management. The complexity of the process requires a deeper and more reflexive consideration than is possible with a straightforward technology management approach. A number of points have been identified from the empirical research underpinning the thesis which both reinforce this conclusion and are important in understanding firm-level product development processes.

Something which has emerged strongly from the research is a sense of *variety* in relation to both the characteristics of companies studied and to firm-specific approaches to product development. Manufacturing SMEs are not a homogenous group, and yet they can be treated as such in policy programmes. Particularly, SMEs are presumed to share certain size-related characteristics (both positive and negative) in relation to product development, but the research has demonstrated that this cannot be assumed to be uniformly so. The communications advantages generally associated with SMEs were not found at all companies. Ways of thinking and understanding were (at some companies) closely tied in to internal functional departments, and resulting differences could cause difficulties and misunderstandings which appeared to have a negative impact on the progress of development projects. Not all companies felt themselves to be hampered either by their smaller size or the resource constraints that are generally associated with that smallness. Those companies who felt most constrained were also likely to struggle to implement (and in some cases resist) 'best practice' prescriptions (termed a 'formal' approach in the thesis) for product development management. The concepts of formality and informality were important in understanding how the product development process was managed, with differences observable between policy 'best practice' recommendations and how

companies (on the whole) managed in practice, but also between how interviewees suggested they 'should' be managing development projects in the light of 'official' company procedures, and again how they did so *in practice*. It is important that these differences are noted and understood by those who are in the business of formulating and delivering innovation-related policy and support, since their existence appears to make the notion of a single best practice route to success redundant.

Firms who managed their product development processes in a more formal way and whose *actual* management practices conformed most closely with official company procedures, appeared to have *adapted* existing best practice recommendations to suit their own particular circumstances. This suggests that managing product development is itself a skill which has to be *learnt*, and can therefore be seen to be a company specific capability. Again, this means that simple replication of best practice prescriptions is not likely to be successful. This leads on to a further significant issue which the research points to, which is that product development is *not just about 'the technical'*. A number of 'softer' issues can affect the progress of product development projects within the firm (for example, relating to miscommunications and cultural or political issues), and yet even where these were recognised by interviewees as significant, they had not been addressed either during or after the completion of a project. This neglect is shared by support services, where the focus is more likely to be on best practice management recommendations and the provision of technical assistance, either directly or through sign-posting services to sources of particular expertise, and while such technical help is important, it is by no means the whole story.

Furthermore, if, as has been demonstrated in the thesis, product development is not just about 'the technical', then the currently used (official) measurement for innovation – the R&D input – is clearly inadequate. The firms studied for this research were all active in product development, and pursued product development projects largely because they believed this improved their competitive position. The contribution of such innovative effort to economic growth should not be overlooked, and yet the potential to view the North East as a region possessing few innovative

companies or industrial sectors is clearly there, given the picture painted by official statistics.

Whilst our conceptualisation of the innovation process itself has moved on from being thought of as a largely linear progression of successive inter-related events (Massey *et al*, 1992) towards a recognition that the reality is much more complex and untidy, there has been no corresponding acceptance or shift in understanding regarding the *management* of that process, particularly in policy terms. Despite studies stretching back over the last thirty years which point to the potentially political and contested nature of innovation within the firm (for example, Cabral-Cardoso, 1996; Freeman, 1982; Jones *et al*, 1994; Thomas, 1996), product development is still largely understood as a substantially unproblematic process which can be rationally managed. The resultant models of both product development processes and the ways in which firms undertaking product development activities can best be supported are oversimplified, and fail to capture the realities of the product development process as experienced.

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Oaks.

Appendix 1 Case study company 'official' product development procedures

Firm A
Front-End of Project • Staff from all sections of the company are encouraged to put forwards ideas, both for new products and for ways to increase operational efficiency. In practice, however, the majority of new product ideas come from observations made in the marketplace, through either the sales side of the business or the technical director. • Potential new product ideas are collected centrally by the technical director and reviewed by senior managers at their monthly management team[1] meeting, and ultimately by the board of directors. Potential projects are scored against a generic list of pre-set criteria drawn up by the management team. • Ideas which pass management assessment are floated to potential customers by members of the sales team, and according to feedback, will then be prioritised for development, again by senior management • The selection of projects to be progressed is felt to be hindered by a lack of available market information relating to Firm A's primary markets. Historically the company has gone ahead with projects based on assumptions about the marketplace, but with varying degrees of success. Senior managers have identified the need for a more concentrated effort at the front-end of product development projects in order to assess more accurately potential markets and sales, and thus hopefully reduce the risk of poor performance following the launch of a product.
Procedures and Project Planning • Written product development procedures are in place and these have evolved from the company's experience in managing previous product development projects. • A product development plan is written for each new project which follows the stages laid out in these generic procedures.
Project Management • Development projects are managed by project teams, each with a designated project leader. Project teams are cross-functional and project dependent, with membership varying according to the stage of development reached. The company appears to have a real commitment to cross-functional involvement in product development, with team members drawn from sales and marketing, design, manufacturing, purchasing and systems, and from non-managerial as well as managerial staff. • Each project is managed by a named project leader (who will normally be a member of senior management), responsible for keeping the project moving forward and within budget and timescales. Ultimately, the technical director suggests that all product development projects are his responsibility. • Projects are reviewed at key-stage review meetings (stagegates), although a 'straightforward' project may not be monitored in as much detail as is specified in the generic product development procedures. • Targets are set up at the beginning of a project, and success is judged in terms of adherence to budget, timescale, speed of commercialisation and an assessment of resource usage and costs versus revenue generated.

[1] At the time of first-stage interviews, the management team comprised the managing director, technical director, sales and marketing director, finance director and logistics director.

Firm B
Front-End of Project • The functionality of products is essentially determined by legislation, but a key element in product design is felt to be conforming to customer requirements, and customer opinions are therefore sought out as part of the overall product development process. Whilst the sales team are an important mechanism in passing on customer comments to the engineering department, the company has also taken the decision to understand its customers as a 'market segment', and has therefore commissioned market research amongst existing and potential customers. • A pro-forma for outlining new product ideas exists, and can theoretically be filled in by anyone from any part of the company. In practice, however, ideas come almost exclusively from the MD, the engineering manager, or the sales and marketing department. • Ideas are initially assessed by the marketing and engineering managers, in terms of both technical feasibility and market potential. Concepts which are thought to be viable are then progressed as a product requirement specification which would normally be written by the marketing department. This details the functionality of the project, and from that, the engineering manager will produce an outline technical concept, highlighting similarity to existing products, technological requirements, and initial projected costs and timescales. These two documents are then presented to the board for approval. • Projects are assessed by the board in terms of how closely the idea will fit into the company's strategy, and also what the expected rate of return on investment on the product will be.
Procedures and Project Planning • The company has a set of generic product development procedures as part of it's overall quality systems. • Once a project has been approved by the board, a detailed project plan will be written by the engineering manager, detailing both available and required resource, and planning project milestones and review meetings.
Project Management • A design engineer is assigned to each project as project leader, responsible for its day-to-day running. Overseeing the project, is a project manager, usually a member of the senior management team, who will chair project reviews and ensure that satisfactory progress is made against the project plan in terms of both timescale and budget. • A cross-functional project team is appointed with representatives from engineering, sales and marketing, finance, purchasing and manufacturing. • Initial stages of the product development process are managed as a series of stagegates through which new product ideas must successfully pass if they are to be progressed by the company. This way it is hoped that poor ideas will be screened out before the company has made any significant investment in them. • Design reviews and project meetings are minuted, and this information collated in a paper project file. • Following the launch of a product, a three month post-introduction review is held, where production and sales feedback is given to project engineers.

Firm C
Front-End of Project • The product development process is visualised by the technical manager as a hopper with a large number of ideas and customer needs feeding in at the top which are gradually reduced in number as the company focuses on particular developments. • New product ideas are initiated mainly through sales (particularly in response to customer comments and enquiries), but can also come from the company's technical helpdesk, where existing customer technical enquiries regarding products in use are routed, and also from the engineering design department, where brainstorming sessions are held to both review existing products and to identify what next generation developments might be. • In addition to this, the company has a continuous improvement philosophy, and runs a business ideas generation scheme, where ideas from any member of staff regarding either new product ideas or efficiency improvement suggestions will be entered in a monthly prize draw. • Ideas for new products are assessed initially by the marketing director and technical manager. • Those which are felt to be feasible (both technically and in terms of a potential market) are then prioritised, and those given a high priority will then be developed as a concept by a design engineer. After a further marketing review, ideas are reprioritised, and a detailed design analysis carried out. Marketing and concept reviews are carried out by a team of people including representatives from design, sales, marketing, sometimes manufacturing, and where the product is one which will be in use in the service arm of the company, engineering services.
Procedures and Project Planning • The design department has procedures for product development (as part of overall quality procedures). • A project plan will be written for each development by the lead engineer working on the project.
Project Management • Following initial reviews, work on a development is the responsibility of the engineering design department, with no further cross-functional involvement until the point when the product is passed on to manufacture. • Usually two engineers will be allocated to a project, with one working as the lead engineer and the other in support. • Review meetings will be held between the lead design engineer and technical manager to ensure that the project remains on track. Following prototype production and testing, the design will pass to the control of the works manager.

Firm D

Front-End of Project

- The company's two main routes to product developments are through either contract design projects for a specific client (by far the most common), or occasionally through a more speculative 'development' project, usually done to prove a more novel technology and done with the intention of securing further customer interest and therefore contract projects.
- Whilst product development ideas can and do originate from sales and marketing or from design engineers, the most usual scenario is for a customer to approach the company with a particular product requirement, necessitating a proposed solution from Firm D within a short space of time. Existing products are reviewed periodically to see how they can be improved and made more saleable.
- There is no formal scoring process or assessment criteria for assessing initial project ideas (wherever these have originated from). Usually an informal discussion regarding potential projects would be held between senior engineers, sales engineers, technical directors and the MD.
- Ideas thought to be of potential benefit to the company will then be investigated further by one of the senior engineers involved in these preliminary discussions. Once the feasibility of a potential project has been established, there will be a further review.

Procedures and Project Planning

- As part of it's quality system, Firm D has written procedures for contract design projects, and development projects will be run in the same way, going through similar processes, but without the added discipline of an external client's required delivery dates.
- If the project is a response to a customer enquiry it will be written up as a technical specification which will then be submitted to the customer as a formal proposal. If the idea has originated from within the company, it will be progressed as a development project.

Project Management

- Overall responsibility for the company's technical development lies with four board members, three of whom are ex-design engineers of the company. As an ex-engineer and founder of the company, the company chairman also takes an interest in and has a significant influence on product development routes the company takes.
- A project team is set up for each new project, with project teams co-located into a separate physical area for each project. Where possible a lead technician from the company's production department will be appointed to the team to follow the project through, but will not be involved in the project in its early stages.
- Each project is led by a project manager, who for contract projects will always be a senior engineer, and whose responsibility it is to write a project plan and ensure that the project is regularly reviewed and progressing according to specification.
- Project reviews are usually done informally, with additionally, on contract projects, formal design reviews with the client in attendance taking place.
- Project leaders are themselves overseen by the technical director, and again this is managed on an informal basis rather than by scheduled project meetings.
- Completed projects are assessed financially, with an end of project report written by the project manager giving an indication of actual versus projected spend, and a justification for any differences which have arisen.
- Also at the end of a project a build round-up will take place, where workshop build records are gone through to identify any problems which have emerged and design drawings updated to take these into account.

Firm E
Front-End of Project • Initial ideas for potential new product developments originate from a variety of sources, including customers (which could be mediated via the sales team, or result from direct approaches from larger customers) and suppliers, but also from internal brainstorming sessions which may involve members of the senior management team, the product development management group, or members of the sales team. • Further to this, the company also uses RTCN and their R&D Quest project to assist in identifying new market and technical opportunities. • Potential ideas are screened and prioritised by two senior managers, the director of buying and development and the sales and marketing manager. Ideas are screened in terms of how well they fit with the company's existing activities and how feasible they will be to progress. Possibilities are then prioritised through a scoring system ranking them on potential speed of implementation, expected profitability, fit with the company's existing customer base, expected costs of implementation and fit with company strategy.
Procedures and Project Planning • Ideas receiving a high score from this initial evaluation are progressed as actual projects. • A proposal will be written by the director of buying and development, and an assessment made of necessary and available resource required for the development. • Proposals initially enter what the company terms an 'evaluation loop' where some basic testing is done by the company's product development technician to further establish the feasibility of a product. Following this the project will be passed to the senior management team for acceptance. • The product cannot go into production until a specification has been written by the director of buying and development. Approval of a specification also indicates that a project has been found to meet all legal and safety requirements.
Project Management • The early stages of a development project are managed by the senior management team. As the product gets closer to launch, control is handed over to a product development management group, meeting fortnightly and made up of a relatively stable team of representatives from areas within the company whose involvement is required to actually bring a product to market, including buying and development, sales and marketing, production and quality control. • Product development group meetings deal with all on-going product development issues rather than focus solely on individual projects. • Following the writing of a specification, the project can then be progressed to a trial production loop where technical details and price can be confirmed. Control now passes to the product development management group. • Once the trial production loop has been completed, the product can be launched and brought into full production. • Project success is judged in terms of the sales of a new product following it's launch.

Appendix 2 All companies – brief characteristics

Company	Sector	Size Band	Nature of Project	Nature of Production*	Accreditation in Design/ Production
1 (case study)	Engineering	51-70	Development	MTO/CMTO	ISO 9001
2 (case study)	Electronics	101-150	Development	MTS	ISO 9001
3 (case study)	Engineering	151-200	Contract	MTS/CMTO/ETO	ISO 9001
4 (case study)	Engineering	71-100	Contract	CMTO/ETO	ISO 9001
5 (case study)	Specialist Process	71-100	Contract/development	MTS/CMTO	
6 (survey)	Electronics	21-50	Development	MTS/CMTO	ISO 9001
7 (survey)	Engineering	* 20	Development	MTO/CMTO	
8 (survey)	Electronics	21-50	Contract	MTO/CMTO	
9 (survey)	Electronics	* 20	Development	MTS	In progress
10 (survey)	Engineering	21-50	Contract	CMTO/ETO	ISO 9001
11 (survey)	Electronics	21-50	Contract	MTO/CMTO/ETO	ISO 9001
12 (survey)	Engineering	21-50	Contract	MTO/CMTO	ISO 9001
13 (survey)	Engineering	21-50	Development	MTS/MTO	ISO 9001
14 (survey)	Medical Equipment	21-50	Development	MTS/MTO	ISO 9001
15 (survey)	Engineering	21-50	Development	MTS/CMTO	
16 (survey)	Electronics	101-150	Development	MTS/CMTO	ISO 9001
17 (survey)	Engineering	151-200	Contract	CMTO/ETO	ISO 9001
18 (survey)	Specialist Process	51-70	Development	CMTO/ETO	
19 (survey)	Electronics	21-50	Development	MTO/CMTO	ISO 9002
20 (survey)	Engineering	21-50	Development	MTS/MTO	
21 (survey)	Engineering	* 20	Development	MTO/CMTO/ETO	
22 (survey)	Engineering	* 20	Development	MTO/CMTO/ETO	ISO 9001
23 (survey)	Engineering	21-50	Contract	MTS/MTO/CMTO	ISO 9001
24 (survey)	Medical Equipment	101-150	Development	MTS/MTO/ETO	ISO 9001
25 (survey)	Specialist Process	101-150	Development	MTO/CMTO/ETO	
26 (survey)	Engineering	* 20	Development	MTS	ISO 9002
27 (survey)	Specialist Equipment	21-50	Contract	MTO/CMTO/ETO	ISO 9001
28 (survey)	Engineering	21-50	Contract	MTO/CMTO	ISO 9001
29 (survey)	Medical Equipment	* 20	Development	MTO/CMTO/ETO	In progress
30 (survey)	Engineering	51-70	Development	MTO/CMTO	

*** Key to Nature of Production Categories: made-to-stock (MTS); made-to-order (MTO); customised-made-to-order (CMTO); engineer-to-order (ETO).**

Appendix 3 Case study first interview schedule

Context

1. Brief history of the firm? (Covering age, major product groups and markets i.e. historically)

2. How many FTE employees? (Is this growing/stable/decreasing?)

3. Latest available turnover (or confirm from company accounts)

4. Copy/description of organisational structure (if not already obtained)

5. Principal products?

6. Main competitors?

7. Major markets (i.e. where are bulk of sales made - local, UK, Europe)?

8. How diverse is your customer base? (e.g. wide customer base/ rely on one or two main customers)

9. Can you identify your customers main criteria (in buying from you) e.g. design, price, quality, service?

10. Does the firm have any quality accreditation? (Or confirm from background search)

11. What are the key strengths of the firm? What makes it successful?

Product Development Process

I'd like to gain an understanding of how the firm manages the product development process and try and identify a PD project which would be suitable to study.

1. Product Development Strategy
    a) Does the company have a product development strategy?
    b) Is it formally documented?
    c) Is it a standalone document (i.e. separate from the business plan)
    d) Who is responsible for writing it?
    e) What timeframe does it relate to?
    f) How often is it revised?
    g) What does it cover? (e.g. types of market, products to be developed, key technologies)
    h) Is it communicated to all members of staff? How? (Innovation as a corporate wide task)
    i) How would you describe the firm's approach to PD (e.g. proactive, reactive)?

2. Nature of product development activity within the firm e.g.
    - enhancement/minor modification
    - addition to product family
    - next generation product
    - new core product

(Wheelwright and Clark 1992)

3. Role of customers/suppliers? How involved are they in PDP? Is there a conscious decision to involve them?

4. Are there written procedures for PD (separate from any PD strategy), i.e. project management rather than overall strategy?
    a) How are project ideas initiated (concept generation)? (e.g. technology watch, in response to legislation, requirements of customers/suppliers, 'continuous improvement' suggestions)
    b) How are initial opportunities/ideas assessed? By who?
    c) How are necessary resources for a project assessed? By who?
    d) Who is involved in PD? Do you have project teams? (And are they all technical staff, cross-functional, formal/informal, fixed/project-dependent?)
    e) Who produces specifications? What do they cover?
    f) How are on-going projects assessed? When and by who?
    g) How are outcomes of individual projects assessed? How is a project judged to be successful? Are measures put in place at the start of a project? On what basis would a 'kill' decision be made?

5. How are resources allocated to PD activity?
    - Is there a fixed budget, money allocated on a project-by-project basis?
    - Do you employ staff with a recognised R&D function?

6. Does the firm maintain any external links which are expected to be useful in PD activity? (e.g. other firms, support agencies, universities, trade associations, chambers etc.) What is the nature of any links? (e.g. formal/informal, frequency of contact).

7. Has the firm been involved in any collaborative R&D/PD activity? If so, how was this brokered, what was the experience?

8. What obstacles has the firm encountered relating to PD activity?

9. Have there been any recent PD projects? Is there one which you feel would be suitable for the case study?
    - what was the project about?
    - what was it trying to achieve?
    - who were the key people involved?
    - who was the project manager?

Evidence for

- **management commitment to and support for PD**
- **long-term strategy in which PD plays a key role**
- **associated long-term commitment to major projects (i.e. not just short-termism), based on a consideration of future market penetration and growth**
- **management acceptance of risks and failure**
- **creation of innovation accepting culture**

Rothwell 1992

Appendix 4 case study second interview schedule

Description of the PDP (relating to the particular project selected for study)
Please describe the PDP for the project. What were the main stages and activities? Timescales.

Areas to be covered

- Motivations
  - What was the project about? what was it trying to achieve?
  - How did it differ from previous products? why was it better?
  - How was the project initiated? (concept generation)?

- Project team: respondents role; interactions with other team members (at each stage)
  - Who was on the project team?
  - Who was the project leader/manager?
  - What is the role of the project manager?
  - Is it policy to represent someone from each functional area on the project team?
  - How are project teams selected? By who?
  - How were the sub-groups selected? How did they work?
  - Was this project typical in terms of how the project team was organised?
  - Nature of internal communications
  - Functional integration
  - Commitment to development of human capital (also resource issue)
  - Role of team members and particularly project manager ('quality' of managerial and other staff

- Specification - who was it produced by, was it adequate as the project progressed?
  - Design for makeability

- Project justification
  - By who? When?

- Planning and control procedures (project management)
  - Resources committed to upfront screening of new project
  - evaluation of initial idea
  - assessment during project (regular appraisal)
  - how was the project 'project managed' - meetings (frequency & with who?), stagegates, milestones, targets
  - documentation

- Strategy
  - does project fit in with company strategy (awareness of strategy)
  - does the company have an overall corporate strategy? What does it cover? (Can I get a copy?)
  - Its been suggested that the separator project was managed differently. Was this the case, and if so, how and why?

- Involvement of suppliers/customers
  - Market orientation
  - Satisfying user needs
  - Were potential users involved in project? How and at what stage?

- Involvement in networks/external links
  - Who with? (& geographical location)

- Nature (e.g. formal/informal, at what point in PDP, problem solving)
- What was transferred into the firm? How was it used?
- Willingness to take on external ideas
- Effective linkages with external sources of knowledge

- Support service links (formality, frequency, what assistance was requested, what assistance was provided, how were inputs used?)

- Collaborative project?

- Asset/competence building
  - Were necessary resources in place? Assessing necessary resources for success of the project
  - Adequacy of existing/available resources e.g. staff, finance, equipment, time (c.f. Christensen - scientific research assets, process innovative assets, product innovative application assets, aesthetic design assets plus complementary assets)
  - Commitment to development of human capital
  - Learning by doing (generation of process knowledge through experience, both formally through review and informally through personal insight) (Rosenberg?)
  - Learning before doing (relationship with knowledge external to the firm, formal knowledge from publications and informal through contacts with other firms - Pisano 1997)

- Presence of key individuals
  - *Product champion* – individual who supports an innovation project and is personally committed to it (but might not want to give up on it when the rest of the org has decided its not an option to proceed with)
  - *Technological gatekeeper* – brings a considerable volume of relevant technical information into the firm and disseminates it to others
  - Individual who is *source of critical technical knowledge*
  - *Organisational sponsor* – deals with procuring resources or convinces hostile or sceptical critics elsewhere in the organisation. Typically has power and influence; not necessarily technical knowledge, but believes in the potential of the innovation
  - Role of *team* members and particularly team leader
  - *'Business innovator'* who could represent and bring to bear the broader market or user perspectives
  - *Negative champions/project assassins*

  (Tidd et al 1997)

- Efficiency in development work
  - Quality control

- Obstacles encountered?
  - How were these managed?

- Success/failure of the project
  - How is this assessed, (for the firm and from your point of view)
  - What would you do differently?
  - Were targets met?
  - Why would the customer buy this product in preference to competition? (e.g. design, price, quality, service etc)

- Factors affecting reception of proposal
  - How complex is the proposal?
  - What is its scale of introduction?

- What is at risk?
- Who is likely to be affected by the innovation, favourably and unfavourably?

(Twiss 1992)

- *Marketing*
  - What is the function of the marketing department? (e.g. long-term market planning, sales)
  - How exactly do they get feedback from the marketplace (e.g. via sales)?
  - Does the company have a marketing strategy? (Separate to or part of overall business plan?)

Appendix 5 Second-stage interviews - company approach letter

24th January 2002

«Title» «FirstName» «LastName»
«JobTitle»
«Company»
«Address1»
«Address2»
«City» «PostalCode»

Dear «Title» «LastName»

New product development is an issue of some importance for the majority of small and medium sized manufacturing firms, and yet we have relatively little detailed knowledge of the actual processes involved. An improved understanding can only come about through talking directly to firms about the ways in which they develop or improve new or existing products.

I am a post-graduate student at the University of Newcastle, currently conducting research on how the product development process is managed by small and medium sized manufacturing firms in the region. I would be very interested in learning about the approach taken to product development at «Company», and wonder if you would be able to spare me some time to discuss this.

The research is part of a PhD project, run jointly between the Centre for Urban and Regional Development Studies (CURDS) and the School of Management, both at the University of Newcastle, and is partly sponsored by RTC North Ltd. It is intended that the research will give a better understanding of the product development process in small and medium sized firms, and that this will be of benefit to firms themselves, and also to policy makers and support organisations working in the region. *Information from the interviews will be treated with the strictest confidence, and all identifying company details will be omitted from any reports resulting from the survey. I should stress that my interest is in the process of product development rather than any technical or commercially sensitive information.*

Interviews are expected to last approximately an hour, and will focus on your approach to product development management by talking through a particular product development project which has been identified by you as suitable for discussion. In return for your time, I will send you a synthesis report of the results of the survey (containing data from around thirty firms), illustrating a variety of approaches to managing the product development process.

If convenient, I would very much like to arrange to come and speak with you sometime in the near future. I hope you won't mind if I give you a ring within the next week to see if you are interested in contributing to the survey, and if so to arrange a suitable time to visit. I will also be able to answer any questions you may have about the project.

Yours sincerely

CATHERINE HODGSON

Appendix 6 Second-stage interviews: schedule

Thinking about a specific project to illustrate your approach to PD

- What was the project?
- What were the objectives of the project?
- What were the similarities/differences to existing products?
- How was the project initiated? Who was involved? (Could include technology watch, legislation, requirement of customers/suppliers, brainstorming or other tools/techniques, continuous improvement suggestion)
- Selection/assessment of initial idea. How? (on what basis do you go ahead with an idea? What is considered in an assessment? Formal/informal process?) By who? How was *this* project assessed? Do you collect information about what the market requires? (How?)
- Specification? Written by who? Was it adequate as the project progressed? (and if not, why not).
- Was a project plan written? Who by? Did it include targets? Was it used? Who by? Was it adequate? (and if not, why not?) If project deviated from the project plan, at what points did this happen?
- Resources (financing of the project, staff, equipment, knowledge).
- Was there a project leader/champion? Seniority? What should their role be? Was that achieved? (Respect for & authority of project manager)
- Staff involved in the development. Was there a team? Was this cross-functional? Is the team project specific? How often did they meet? How did they communicate? Sales/marketing/production involvement. Links/ communication between different functions. Key individuals for the project.
- Production implications. Involvement of production/operations staff.
- On-going project assessment. How? When? By who?
- How are senior management team kept informed/involved?
- Any other project meetings?
- Project documentation? What happens to this?
- How did you know when the product was ready to launch?
- Any external inputs to the project? (e.g. customers (could float potential ideas), suppliers, support agencies, universities etc.) At what stages? Nature of contact/relationship?
- Testing? (When? By who? Was it adequate?) Was there a prototype stage? Trial production run? Field trials?
- Any post-launch review? (About product or project?). What happens to information from this? (Organisational learning).
- Were targets met? Were objectives met?
- What went well?
- What obstacles/constraints/problems? How were problems managed?
- What would you do differently in the future?

Context

- Brief history of the firm? (Covering age, major product groups and markets i.e. historically)
- How many FTE employees? (Is this growing/stable/decreasing? How does it compare over last 3 years?)
- Latest available turnover (How does this compare over last 3 years?)
- Copy/description of organisational structure (if not already obtained – request in initial approach)
- Principal products?

- Main competitors (number of)?
- Major markets (i.e. where are bulk of sales made - local, UK, Europe)? Nature of markets e.g. make to order, mass market etc.
- Diversity of customer base? (e.g. wide customer base/ rely on one or two main customers)
- Can you identify your customers main criteria (in buying from you) e.g. design, price, quality, service?
- Does the firm have any quality accreditation? (Or confirm from background search). How is that used?
- What are the key strengths of the firm? What makes it successful?
- Does the company have a 'vision'? What is it?

Product Development Process

- Nature of business planning. (Overall company strategy/business plan? Written by? Timeframe? Revisions?)
- Product Development Strategy
    - Does the company have a product development strategy? If yes, how does that support/fit in with overall business plan?
    - Is it formally documented?
    - Is it a standalone document (i.e. separate from the business plan)
    - Who is responsible for writing it?
    - What timeframe does it relate to?
    - How often is it revised?
    - What does it cover? (e.g. types of market, products to be developed, key technologies)
    - Is it communicated to all members of staff? How? (Innovation as a corporate wide task)
    - How would you characterise the firm's approach to PD (e.g. proactive, reactive)?
    - Do you have targets for the introduction of NP? If yes, what's the rationale for those?
    - Are you doing more NPD now than in the past?
    - Do you use any formal tools/systems for NPD?
    - Principle driver for NPD?
    - Principle constraints/obstacles in NPD?
- Nature of product development activity within the firm e.g.
    - enhancement/minor modification
    - addition to product family
    - next generation product
    - new core product
- Role of customers/suppliers? How involved are they in PDP? Is there a conscious decision to involve them? How are their views sought out/ incorporated into the firm's thinking? (Channels of communication)
- Are there written procedures for PD (separate from any PD strategy), i.e. project management rather than overall strategy? If yes, who writes those? How are they used? Revisions? Flexibility in the application/following of these?
- How are resources allocated to PD activity?
    - Fixed budget/money allocated on a project-by-project basis?
    - How many staff involved in PD? (sole or primary function/secondary function. Who in the firm 'does' PD?)
- Does the firm maintain any external links which are expected to be useful in PD activity? (e.g. other firms, support agencies, universities, trade associations, chambers etc.) What is the nature of any links? (e.g. formal/informal, frequency of contact).