

**The Role of Innovation Processes within Small and Medium-sized  
Mechanically-based Firms**

Submitted by **David Glenn Brophey** to the **University of Exeter** as a thesis for the degree of **Doctor of Philosophy in Management, May, 2007**

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## ABSTRACT

The majority of previous research into innovation has taken place within the context of large firms of all types and small firms that are new technology-based firms - for example biotech and software. This thesis addresses a gap in the literature by studying innovation within the traditional sector of small to medium-sized mechanically-based manufacturing firms (MechSMEs), a sector that has been virtually ignored despite its significant economic impact (for example, it accounts for approximately 4% of the labour force within Canada).

In addition, this sector provides a particularly rich setting for the study of innovation. The sector has been found to compete primarily on product differentiation (von Hippel, 1998) without effective intellectual property protections (Taylor, 1973 cited in von Hippel, 1998, p.47) that provide monopolies that can accommodate temporal gaps in innovative activities. Survival in this sector requires ongoing innovation, and given the size of the firms, there is little room for error in their innovation processes.

This research consists of case studies of the practices and processes involved with thirteen innovations (including a mix of product and process innovations) and the overall innovation processes of four surviving firms within two industries. The findings of previous innovation research were used to identify the typological foci for the interviewing of respondents.

In the absence of a dependent variable (a well-accepted definition of innovation or innovativeness) and any consistently-used method to measure innovation success within the respondent firms, an attempt has been made to identify the two most innovative firms. This identification has been based on the assumption that the firms that are more highly influenced by innovation practices and suffer fewer influential barriers to innovation are likely to be more innovative. Based on this determination, the findings indicate that approximately half of these firm's innovation practices were shared with the other firms, while the other half of the practices were found to be either idiosyncratic or only partially shared. Of particular interest were twelve innovation practices that were particularly influential within the two most innovative firms and shared by both firms. The identification of these practices offers a potential starting

point for a future research project to evaluate their relative contributions to innovation in this and other sectors.

Another important contribution is related to the absence of use of innovation metrics identified in the extant literature by the respondent firms. This absence either provides an opportunity for outside agencies interested in helping MechSMEs become more innovative (i.e. governments) by introducing MechSMEs to these conventional metrics and the connected improvements that would likely follow, or sounds a warning to those agencies designing assistance programmes based on performance metrics that are not commonly used within this operating context.

## ACKNOWLEDGEMENTS

I have been extremely fortunate to have been supported in the pursuit of this endeavour by many people with generosity of spirit, cogent professional advice and kindness beyond the call of duty.

In particular, I wish to express sincere gratitude to my supervisor and friend, Professor Steve Brown, for his patience and the hard work required to convert this experienced (and stubborn) practitioner, with a dream to fix innovation issues for all organizations, into what I would like to think is a capable, focused researcher. This transformation did not happen overnight and without Steve's persistence and common sense probing aimed at creating something that mattered and was defensible, this end product certainly would not have been possible. I also wish to thank Steve's family for welcoming me into their home on repeated visits 'across the pond' and for their great hospitality.

Thank you to my examiners, Professor John Bessant (external) and Dr. Ian Hipkin (internal), for managing to read the whole thing so thoroughly, and for a surprisingly enjoyable Viva. In particular, I appreciated their positive approach to the task and the suggestions they made that I believe have resulted in a stronger dissertation. Thanks are also in order to Professor Rod Coombs for his useful advice about 'piles of knowledge' and Dr. Harvey Maylor for his insightful thoughts on the structure of my research question and to Dr. William Procnier for the Canadian-based dry run of the Viva process.

A great deal of thanks is owed to my employer and colleagues at Nipissing University for the moral and financial support and the flexibility they have exhibited to facilitate the pursuit of this goal. In particular the development of this dissertation has benefited from the wisdom of Drs. Hemsworth, Hall, Dean, Vanderlee, Kovacs, Knox, Sarlo, Ford, and Jones and research personnel such as Derek Stacey, Ashley MacDonald,

Melissa Toupin-Laforge, and Anthony DiGiacomo. Thank you for your support, ideas and interest.

Of course this dissertation would not have been possible without the cooperation of the senior management and employees of the four case study firms and I am grateful for their participation, interest and candor during the interviews. I can only hope that the attached result will prove as helpful for you as you continue to develop your businesses and personnel.

Finally, and most importantly, I have to express my sincere appreciation for the love and encouragement of my family, my 'kids' Erin and David, who have cheered on Dad through thick and thin, and my wife Karen who has adopted this adventure as 'not mine, but ours' as it would not have been possible without her understanding and ongoing support.

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## Chapter 1 Introduction

This thesis focuses on innovation within mechanically-based small to medium-sized manufacturing firms. This economically-important sector is faced with a dearth of previous research that considers their special circumstances with respect to innovation. This thesis begins to address this lack of context-specific research by performing a broad and deep case study analysis of several firms with multiple innovations. The chosen context offers a particularly rich setting for the study of innovation management, and as a consequence the findings of this research provide a useful contribution to the innovation debate for sectors with similar characteristics.

The pursuit of innovation as a management practice that contributes to survival in competition-based economic systems has been an ongoing factor within firms. Acceptance of this requirement by managers seems to be more widespread as rates of innovation accelerate (Lipsey, 1996; Johannessen et al. 1997).

Academics have responded to this trend with a broad array of research that has resulted in an extensive body of literature within a range that includes process theory, strategy, marketing, new product development, change management, theories of the firm and numerous disciplines that each claim to provide insights into the complexities of innovation (e.g. economics (Schumpeter, 1939; Porter, 1998; Cumbers and MacKinnon, 2004; Cooke and Wills, 1999), sociology (Williams and Edge, 1996; Gopalakrishnan and Damanpour, 1997), and engineering (Keegan and Turner, 2002; Smith and Eppinger, 1997; Hobday and Rush, 2000; Tyre and Hauptman, 1992)).

Research on innovation in an extensive variety of industry settings has been carried out with the bulk of the work taking place inside large organisations or within new technology-based firms, some of which are small to medium-sized. The innovation research that concentrates on manufacturing has primarily been carried out inside large companies (Saviotti et al. 1982). Surprisingly, given all of this previous work, very little innovation research has been done in the SME portion of this traditional sector of mechanically-based manufacturing even though it is economically quite important. For example, inside Canada alone, small to medium-sized mechanically-based manufacturers (MechSMEs), that is, firms employing between 50 and 500 employees in

this sector (NAICS codes 332, 333, 336, and 339) are responsible for providing employment for approximately 405,000 Canadians, or 4% of the labour force (Industry Canada, ; StatsCan, 2003; 2005a;b;c ). Since similar proportional contributions are likely occurring throughout other Western countries, this sector certainly qualifies as an economic sector worthy of some attention.

A well-accepted approach to studying MechSMEs would be to test within MechSMEs for applicability of an innovation framework previously defined as the result of work in other sectors. Unfortunately, the multi-characteristic dimensions of innovation have resisted definition and there is widespread disagreement on whether these frameworks have been defined. For example, some researchers suggest that frameworks have been developed (such as the stage-gate system) that appear to work for new product development for specific firms or a set of firms with similar characteristics (Cooper and Kleinschmidt, 1995). On the other hand, different researchers within the same field see the literature as “varied and vibrant, yet large and fragmented ....yet because it has not been tied together to create cogent understanding it is difficult to grasp what is actually known” (Brown and Eisenhardt, 1995). A more sweeping indictment of the previous innovation research states the following:

An accepted comprehensive and systematic framework guiding managers toward successful innovation does not yet exist. Many firms and academics have suggested that innovation management may be sector or industry specific, if not firm specific. (Lawson and Samson, 2001, p.378).

Similar differences of opinion about the state of conclusive innovation results are common throughout the innovation literature. These differences are not surprising when repeated occurrences of similar higher-level findings (including investing more in marketing; actively seeking new ideas from outside the firm, (Montoya-Weiss and Calantone, 1994)) are compared to the sometimes contradictory findings of detailed innovation practices when different industry contexts are studied. Managers who look to this research as a resource find the advice offered to be sometimes complementary but too often they find it to be contradictory (Brophey, 2005). The resulting confusion for managers is consistent with the author’s experiences throughout the 1980s and 1990s as a manager in a business context that relied upon innovation.

Given the shortage of research in this economically important sector and the disagreement about whether generic frameworks have been developed for innovation, the conventional approach to exploring the theory of innovation for this context would

begin with grounded theory exploratory studies. This methodological approach is based on an inherent assumption that very little is known about the phenomenon in question. Effectively this would ignore the findings of earlier studies and assume that none of the previous voluminous innovation research is transferable to MechSMEs. However, this is not a valid assumption for this thesis.

In methodological terms, this research takes the middle ground. It seeks to take advantage of previous innovation research efforts by utilizing the identified concepts that are likely to be applicable to MechSMEs. The particular concepts used are grounded in the substantive content of the literature and appear to have face validity. These concepts have then been used to guide the direction of the questions used in semi-structured exploratory interviews within these firms. This combination of literature-directed questions and a structure designed to create opportunity for new concepts to reveal themselves, leads to a comprehensive documentation of how innovation happens inside the respondent firms.

Summarizing briefly, this research takes note of the accelerating rates of innovation and the broadly-based response of the academic community. A particular economically important sector that has not been adequately studied is targeted, as very little useful advice for managers in this sector has been provided by the previous work. In order to ensure that a complete documentation of innovation in this sector is completed, the previous research has been reviewed to ensure all potentially material concepts are considered. These concepts are then used to assemble the questions asked during the exploratory research process.

Before the review of the previous research is focused through the lens of MechSMEs, it is helpful to establish the innovation milieu by reviewing macro-level issues and findings described by the broad literature.

## ***1.1 The broad context of innovation***

Innovation plays a role in every sector of our economy and is an important topic throughout society (LePoire, 2004) as a number of macro trends have come together to increase the profile and importance of innovation as a tool for firm survival in the modern economy. For example, the ubiquity of the Internet has extended into many

sectors of society and eased access to knowledge which is seen by a number of researchers (Nonaka and Takeuchi, 1996) as an important precursor for innovation. Globalization and the increased mobility of populations when combined with the Internet have increased accessibility to new markets, but also have exposed firms to new competitors. This increased access to information has made duplication of ideas easier, resulting in quicker and more comprehensive competitive response. The resulting reductions in expectations for the period when economic rent can be extracted from innovations has forced firms to produce innovations more frequently and do it with greater efficiency (Kanter, 1998). As a consequence, organisational innovativeness is now seen to be a prerequisite for survival in both not-for-profit and for-profit sectors.

In terms of economic analyses, arguably the most influential economist researching innovation was Joseph Schumpeter who suggested that innovation was a method used primarily by large firms to change the rules for competition. In *Capitalism, Socialism, and Democracy*, the resulting waves of “creative destruction” (Schumpeter, 1942) served to significantly devalue pre-innovation productive assets on the one hand and create valuable post-innovation assets on the other. Translating this into classical economic theory, Schumpeter suggested that innovation created new cost curves for innovative producers, while their status quo competitors lost business to the innovations and were then penalized by the resulting volume reductions through their traditional cost curves. The economic impact of innovations have been found to far outstrip the classical investments in labour and capital at the margin, to the extent that noted economists estimate that seven-eighths of economic growth is attributable to technological change in the broad sense. (Lipsey, 1996; Solow, 1988)

Other economists have documented the clustering of innovations over time that results from developments of enabling technologies and the resulting technological trajectories (Coombs, 1981; Lipsey, 1996) while other authors suggest that innovation within tangible product-focused industry sectors (including automotive, telecommunication, and packaged goods) has migrated from a series of fits and starts to a process of continuous change (Olin and Shani, 2003; Brown and Eisenhardt, 1995).

These temporal analyses of innovation activity have been complemented by industry-level analysis to identify the most likely sources of innovation within a given industry (von Hippel, 1998). This research looked for patterns of innovation sources by

separating their industry functions into categories of raw materials suppliers, manufacturers and users. The stated findings were that innovations are most likely to be stimulated by the groups with the highest expectation of economic rent (in terms of degree of advantage and expected monopoly rental period offered by the innovation being considered) with expected efficacy of patent protection playing a role in this rent expectation. An additional finding was that expected efficacy of patents is low in mechanical industries and high in chemical industries.

The same study found that firms that produce assembled products compete primarily based on product differentiation, which requires the ongoing development of new products as a prerequisite for survival. Non-assembled product firms on the other hand compete primarily on low cost which require that process innovations are pursued to drive out costs. These findings support the seminal work on competitive advantage (Porter, 1985) which suggests broadly that firms must compete either on a basis of product differentiation or by being the lowest cost supplier, and that firms must align their internal efforts to these strategic orientations. A more detailed discussion of these findings is contained later in the thesis in the section describing the impact of organisational factors on innovation.

In summary, the confluence of a number of factors has resulted in an increased recognition for the need for innovation within broad sectors of our society. This recognition has led to significant efforts by academics to explore how innovation happens within an extensive cross-section of mostly large organisations. Attempts to classify and define innovation have made up a significant portion of this work.

## ***1.2 Definitions of innovation***

A significant number of definitions of innovation have been proposed in the literature. It has been described at various times as a function (Schumpeter, 1939; Drucker, 2002), a product or group of products, an activity or group of activities, and even a state of mind (Zien and Buckler, 1997; Kanter, 2000a;b; Kanter, 2002). Of particular interest are the definitions related to functions and activities, as this research is aiming toward assisting in the understanding of the manageable portions of the process of innovation as opposed to studying the artefacts that are the result of the process. An overall review of innovation definitions reveals that innovation shares a common foundation in that it

invariably consists of the adoption of a change in some product attribute, process or service.

Early efforts to quantify innovation began with the assignment of a variety of typological labels. A meta-analysis of the extant innovation literature (Damanpour, 1991) catalogued innovation types including:

- technical (technically challenging changes),
- administrative (e.g., new business processes/structures),
- radical (e.g., creation of new product/service categories),
- incremental ( e.g., line extensions, market expansions),
- product (for tangible items),
- service (e.g., changes in services provided to customers), and
- process (using new methods of manufacture)

This research added moderating descriptions for each innovation as either being at the initiation (idea generation) stage or implementation stage. Other scholars describe innovation types as either ‘variation’ or ‘reorientation’ (Normann, 1971) and separated ‘routine’ and ‘radical’ innovations (Nord and Tucker, 1987).

These short form definitions have been expanded by other scholars. Incremental innovation is seen as any innovation that uses technology that is not new to the adopting unit or new to the referent organisation (Daft and Becker, 1978), or as innovation involving adaptation, refinement, and enhancement of existing products and services and/or production and delivery systems (Burgelman et al. 2004), or any innovation that only embodies a product change, or just a process change, as innovations defined as radical must require both product and process to be changed (Hage, 1980).

Radical innovations are defined as follows: ‘A radical innovation is a product, process, or service with either unprecedented service performance features or familiar features that offer significant improvement in performance or cost that transform existing markets or create new ones’, and ‘Radical innovation has traditionally been defined as that arena

where technical and market uncertainties are high’ (Leifer et al. 2001, p.102,103). Other definitions suggest that radical innovations all incorporate technology that is a clear, risky departure from existing practice (Duchesneau et al. 1979) (Hage, 1980).

Innovation has been defined by describing what it is not. For example:

Ideation and innovation are not synonyms. The former deals with the generation of ideas; the latter, with their implementation. (Levitt, 2002, p.138)

This definition suggests that ideation and innovation are separate activities rather than related activities within the same process. More properly this construct could be characterized as innovation is a broader process that always includes attempts to implement and sometimes includes ideation.

These attempts at parsing innovation into types wholly ignore the holistic impacts on events, management practices and innovation actors that often occur during innovative activity. Such factors include product modifications that lead to manufacturing improvements, and business process improvements that lead to improved identification of customer needs resulting in product innovations. Recognition of this holistic nature has led to other attempts to define innovation. Innovation has been categorized based on the interplay of new and old technologies, its impacts on inter- and intra-organisational networks and its associated behaviours, and management practices. Separate sections describing the work to define innovation from each of these different perspectives follow.

#### *Industrial and technological innovation definitions*

An early definition of industrial innovation resulted from the case studies of pair comparisons of successful and failed innovations aimed at the same market niches conducted as part of the SAPPHO project and subsequent work. The definitions coined as a result of this work suggested that “industrial innovation includes the technical design, manufacturing, management and commercial activities involved in the marketing of a new (or improved) product or the first commercial use of a new (or improved) process or equipment” and “the creation of an idea and its reduction to practice” (Rothwell et al. 1974), and “industrial innovation involves the commercialization of technical change, and invention is simply one element, albeit an important one, in the overall innovation process” (Rothwell and Zegveld, 1985). These works also seem to suggest that an important characteristic of technological innovation is the requirement for integration of multiple functionalities.



Problems encountered during attempts to measure the amounts of technological innovation or change (Saviotti et al.1982) and to scale the importance of technological innovation (Coombs and Thomlinson, 1998) only served to highlight the holistic integrated nature of technical innovation. Measuring technological change in the restricted context of new multi-characteristic products raised the question as to how to weight particular changes. Should it be by novelty, and if so, is it novelty to the producer's engineers, manufacturers or customers that should define novelty? Alternatively, should technological innovation be defined by the degree of technical challenge, or as it affects designers, or users? Or, should the quantity of technological innovation be defined by the market as customers indicate the value they ascribe to particular technologies when they pay for the additional technological features? When these valid measurement issues are considered in light of attempts to state a definition of technological innovation, it is logical to include a requirement to consider multiple functionalities.

The concept of novelty has been refined to perceived novelty (Tidd et al. 1997) suggesting that no particular innovation can ever be objectively measured for its degree of technological innovation due to the variety of perceptions brought by personnel involved in these multi-functional innovations. In their summation, these authors state their definition of innovation to be “a process of turning opportunity into new ideas and of putting these into widely used practice” (Tidd et al. 1997, p.38)

#### *Disruptive and sustaining innovations*

A novel approach to categorizing and defining innovation was taken by comparing the rate that successful firms are able to add features to their product/service offerings with the rate that the market is able to absorb and will pay for these additional features (Christensen, 1997). Christensen found that many customer-focused firms actively work toward ramping up their ability to deliver more features and benefits (by investing in technical capabilities and capacities) in order to increase their margins by satisfying the firm's more profitable customers. He categorized these innovations as *sustaining*.

Christensen found that sustaining innovations work well as long as their markets are able to absorb and value the new benefits delivered, but not so well when the firms leave the market behind by producing products or services that the market is unable to absorb, or does not value highly enough to pay for the additional features. He also found that when firms begin to recognize the disconnect between what the broader

market values and their firm's offerings, that the firm's personnel, embedded in the cost and organisational structures that had been created to serve the high margin business, resist any moves down-market or into new and different markets created by the introduction of enabling technologies. These attempted moves down-market or into newly created markets, either by the firm or by competitors, he labelled as *disruptive* innovations as they serve to disrupt the status quo for the market leaders and other associated stakeholders. This categorization of sustaining and disruptive is proposed as being useful to help make decisions about the suitability of particular organisational structures as potential innovations present themselves for implementation. Broadly, Christensen states that disruptive innovations can not be successfully implemented by existing organisations primarily because of the barriers erected by the powerful vested interests interested in maintaining the status quo. Christensen's proposed solution for successfully implementing disruptive innovations is to create entirely new purpose-built organisations, or by extensive redesign of the existing organisation.

Other parallel research efforts labelled these innovations as "discontinuous" and "radical and shared many of the same conclusions about management of this type of innovations. For example, these authors also found that previously established vested interests played a significant role in delaying progress for these types of innovation whether they were discontinuous and "required dramatic leaps in terms of customer familiarity and use" (Veryzer Jr., 1998, p.305) or were radical and "traditionally defined as that arena where technical and market uncertainties are high" (Leifer et al. 2001, p.103)

#### *Behaviour-based definitions*

The highly influential work of Schumpeter (Schumpeter, 1939) addressed the nature of innovation from a human skill perspective stating that

the making of an invention and the carrying out of the corresponding innovation are two entirely different things. They often have been performed by the same person; but this is merely a chance coincidence which does not affect the validity of the distinction. Personal aptitudes – primarily intellectual in the case of the inventor, primarily volitional in the case of the businessman who turns the invention into an innovation – and the methods by which the one and the other work, belong to different spheres. (Schumpeter, 1939)

Extension of this entrepreneurial nature of innovation has been described when innovation is defined as a function:

Innovation is the specific function of entrepreneurship, whether in an existing business, a public service institution, or a new venture started by a lone individual in the family kitchen. It is the means by which the entrepreneur either creates new wealth-producing resources or endows existing resources with enhanced potential for creating wealth. (Drucker, 2002, p.95)

If Drucker had the classic definition of wealth in mind, what the wealth creation concept does not hold for is the breadth of innovative activity that occurs in non wealth-producing scenarios (e.g. management of not-for-profit organisations). Also not captured by the suggestion that entrepreneurial activity is a required precursor for innovation are those significant innovative efforts that occur within firms where change is the normally accepted method of doing business (e.g., firms with well established new product development or total quality management routines).

The entrepreneurship/innovation connection is pushed further by proposing that a reliance on frequent and extensive product innovation is a natural outgrowth of an entrepreneurial strategic posture displayed by a firm's propensity to take risks and to act in a competitively aggressive and proactive manner (Covin and Slevin, 1991). This defines innovation as the natural result of a strategic posture without consideration for the processes or structures that underlie innovation.

Leadership behaviour has also been used as another context for defining innovation. Farson and Keyes (Farson and Keyes, 2002) suggest that innovation is the result of leaders that display behaviour that actively tolerates failures and, above all else, values lessons learned from failures. The suggestion is that attempts at innovation for the sake of learning are valuable in and of themselves. This concept makes up part of the school of thought that an effective management strategy is to 'innovate in order to learn to innovate'.

These behaviour-based definitions appear to be closely aligned with the definitions that have arisen as the consequence of innovation process research.

#### *Definitions based on the process of innovation*

Early work looking at the process of managing innovation and the associated barriers and enablers resulted in the following less-than-hopeful definition:

Innovation tends to be individually motivated, opportunistic, customer-responsive, tumultuous, non-linear, and interactive in its development.

Managers can plan overall direction and goals, but surprises are likely to abound. (Quinn, 1986, p.20).

Related findings from research into repetitive innovation practices in a telecommunication firm found that “new product development is an inherently orderly and disorderly process” (Olin and Shani, 2003, p.2). In a discussion of theoretical perspectives on innovation research Slappendel (1996) argues that research frameworks have migrated towards innovation process research based on innovation being defined as the

process through which new ideas, objects and practices are created, developed, or reinvented. In its broadest conceptualization, the innovation process typically embraces periods of design and development, adoption, implementation, and diffusion. (Slappendel, 1996, p.108)

In a long-term comprehensive innovation process study, the Minnesota Innovation Research Programme was conducted throughout the 1980's and 1990's (Van de Ven et al. 1999; 2000). Within this study, thirty-four academic researchers conducted long-term longitudinal research into 14 widely varied innovations (i.e. technological, administration, process and product innovations) in multiple operating contexts including private, not-for profit and public sectors. In setting out their criteria for innovation process studies they focused on defining innovation as a process “that 1) consists of a purposeful, concentrated effort to develop and implement a novel idea; 2) is of substantial technical, organisational, and market uncertainty; (3) entails a collective effort of considerable duration; and (4) requires greater resources than are held by the people undertaking the effort”. Part of their findings included an observation that (Van de Ven et al. 1999, p.22) “This journey typically includes entrepreneurs who, with support and funding of upper managers or investors, undertake a sequence of events that creates and transforms a new idea into an implemented reality” (Van de Ven et al. 1999, p.3), and that “the underlying structure can be represented by the metaphor of an 'innovation journey', which has key phases of initiation, development and implementation/termination” (Van de Ven et al. 1999, p.41). These authors synthesized their findings by stating that “The map of the innovation journey crosses a rugged landscape that is highly ambiguous and often uncontrollable and unique to its travelers.” (Van de Ven et al. 1999, p.21)

Focused case study research among the managers of a telecommunications firm led to the observation of how managers defined innovation:

‘Innovation is far more than simply technical innovation. It covers all aspects of the business. Actually there's a risk that by stressing the technical stuff we downplay the other sorts of innovation. Innovation is about seeing new ways of doing things, including new ways of working with clients, new ways of putting together packages of existing technologies, and new ways of working with partners to develop common areas of interest’. (Salaman and Storey, 2002, p.154)

The bulk of the foregoing innovation definitions have been developed as the consequence of research performed in large firm contexts. In the interest of serving the smaller firm research interests of this thesis, the following definitions of innovation developed within the SME context are reviewed:

#### *Work on defining innovation inside SMEs*

Surprisingly little original work has been undertaken to define innovation in the operating context of SMEs. Work by a number of authors in the SME context (Motwani et al. 1999; Brown et al. 2000; McAdam et al. 2004) utilizes definitions developed within large organisation contexts and makes the questionable assumption that these definitions can be correctly transferred to the SME context.

A few attempts have been made to create operational definitions for innovation that is specific to the SME sector. For example, over the period of 1991-1996 innovativeness in rural English SMEs ruled out location as an important contributing factor (North and Smallbone, 2000). The operational definition of innovativeness was based on four principles:(1) the degree that firms made changes to support their competitiveness, 2) all types of innovation were seen to be of equal importance, (3) measurement of innovativeness requires an assessment of different degrees of innovation, and (4) innovativeness should be assessed against the role of innovation in competing in the sector in question.

Studies of Canadian SMEs suggest that “An innovation was defined as the introduction of a new or improved product or process, but did not include the introduction of aesthetic changes that fail to affect the technical construction or performance of the product” (Baldwin and Gellatly, 2003, p.76), and

“The term innovation process refers to the key features of – inputs to and outputs from – an innovation strategy. It is comprised of several elements: the set of objectives that new products, processes or business routines are designed to address, along with the array of sources, both external and internal, that contribute to their development. Other elements include the

benefits that innovation brings to the firm, along with factors that hamper innovation activities. (Baldwin and Gellatly, 2003, p.217)

Note that the innovation definition has a requirement for novelty but excludes what are commonly known as incremental innovations.

In a study of innovation and skill patterns among northern British SMEs, innovation was defined as an

“innovation production function [...] thought to take the general form of

$$I_i = \beta_1 R_i + \beta_2 T_i + \beta_3 X_i + \varepsilon_i$$

where  $I$  is some innovation output measure (e.g. patents or new product introductions),  $R$  is a direct measure of firm R&D expenditure and  $T$  and  $X$  are vectors of internally and externally sourced technological competence, respectively. (Freel, 2005, p.23)

Not surprisingly, this skills and training based research focused exclusively on the importance of technical skills without evaluation of the importance of other requisite business skills.

Finally, case study research among small British firms suggested an anecdotal innovation definition represented by the following statement:

“Indeed, among managers in all sectors in our research, we found that stories of ‘new business’ as well as ‘new product development’ were usually considered synonymous with innovation. Invariably, the rationale given for this was that the new business or the new customer-focused strategy had taken the firm either into new areas of business, or into a new stage of existence; that is, it was seen as a transformative event.” (Barnett and Storey, 2000p.321)

While the advantages of case study research permitted their respondents to consider multiple perspectives as important to innovation when they tried to define it, the biased sample selected from a sampling frame of firms that deal with a particular government programme leaves open to question the ability to generalize this definition for all SMEs.

#### *Discussion of previous attempts to define innovation*

Previous work on defining innovation, primarily in larger organisation contexts, has been extensive. Upon reviewing this work, lists of characteristics of the definition continually recur:

- Innovation can be an improved archetype, process or service improvement (Atherton and Hannon, 2000; Bonner et al. 2002 Brown, 2000; Salaman and Storey, 2002; Baldwin and Gellatly, 2003)
- Innovation can be a type of entrepreneurial behaviour (Miller and Blais, 1990; Burgelman et al. 2004)
- For technical innovations, multiple functions (i.e. marketing, manufacturing) must be involved (Chiesa et al. 1996; (Burgelman et al. 2004)
- Innovations can engender varying levels of disruption to the status quo with at least a perception of novelty being required before something is innovative (Slappendel, 1996; Tidd et al. 1997; Leifer et al. 2001; Levitt, 2002)
- Innovations involve a process which always requires an attempt to implement and sometimes starts with invention (Tidd et al. 1997)
- Innovations are traveller-specific journeys with many starts, stops and frequent changes in personnel and direction, and management cannot assure a successful journey, just increase the chances of success. (Van de Ven et al. 1999)

The lack of a well-accepted definition of innovation has been identified as a significant management problem (Storey, 2000). It leads to tension between managers concerning many dimensions of innovation as they express fundamental disagreements about innovation's meaning, priority, the types required, how it should be achieved, and the expected consequences. This is quite an important gap of knowledge as it seems logical that problems created by lack of definition encountered in larger organisations is transferable to the smaller firm context.

Academics working in the field of new product development research see this as a problem also. Considerable empirical work that was repeatedly exploratory in nature was reported to be "surprisingly nonconvergent" (Montoya-Weiss and Calantone, 1994, p.397). Other product development researchers also see the innovation literature as "varied and vibrant, yet large and fragmented [...] yet because it has not been tied together to create cogent understanding it is difficult to grasp what is actually known" (Brown and Eisenhardt, 1995, p.343).

Each of these definitions attempts to parse innovation into separate categories with a supposed eventual purpose of measuring each type, assessing how well firms are performing with respect to benchmarks for each innovation type, and what they should

do as a consequence. Any acceptance of this advice presupposes that there is a considerable degree of acceptance and agreement between users (e.g. government, academics, and practitioners) with respect to these divisions of innovation. But this acceptance does not exist. For example, a study commissioned by the U.S.-based Product Development and Management Association looked at a relatively narrow scope of firms that saw themselves as competing primarily through product innovation. They found as many as seventy-five different metrics of innovation that have been used either by academics or practitioners (Griffin and Page, 1993). Another example of this lack of agreement between users occurs when you consider that categorization of particular innovations as disruptive or sustaining depends upon who is doing the categorizing. Innovations that are disruptive to existing organisations could very well be sustaining for an upstart competitor. Likewise, innovations that are seen as disruptive by some parts of an organisation may be seen as sustaining for another part of the organisation (e.g. the disputes within IBM between the team selling groups and the retail sales group as they moved away from direct sales to small business customers (Brewer, 1998). In a similar way, an innovation could be characterized as radical for one part of an organisation but for another organisation, or even another part of the same organisation, the same innovation would be considered incremental (e.g. capabilities within multi-location companies can vary greatly creating different starting points for innovations). One of the consequences of these fundamental measurement problems is that no well-accepted benchmarks for narrow categories of innovations are ever likely to be created, and no broadly applicable prescriptions for management based on these typologies are likely.

This is not to say that the previous work on defining innovation has been fruitless. For the previously stated reasons, it is not likely to be of use for stakeholders interested in generalizations about innovation (i.e. government policymakers and academics). However, in those specific circumstances where innovations clearly fall into one or another category, and there is agreement on the category within the business unit responsible for the management of the innovation, the work is likely to be useful. One example of potentially useful work would be Christensen's research (Christensen, 1997) which has resulted in specific recommendations to implement disruptive innovations. Another example is the practices developed within 3M to work with lead users to enhance the size of the breakthrough portion of their innovation portfolio (Von Hippel et al. 1999). These practices provide at least part of an effective method for those firms



that make the proactive choice to chase more breakthrough or disruptive innovations. A third example is the delineation between product and process innovations as it provides information on the management of the role of the customer in the innovation process (Abernathy and Utterback, 1978). Innovations identified as process innovations are more internally-focused and should be managed accordingly. Product innovations have customer acceptance as an immediate goal resulting in a greater need for customer involvement.

Even though there seem to be some useful management prescriptions resulting from the foregoing definitional work inside larger organisations, there is a paucity of research on these topics inside smaller firms. This research begins to address these gaps in the SME literature by asking managers within this context what innovation means to them.

### **1.3 Innovation metrics**

An objective review of the foregoing section should lead the reader to the conclusion that there is significant disagreement about the definition of innovation among and between academics and practitioners. This does not appear to have dissuaded a number of researchers from attempting to develop metrics (for a listing of metrics developed in the literature, see Table 1.1) and auditing tools to provide benchmarks in a variety of contexts.

For example, industry-specific benchmarks have developed that seem to be driven by, among other things, product life cycle and government regulation considerations. An illustration of this occurs when video game suppliers find themselves facing complete product life cycles that are expressed in months with a need for a corresponding new product development time, whereas prescription drug developers approach new drug development knowing that the clinical trials and associated regulatory hurdles will likely take most of a decade to complete. Clearly what might pass as exceptional performance for the latter would be disastrous performance for the former. This inability to use benchmarks and metrics across industries does not seem to have discouraged researchers interested in measuring innovation.

Included in the attempts to measure innovation are the enumeration of innovation inputs, innovation outputs and impacts of innovation activity. In addition, specific

Table 1.1 Innovation metrics – A review of the literature

|  | <b>Innovation Metrics</b>                           | <b>Selected References</b>  |
|--|---|---|
| <b>Measures of financial performance</b> | % of sales from products introduced within x years  | (Griffin and Page, 1993; Griffin and Page, 1996; Bartlett and Mohammed, 1995; Amabile and Whitney, 1997; Thomke and Nimgade, 1998)  |
|  | % of profit from products introduced within x years | (Griffin and Page, 1993; Griffin and Page, 1996; Bartlett and Mohammed, 1995; Amabile and Whitney, 1997; Thomke and Nimgade, 1998)  |
|  | Market share gained                                 | (Griffin and Page, 1993; Chiesa et al. 1996; Griffin and Page, 1996)  |
| <b>Product-level measures</b>            | Time to market                                      | (Griffin and Page, 1993; Chiesa et al. 1996; Griffin and Page, 1996)  |
|  | Conception time                                     | (Chiesa et al. 1996)  |
|  | Design time   | (Chiesa et al. 1996)  |
|  | Prototyping time                                    | (Chiesa et al. 1996)  |
|  | Market launch time                                  | (Chiesa et al. 1996)  |
|  | Customer acceptance                                 | (Griffin and Page, 1993; 1996)  |
|  | Amount of technological change                      | (Saviotti et al. 1982)  |
|  | Targets shift during innovation process             | (Utterback, 1996; Van de Ven et al. 1999)   |
| <b>Programme-level measures</b>          | R&D Expenditures                                    | (Taylor, 1973; Cockburn and Griliches, 1988)  |
|  | Patents granted                                     | (Taylor, 1973; von Hippel, 1998; Cockburn and Griliches, 1988; Acs and Varga, 2005; Deyle and Grupp, 2005)  |
|  | New product announcements                           | (Kleinknecht, 1991)   |
|  | Response to customer time                           | (Chiesa et al. 1996; Griffin, 1997)   |
|  | Learning about innovation process                   | (Chiesa et al. 1996)  |
|  | Implemented ideas/person/time                       | (Kanter, 1999)  |
|  | Metrics differ for different market types           | (Baldwin and Gellatly, 2003)  |
|  |   | Product family performance  |
|  | Absorptive capacity                                 | (Cohen and Levinthal, 1990; Dogdson and Rothwell, 1991)   |
|  | Portfolio measures                                  | (Quinn, 1986; Tidd et al. 1997; Zahra and Nash, 1995; Chiesa et al. 1996; Brown and Eisenhardt, 1997; Griffin, 1997; Tidd et al. 1997; Thomke and Nimgade, 1998; Pearson, 2002) |
|  | Innovation supportive culture                       | (Chandler et al. 2000)  |

metrics have been proposed for specific aspects of the innovation process. This has been complicated by the finding that metrics seem to mutate as expectations change during the innovation process (Van de Ven et al. 1999).

Some scholars have attempted to quantify innovation by focusing on measurement of R&D inputs as a proxy for innovative activity (Cockburn and Griliches, 1988). An effective discrediting of utilizing R&D expenditures to quantify innovation outputs is described in later works (Coombs et al. 1996). More specifically, these critical authors identified that R&D expenditures are not seen to capture the measurement impacts of variable R&D efficiencies and variations in the value and/or technological complexity of any innovations produced resulting in questionable correlation between R&D expenditures and innovation outputs.

Other authors have attempted to quantify innovation by evaluating outputs through the enumeration of patents (Deyle and Grupp, 2005; Acs and Varga, 2005) and new product announcements made by editors within trade magazines (Kleinknecht, 1991; Acs et al. 1994; Coombs et al. 1996). Unfortunately, these enumerations of publications of the completion of an innovation miss a substantial percentage of process innovations simply because these innovations remain in-house. This is a material shortcoming of this method as process innovation has been shown to have the potential to be an extremely important portion of the overall innovation picture (Hollander, 1965).

The ease of duplication also plays a role in deciding what metrics are most appropriate to use for particular industries. Von Hippel, (1998) found that the value of patent protection varies with industry with efficacy being high for chemically-based industries and low for mechanically-based industries. More specifically, within 80% of mechanical engineering-based firms the granting of patents were found to have negligible or very little influence on R&D expenditures (Taylor, 1973 cited in von Hippel, 1998, p.47). This indicates that managers of these firms have learned that patents have little value and as a consequence there is likely to be little correlation between registered patents and innovation. As a consequence, for the mechanically-based industries which are the subject of this thesis, enumeration of patents is likely to underreport the innovation outputs of these firms.

Other approaches have been developed in an attempt to measure innovation performance with the typology of the innovation (for example, product or process, radical or incremental) playing a role in deciding what metrics are most appropriate. For example, product innovation performance metrics logically focus more on measures external to the firm (e.g. customer acceptance), whereas process innovation metrics are primarily internal (e.g. effects on variable costs).

Utterback (1994) determined that manufacturers of assembled products competed more often on the basis of product differentiation resulting in their innovation efforts being primarily focused on product innovation. As a consequence, the most useful sector to look for metrics for this research on mechanically-based product producing firms lies within the new product development literature. One organisation that has done significant research into the task of new product development is the Product Development and Management Association (PDMA).

In the early 1990s, the PDMA commissioned an extensive survey of the work of more than thirty authors who attempted to measure success and failure for firms involved in new product development (Griffin and Page, 1993; 1996). A group of new product development experts (primarily made up of new product development academics) then reduced these measures into five general categories of success/failure measures. This group's selection of categories was then compared to practitioner responses using correlation and factor analyses to check for independence of measurement between categories. This process resulted in five statistically independent categories of success/failure metrics:

- measures of firm benefits,
- programme-level measures,
- product-level measures,
- measures of financial performance, and
- measures of customer acceptance.

The use of these categories by academics and practitioners was then compared and it was found that there was use by both groups except for the programme-level measures which were found to be only used by academics.

This research (Griffin and Page, 1996) was developed to serve the needs of the PDMA membership and it reflected input from the membership. While firms of similar context

to the planned research context are represented within the membership, they are just one of a group of industry contexts that includes firms of all sizes ranging from capital goods, to high-technology and software, to packaged goods, and to service-providers of all kinds. The applicability of these results to the research question may prove to be germane, but it is uncertain until members of the research context are asked how they measure innovation success.

A similar product-innovation-focused sample of larger companies (median sales of \$US583MM) was the subject of the benchmarking study (Cooper and Kleinschmidt, 1995) that focused on innovation practices behind new product development (NPD). This study's ontological position was based on the authors' conviction that NPD is best served by use of a highly prescribed stage-gate process. Many of the benchmarks assessed the respondent's practices as compared to the 'ideal' stage-gate process. Their findings indicated a relatively high number of adherents to the stage-gate process among the sample group to a sufficient extent that this process should not be ignored when companies similar to the sample group are considering product innovation. What this benchmarking study and the resulting score carding process do not address however, is how the needs of SMEs can fit within the highly proscribed nature and the resulting required investment of time in the stage-gate process.

Case study research focused on companies well known for consumer product innovation such as 3M (Bartlett and Mohammed, 1995; Zien and Buckler, 1997; Thomke and Nimgade, 1998) and Rubbermaid (Amabile and Whitney, 1997) revealed extensive use of innovation metrics in their management systems with a particular focus on achieving a target percentage of commercial results from products previously introduced over a period of typically three to five years.

A meta analysis of the new product performance metrics literature stemming from the disciplines of engineering, operations, management, marketing, and organisational behaviour reported considerable empirical research that was repeatedly exploratory in nature and "surprisingly nonconvergent" (Montoya-Weiss and Calantone, 1994, p.397). They found that the reported metrics of innovation were focused around issues of strategy, development process, and organisational performance and/or market environment factors as drivers of new product performance. Dependent variable analysis was found to focus primarily on commercial new product success measures

with a few studies also focusing on achievement of technical objectives. Independent variables reported to be measured fell into the aforementioned issues of strategy. These authors speculated that the nonconvergence and continuing exploratory nature of the research “in this area was likely due to a lack of an organized synthesis of past research”.

Broadening the survey of innovation metrics literature beyond new product performance reveals a considerable body of literature stemming from a variety of perspectives. Metrics suggested include an index of technological change for complex products, (Saviotti et al. 1982), a scale of innovation importance (Coombs and Thomlinson, 1998), evaluation of learning from previous new product development performance, (Griffin, 1997; Kerssens-van Drongelen and Weerd-Nederhof, 1999) and measuring development of absorptive capacity through investments in personnel to facilitate assimilation, improvement and exploitation of existing information (Cohen and Levinthal, 1990; Dogdson and Rothwell, 1991). Process metrics are suggested for the “holistic front end” of new product development, (Khurana and Rosenthal, 1998, p.63) whereas other authors suggest that the appropriate process metrics for mature markets differ from those appropriate for high growth markets (Baldwin and Gellatly, 2003) and that the metrics used shift during the innovation process (Van de Ven et al. 1999). Reviews of normative product development strategies suggest measuring the balance of incremental and radical new product introductions to facilitate the use of a portfolio approach to new product planning (Quinn, 1986; Zahra and Nash, 1995; Chiesa et al. 1996; Griffin, 1997; Brown and Eisenhardt, 1997; Tidd et al. 1997; Thomke and Nimgade, 1998; Pearson, 2002) and a product family approach to assessing innovation success (Maidique and Zirger, 1985).

Most of these efforts at defining metrics have taken place in the context of larger organisations than those with which this research is concerned. In addition, there is some sentiment within the academic community questioning whether the efforts to improve NPD performance are paying off in improved management practices (Cooper, 1988; Stagg et al. 1996). Given that the findings of the NPD literature are of questionable value for SMEs, a review of the entrepreneurial literature seems logical to search out useful innovation metrics. Unfortunately, this work (Chandler and Hanks, 1993) found that entrepreneurs do not identify explicit innovation measures as playing *any* role in their success metrics. These entrepreneurs were found to be primarily

interested in measuring business volume and growth. In a later study, (Chandler et al. 2000) tested whether the presence of a 'innovation-supportive culture' (used as a proxy for innovativeness) affected firm performance (in a context of a survey of 23 manufacturing companies) and found that only in circumstances of a highly dynamic environment did an innovation supportive culture seem to enjoy a positive relationship with firm earnings. This finding is disturbing to advocates of the 'innovate or die' mantra and raises questions as to whether creating an internal culture of innovativeness is effective financially, or whether there is differing appropriate levels of innovation supportive culture for differing environments.

Another specific assessment of innovation metrics that directly relates to SMEs was included in the work which attempted to quantify innovativeness within rural SMEs to evaluate the impact of location (i.e. accessible vs. remote) on innovativeness (North and Smallbone, 2000). Individual managers' opinions were sought as to the number of innovative product innovations, market developments, new marketing methods, process innovations and changes in administration methods their firm had been involved with in the previous five years. A validation of the firm's innovativeness by external sectoral representatives was also used to classify firms into categories of relative innovativeness. The results of this study indicated that location does not seem to affect levels of innovativeness. This attempt to quantify innovation for government purposes directly applies to SMEs but no evidence was found that these measures were used internally by management of the SMEs in question.

The previous work describing the metrics of innovation adds to the work on the definition of innovation in aiding our understanding of product innovation practices within predominantly larger organisations. Unfortunately, the literature does not adequately address if and how innovation is measured within SMEs, and if so, which metrics are found to be effective in aiding the management of the process of innovation. Part of the purpose of this research is to ask the question about which innovation related metrics are in use for the sampled context and if none are used, why not?

A number of different approaches or schools of thought seem to be assembling from the previous research efforts.

## **1.4 Current innovation debates**

The alternate schools of thought that seem to be developing in the form of advice for managers on how best to manage innovation are briefly described within this introductory chapter so that the reader can begin to appreciate the underlying concepts of the current debate within academic literature. A more extensive review of the literature supporting the various sides of the debate about how to achieve innovation is contained within Chapters 2. The current principal schools of thought include the following:

### *Innovate in order to learn to innovate*

This school of thought suggests that management should be:

- a) focused on creating and managing knowledge (Kanter, 2000a) as knowledge is seen to lead to innovation (Nonaka and Takeuchi, 1996); and
- b) acquiring knowledge, either by utilizing repeated quick, cheap prototyping and test marketing to learn iteratively (Schaffer, 2002), or by utilizing thorough and comprehensive research and design practices to increase the chances of being successful during testing and market launch (Cooper, 1990); and
- c) using proactive knowledge management practices to enhance the value of their knowledge assets. In other words, reinforcing and evolving routines (Nelson and Winter, 2002) that result in organizational capabilities (Dosi et al. 2000) to enable survival of the firm in a changing environment.

Core competency-based management (exploiting and enhancing current competencies and consciously developing new competencies) is a form of the type of management advocated in this school of thought (Daneels, 2002).

### *New economy model*

Managers of market leaders are advised to be alert to the possibility of breakthrough innovations arising that may disrupt their market leadership position. One group of



researchers (Coombs et al. 1996; O'Connor and Rice, 2001) suggests that these innovations can only be embraced by new organisations in order to bypass the vested interests aligned with established structures, methods and personnel within existing organisations, whereas another group of researchers (Veryzer Jr., 1998; Leifer et al. 2001) have suggested that these innovations can be embraced within the current organisation by utilizing novel organisational structures (e.g. working with lead users, skunk works, internal venture and capital arrangements).

#### *Intrapreneurship can solve everything*

Intrapreneurship is a method of fostering entrepreneurial spirit in large organizations by tapping into a passionate drive by individuals and small groups of personnel to make things happen. “Zealous volunteer champions” are seen as requisite elements for new product introductions to be successful (Pinchot, 1985, p.7). Within this school of thought (Van de Ven et al. 2000; Cooper and Kleinschmidt, 1995; Leifer et al. 2001), supra-normal project champions are seen as the forces required to overcome the barriers to innovation inherent in all organisations. Acquiescing to their arguments for resources and providing tacit permission to break organisational ‘rules’ are seen as key levers within this school of thought (Howell et al. 2005).

#### *Organic, or disciplined, or organic then disciplined*

There are three contradictory sets of recommended management practices embedded in this school of thought centred around finding the right level of control inside organisations to support innovation in the most effective way.

The ‘organic’ model suggests that everyone inside the organisation should be continuously thinking ‘outside the box’. In order to support these creative moments, organisational structures should be organic, egalitarian and environmental scanning should be wide ranging (Kanter, 2002; Covin and Slevin, 1991; Kidder, 1981). The expected result of this approach is that more ideas with greater degrees of novelty will be created. This larger quantity of ideas then can be fed into a new product development funnel (which is fuzzily defined so that new ideas that arise during development are not stopped) and because of the larger quantity of inputs, more ideas should survive and reach market launch.

The ‘disciplined’ model takes a contradictory approach. Within this approach, the firm is recommended to adopt a hierarchical organisational structure, performing narrowly focused environmental scanning that allows the firm to cut off efforts to develop any

new ideas that do not fit their organisation (Pearson, 2002) and to help it to ‘stick to its knitting’. Once an idea survives this level of review, because the organisation has expertise with all the ideas that have survived the improvement in the new product development ratio should result in a larger ratio of products that reach market launch. In addition, the new product development process is highly proscribed, often using project management methods and/or a number of stages and approval gates (Cooper and Kleinschmidt, 1995). The new product development teams are recommended to be cross-functional to reduce functional myopia during development.

The third control option offered suggests that ‘organic’ methods should be used during idea generation followed by ‘disciplined’ management practices during new product development. The term “planned flexibility” has been coined to describe this approach (Verganti, 1999, p.370). The acknowledged difficulty with this approach is determining when managers should switch from one mode to the other and the inherent difficulty of making the comprehensive cultural change required to effectively switch modes.

With the exception of the contradictory organic and discipline suggestions, the advice offered by each school of thought could be complementary to the advice offered by the other schools of thought. What is not clear is whether a particular school, or combination of schools, is more effective as a generic method for increasing an organisation’s innovativeness. This research does not attempt to inform the debate about generic methods, but does present findings from MechSMEs which are a particularly rich source of information about organisational innovation practices that work. The rationale for choosing this sector is described in the next section.

### ***1.5 Rationale for study of selected context***

The principal reason for selecting this sector to research is that there is a gap in the literature that seems illogical given the economic importance of the sector. Other authors have recognized this gap and that SMEs present unique characteristics for the challenge of innovation and have called for additional research among traditional SMEs (Hoffman et al. 1998; Tidd et al. 1997; Edwards et al. 2005).

For example, the number of possible interactions between employees is reduced for smaller firms. Smaller firms are also less likely to be far-flung enterprises so that geographic barriers to communication are expected to be reduced. Both of these factors

suggest that formalized knowledge transfer processes are used less frequently and informal knowledge transfer processes are used more frequently.

Less specialization is expected to be available within smaller firms and a greater proportion of managers are expected to perform a greater variety of functions. This reduced level of sophistication in specialist knowledge will likely lead to more offers and requests for help which supports the use of more cross-functional teams. Similarly, lack of specialist innovation accounting expertise is likely to lead to a lack of measurement of innovation activities. This is expected to reduce the use of innovation-related incentives and measurement and forecasting of innovation results. This lack of specialist expertise also is likely to extend to a lack of training and development and other forms of support for project champions.

Another factor that is likely to materially affect innovation practices is the higher involvement levels of the senior managers and owners with both customers and manufacturing. For project champions seeking permission to proceed, more informed and more accessible decision-making authority is likely to result in quicker decision processes. These decisions are more likely to be based on the experience set and biases of the senior manager/owner with much less rigorous and formal analyses required before a decision is rendered.

These factors justify the separation of SMEs from other sectors and suggest why the size of the firm has an important influence on innovations.

Performing innovation research inside SMEs offers a number of advantages:

- SMEs are 'lead users' of innovation processes. For example, eighty percent of Canadian SMEs fail in their first decade and innovators have been found to be better at surviving (Baldwin and Gellatly, 2003). Managers of surviving SMEs recognize the innovation imperative and as a consequence they have invested thought into how it should be best accomplished. From a methodological perspective, the managers are informed respondents.
- By virtue of their size, they find themselves continually sifting between the entrepreneurial characteristics that worked for them at earlier stages and the corporate practices to which they have been exposed as a result of their growth.

- Most SMEs are not pushed or prodded into short term decisions by the pressures of public share ownership and the stock market, so it is a purer reflection of the balance of long term and short term internal management priorities that are being studied.
- By virtue of their size, and often limited history, they have not developed innovation-supportive or innovation-blocking behaviours by large numbers of personnel. As a result, their innovation competencies are under construction, not just existing as the result of previous work. As a consequence, choice-making on how to innovate is not beyond the ‘view’ of the researcher and SMEs are well suited to explore the importance and effectiveness of the different schools of thought without needing to cut through the fog created by previously developed path dependencies.

Focusing on mechanically-based SMEs offers the following additional advantages in terms of researching the management of innovation:

- When compared to new technology-based industries, the capital intensive nature of the extensive installed base of production equipment and complementary skilled labour means that industry-wide change is not easily scalable. Significant capital investments, large numbers of workers requiring retraining and significant geographical diversity all will conspire to make industry-wide change a slow process. As a consequence, the industry has a relatively stable competitive structure, and the context should remain stable over the period of the study resulting in reduced time-based threats to dependability of results.
- Intellectual property protection is broadly ineffective for mechanical products so this group is less affected by jurisdictional effect on intellectual property regulations (Zahra and Nash, 1995; Robinson, 2001).
- Mechanically-based firms compete primarily through product differentiation (von Hippel, 1998) so identifying and quantifying particular innovations should be less problematic.
- The lack of effective intellectual property protection and need to compete on product differentiation results in a bias toward a need for ongoing product innovation, so that innovation practices examined will likely be quite current.
- Many mechanical components are faced with replacement by electronic components over time. This provides an opportunity to study the internal

organisational effects of a disruptive innovation (Christensen, 1997) in a stable industry.

In summary, the MechSMEs research context should be a rich source of concepts about innovation, some of which will likely be specific to MechSMEs, some to SMEs. Beyond the direct benefits this research should deliver to MechSMEs, other traditional SMEs that exhibit broadly similar characteristics should gain some insights that can then be tested within those sectors. Also, due to the number of external variables that are inherently controlled or reduced within this sector (for example, path dependency effects and short term stock market bias) some concepts may prove useful to add to the generic innovation debate on management practices.

## ***1.6 Thesis outline***

This Chapter began with a brief overview of the research project. This was followed by a description of the broad context of innovation and current debate between schools of thought on how innovation is best managed and a description of the rationale for selecting MechSMEs as the context for the research. This final section provides a brief description of each of the remaining Chapters.

Chapter Two reviews the innovation literature from a variety of perspectives. The issues examined include theories of the firm and other theoretical perspectives, barriers to innovation, externally-sourced innovation enablers and organisational factors such as size, operating strategies, structure and culture. A description of each issue begins from a generic perspective (usually based on large organisations) followed by a description of any research or gaps in the literature that relates to SMEs. The following portions of this Chapter reviews the literature based within the practitioner's context. Change management literature is reviewed due to its linkages with the changes associated with innovations. This is followed with an expanded review of the literature describing the various schools of thought on the most effective management practices which were briefly introduced in this Chapter. Chapter Two concludes with a review of past empirical work documenting innovation processes in a variety of settings.

Chapter Three summarizes the findings of the literature review, specifically listing the gaps in the SME-based literature, and develops the rationale for adding to the

innovation process literature. The research question is developed to respond to the identified gaps and address the need for more information on how innovation happens inside MechSMEs. This is followed by the rationale for and description of the required methodology to address the research question. The Chapter addresses specific issues of the rationale for case studies, sampling options, analytic techniques and the protocol used for the multi-firm case study. Within this Chapter, there is a listing in a graphical format of the concepts selected from the previous phenomenological innovation research to ensure key concepts were included during the semi-structured interviews.

Chapter Four provides a description of the case study firms and characteristics of the specific innovations studied and a listing of the respondents within the firms. Innovation practice related findings from each case study are also listed here.

Cross-case analysis of the individual case findings and the questioning undertaken to confirm/deny the presence of patterns in innovation practices is described in Chapter Five. The major findings of the thesis form the conclusion of this Chapter.

Finally, Chapter Six presents the contributions of the study, its limitations and some possible directions for future research.

## **Chapter 2 Literature Review**

### ***2.1 Introduction***

This Chapter begins by setting the context for the literature review with a discussion of the previous work aimed toward defining innovation and a review of innovation-related work within SMEs. This is followed by topic-focused sections describing research undertaken primarily in larger organisational settings. Each of the topic-focused sections starts with a description of generic innovation concepts and any applicable SME-based work and concludes with an identification of the related gaps of knowledge as it applies to SMEs.

### ***2.2 SME-based innovation research***

This section describes work based in the context of SMEs, which has not been covered in the preceding section regarding definitions of innovation and is not covered in the more specific topic sections that follow. An overview of these articles and the SME-based articles in each specific topic section reveals that the bulk of SME-based work has either been cross-contextual with firm size as the principle sampling basis, or focused on information technology or new technology firms, and/or focusing on the entrepreneurial characteristics of these firms. Other than being part of larger cross-contextual surveys, very little work appears to have been done on craft-based manufacturing SMEs similar to the context of interest for this research. Reviews of some notable exceptions to this overall approach of innovation research (Chandler et al. 2000; Coombs and Thomlinson, 1998; Covin and Slevin, 1989) are contained in this and the remaining topic-focused sections.

Quantitative research addressed towards finding the determinants of innovation has been conducted for SMEs across Canada in multiple industries (Baldwin and Gellatly, 2003), for French SMEs in the manufacturing, construction, communication and transport industries (Motwani et al. 1999), and for manufacturing companies located in the American southwest (Chandler et al. 2000).

The Canadian effort conducted under the auspices of the government body known as Statistics Canada was by far the most comprehensive study reviewed in terms of objectives, sample sizes, and industries studied. Five government-administered projects focused on SMEs took place between 1992 and 1996 and included surveys focused on growth companies, innovation and advanced technology, characteristics of bankrupt firms, operating and financing practices, and generic innovation. Synthesis of the results of these surveys used survival past the ten year anniversary of the firm's inception as a proxy for innovativeness and questioned the managers of these firms as to their perceptions of important management practices and strategies for innovation.

A sub-sample of higher growth firms (defined as an index of business success constructed from data on increasing profitability, productivity, and market share) was also analyzed to search for correlations between growth and innovation strategies. It attempted to find the determinants behind small firm performance (from both product and service-based sectors) with respect to innovation strategies and claimed to have made several findings of importance to this research. In the concluding section of the study, the authors suggested that the extreme variability of the responses they received leads to a conclusion that appropriate innovation strategies are at best industry specific, if not firm-specific. Notwithstanding this rather dire prediction about any attempts to generalize innovation research, they did offer some specific findings. For example, they have suggested that proactive management (e.g., more emphasis on marketing or the creation of a culture to generate ideas internally) leads to innovation, more innovation leads to faster growth and that appropriate innovation strategies (primarily product innovation followed by primarily process innovations) follow product life cycles to some degree. They also found that comprehensive innovators are the most profitable, with primarily process innovators the next most profitable, and primarily product innovators the least profitable of the three groups.

The sample size and response rates achieved by this government body within this research are notable. Unfortunately the cross-contextual samples leads to such general findings (i.e. "high growth entrants develop a sharper strategic stance in several areas: marketing, management, human resources and financing" (Baldwin and Gellatly, 2003, p.352) that they are of limited use to managers in manufacturing SMEs who are seeking more specific advice on management practices for their circumstances.



Research on French SMEs (Motwani et al. 1999) tested frameworks developed within high technology innovation literature in the context of the manufacturing, communication, construction, and transport sectors. Senior managers of these firms were asked for their perception of the importance of certain factors in influencing their satisfaction with innovative actions within their firms. These perceptions were then examined for their relationship to the firm's product and process innovation performance. A general association was found between the identified factors and product innovation with factors of importance found to be (a) sectoral technological innovativeness (primarily importance of high/new technology in sector), (b) internal management systems (efforts to measure and manage innovation performance), and (c) structures for managing innovation (established technology review processes and supports). For process innovations, the important factors included all three product innovation-related factors along with actions for continuous improvement. Unfortunately this small sample of manufacturing firms (the total study reviewed 87 firms in four sectors) raises questions about the ability to generalize the findings. In addition, only executives were questioned from each firm (which may not be representative of perceptions among other managers inside the firm) and only about the importance of factors leading to successful significant innovations. Surveys of a broader cross-section of personnel and questions about the importance of factors that lead to multiple incremental innovations and failed innovations would have provided a more complete picture of factors affecting innovation within these firms.

A complementary study of Utah-based manufacturing SMEs, studied innovation by assessing a broader sampling of employees (average of nearly 19 employees/firm or about 25% of each firm's total employment) and their perceptions of the presence or lack thereof of an innovation supportive culture (Chandler et al. 2000). Management practices which were found to have a positive influence on the perception that an innovation-supportive culture existed (includes a) support by management for innovation, and (b) organisational reward systems that reward innovation. On the other hand, workload pressures and more tightly defined human resource practices were seen to inhibit the perception of the presence of an innovation-supportive culture. The study then went one step further and assessed whether the presence of an innovation-supportive culture necessarily led to either increased profitability or sales growth. Interestingly enough, it was found that only in volatile business conditions does an

innovation-supportive culture positively affect profitability. One without the other was not found to enhance profitability, nor was any significant relationships found where sales growth could be linked to either perception of an innovation-supportive culture or environmental dynamism. This is a surprising finding and seems to suggest that perception of an innovation-supportive culture is not a requirement for innovations that help grow the firm financially. This could be interpreted as (a) just because personnel feel supported in their innovation endeavours, their perception of support is not correlated with their level of financially significant innovation outputs, or (b) for the chosen context, the costs of pursuing innovation through an innovation-supportive culture outweighs the financial benefits which accrue. At the very least, this disagrees with the findings of the cross-contextual Canadian research (Baldwin and Gellatly, 2003) which states that more innovation leads to faster growth. What remains an open question is whether this lack of impact of the presence of an innovation supportive culture is context-specific or is more generally applicable to all contexts not competing in dynamic environments.

Case studies (Barnett and Storey, 2000) of five medium-sized British firms (identified as their region's most innovative SMEs by UK Business Link innovation counsellors) also seem to contradict the findings of Chandler, Keller, and Lyon (2000). These firms had actively worked toward expanding the depth and long term nature of their relationships with customers through a series of creative configurations (e.g. interlocking investments) such that major portions of their revenues accrued through these relationships. Within these successful firms, their strategy focused on forming these long term relationships, organisational evolution through innovation, and skills development of their employees over the long term. In terms of management practices,

by far the most common theme with regard to customer relationships was that of engineers (in R&D, design and production) working together to develop new ideas and products across the customer-supplier divide. The perceived facilitators of this cross-firm inter-working were invariably sales and marketing staff, operating as agents for knowledge transfer. Not only was their role seen as to make the initial customer contact and, subsequently, to keep nourishing the relationship, but above all to facilitate what is effectively project-based working, creating operational ad-hocracies (Barnett and Storey, 2000, p.319)

This core activity for these firms seems to embrace innovation as a requirement to maintain and enhance their long term links with their major revenue source.

In a follow-up article that more intensely studied Tensator, one of the case study firms (Barnett and Storey, 2001), the findings suggested that this firm's extensive history of innovation has resulted in a connection between innovative performance and their investments in management training and development of their personnel conducted over the longer term. The embedded history of survival through product innovation and practice of loyalty-based human resource policies has led to high levels of trust and the generation of ideas internally. One of the differences from their earlier study (Barnett and Storey, 2000) that they found within this firm was the high level of agreement among managers and shop floor employees on the meaning and importance of product innovation to their history.

At the opposite end of the methodological spectrum, a broad survey of 3800 respondents from 88 SMEs located in the American Midwest was conducted in order to enumerate innovative activities (Sebora et al. 1994). This study was undertaken to try to characterize differences in the quantity of innovative activities between firms serving industrial markets and consumer markets, between goods-producing and service-providing firms and between levels of personnel within the firms. The findings of this study suggested that the amount of innovative activity is directly affected by the operating context and by the employee's level within the firm. Their findings suggested that service-providers report less innovative activity than goods producers, industrial and consumer market types report similar levels of innovative activity with firms serving industrial markets converting a slightly increased percentage of ideas into implemented ideas. Personnel at the strategic level reported innovative activity at twice the levels of administrative personnel, which was twice the level of personnel at the operative level.

Other SME-based studies have focused on the interplay of chosen strategies and the innovation approach adopted. In a study based on a sample of 161 small- to medium-sized manufacturing firms in 25 different industries (average employment 73), approximately 20% of the variance in firm performance was found to be influenced by the choice of the correct strategic approaches to fit the firm's operating environment (Covin and Slevin, 1989). Effective strategic approaches for "hostile" environments were defined as "an organic structure, entrepreneurial strategic posture and a competitive profile characterized by a long term, goal oriented approach to management, high product/service prices and a concern for industry trends" (Covin and

Slevin, 1989, p.83). On the other hand, for “benign” environments the most effective strategic approach was found to “include a more mechanistic structure, a more conservative strategic posture, and a competitive profile characterized by conservative, risk-adverse financial management, an emphasis on immediate profitability and the development of existing products and services and a strong dependence if necessary on individual customers for the firm’s sales revenues” (Covin and Slevin, 1989, p.83) From an innovation perspective, the same study suggests that benign environments are most profitably served by firms focusing on incremental innovation, whereas hostile environments are more profitably exploited by development of novel products and services.

Other strategy-focused research within SMEs found that utilizing a strategy of ‘innovation is a priority’ is seen as a viable option for SMEs to compete with larger firms (Acs and Audretsch, 1990a; Dogdson and Rothwell, 1991) with the later article taking it a step further for high tech firms. These authors suggest that SMEs can compete in technology markets by utilizing a strategy of exploiting advantages of flexibility, speed of response (including reduced time-to-market for new developments) and external sources of knowledge to leverage their internal technical competencies to produce innovations.

This introductory literature review section begins to reveal the depth of the uncertainties surrounding innovation within SMEs. Questions are even raised as to whether creating a culture supporting innovation leads to improved firm performance for certain operating contexts. This seems to fly in the face of the ‘innovate or die’ mantra that pervades the remaining body of innovation literature and the popular business media. If innovation is accepted as a positive activity for SMEs then how it is best accomplished is also surrounded by uncertainty. Management methods seemingly at cross-purposes have both been found to support innovation (e.g., management should increase emphasis on internal idea generation (Baldwin and Gellatly, 2003; Barnett and Storey, 2001) as opposed to advice that management should increase their linkage with external sources of knowledge (Dogdson and Rothwell, 1991). In addition to this and other seeming contradictions and the repeated statements that innovation is context-specific (Covin and Slevin, 1989; Sebor et al. 1994) if not firm-specific (Barnett and Storey, 2001; Baldwin and Gellatly, 2003) it becomes important to assess innovation in specific

contextual situations and address the conflicting advice being provided to managers of SMEs.

## **2.3 Theoretical perspectives**

The significant variety of constructs used to define and measure innovation reflects the diversity of approaches to the study of innovation. This same richness is also reflected in the study of innovation from multiple theoretical perspectives including the theoretical work based on the theory of the firm and innovation as a process.

### *Theories of the firm*

The theory of the firm paradigms utilized most often throughout the innovation literature are the resource-based view (RBV), learning organisation (LO), and institutional theory (IT). More recently, these approaches have been joined in the innovation literature by work based on the actor network theory (Verganti, 1999) as a subset of process theory.

The RBV of the firm suggests that any firm's ability to construct a competitive advantage is principally a function of the resources that the firm can apply to delivering an advantage important to its customers. Sustainability of the competitive advantage is enhanced if these resources are difficult for competitors to copy or acquire. Hence, RBV contends that those internal resources of the firm that are valuable, rare, imperfectly imitable and non-substitutable are important components of the firm's ability to construct and sustain a competitive advantage (Peteraf, 1993; Barney, 1991; Castanias and Helfat, 1991; Wernerfelt, 1984; Conner, 1991). Critics of RBV (Fahy, 2000; Priem, 2001) cite the weaknesses in this theory as being the internal approach to resource valuation (they argue that the external market sets these values), and more importantly from an innovation management perspective, the lack of valuation of the firm's ability to develop new resources (e.g. ability to develop new products) as a key issue.

The LO paradigm asserts that learning is critical to innovation and its study is concerned with organisational learning processes (Barringer and Harrison, 2000) and absorptive capacity (Cohen and Levinthal, 1990) that lead to knowledge-based resources, which can be used to create innovation (Hauschild et al. 2001). These

knowledge resources are also referred to as competencies that either require exploration to acquire or as existing competencies ripe for exploitation (Chesbrough and Teece, 2002; Daneels, 2002; Galende and de la Fuente, 2003). In the context of innovation management, the resource development criticisms of the resource-based view appear to be addressed in the LO paradigm. Consequently, it is not a great surprise that innovation-related articles commonly link these two theoretical paradigms.

One example of this linkage details Xerox's recent efforts to build its knowledge management practices (Hickins, 1999). Xerox's recent development work is rooted in its beliefs that knowledge management practices (KMPs) form significant resources that are critical to their firm's ability to innovate and compete. Another example is the description of IDEO, a California-based knowledge brokerage firm that describes its business as helping firms innovate. This firm has been called an innovation factory with its strength (or key resources) being defined as the processes it has put into place to manage knowledge (Hargadon and Sutton, 2000). The KMPs highlighted include the capturing of good ideas, keeping ideas alive, imagining new uses for old ideas and testing ideas quickly. Throughout the article, knowledge is referred to interchangeably as a resource and a process.

Other examples where the RBV and LO paradigms are linked within the context of innovation include: 1) a description of technology transfer between the Japanese and British Steel Industry (Collinson, 1999), 2) a discussion of the value of building intellectual clusters as resources (Quinn, 1992), (3) an outline of the knowledge management practices as resources at Viant, a management consulting company (Stewart, 2000b-), (4) a description of knowledge-path dependency and the resulting resources and restrictions (Coombs and Hull, 1998), (5) a discussion of the importance of developing core competences as a resource as a method for providing direction for the management of multi-product firms (Prahalad and Hamel, 1990) and finally, (6) a testing of the tradeoffs between the process of knowledge sharing and power in innovation teams, wherein knowledge is seen as a resource and source of power for the firm, groups within the firm, and individuals within the firm (Scholl, 1999).

Other innovation researchers have viewed firms as mechanisms of influence over individual decisions. These theoretical approaches include Institution Theory (IT) and Actor Network Theory (ANT) (Verganti, 1999) with IT being defined as a "theory of

the middle range” (Bulmer and Burch, 1998, p.601) between economy, society and politics on one end, and individual human agency on the other. This theory suggests that the objectives and policies within the institution (i.e. the firm) play an important role in shaping actors’ behaviour and channelling energy and prioritizing of choices. ANT takes this influence concept further, and argues that the social and internal political influences have more impact on innovation than do an institution’s objectives and policies.

ANT is a combination of network theory and classical exchange theory between actors who are seeking rewards and utilities (Turner et al. 1998). Innovation is a particularly rich environment for consideration of network effects and impacts on actors as innovation often affects the identities of actors, the establishment of social roles, and most importantly, the positions of power. More specifically, ANT provides a theoretical framework for analysis and prediction of exchanges between actors that have an interest in the issue under consideration. For the purpose of ANT, actors such as individuals, groups of individuals and even non-human objects such as industry associations or knowledge bases are considered as members of the network (Harrison and Laberge, 2002). In an innovation setting, ANT describes how one actor attempts to construct the identities of the other actors in order to have them act in accordance with their wishes. In successful innovations, the network assists actors’ interests to converge toward a solution that satisfies the important actors’ interests. In challenging innovation attempts, the network can serve to disguise actors’ interests making it difficult for proponents to know which concerns are genuine and important. In some circumstances, the network can magnify individual actors’ resistance to a change (e.g. individual personnel within a union using the union’s interests as an ally to resist technological change).

When questioned about the innovation process, ANT concepts seem to have support among managers. For example, in a case study of a telecommunications company, managers state that innovation theory is intertwined with power relations (Salaman and Storey, 2002). The history of the cement, mini-computer, and airline industries until 1980 found that within the firm, those who control technological advances (whether competence destroying or enhancing) will gain power at others’ expense (Tushman and Anderson, 1986) . As a consequence, technological discontinuities affect the distribution of power and, in turn, the decision-making processes. Finally a study of 21 successful and 21 unsuccessful innovations revealed that filtering and withholding of

information inside firms is often used as a source of power (or in ANT parlance - the network is used to shield, promote or disguise interests) during innovation processes with reduced communication often linked with failed innovations (Scholl, 1999).

The social capital theory of the firm (SC) embodies many similar concepts to ANT but takes the tact that social processes in the structural, cognitive and relational dimensions are the motivating factors behind knowledge exchange and participation in combinatorial activities including innovation (Nahapiet and Ghoshal, 1998, p.251). Construction of SC collaboration networks between firms are seen as important precursors to resource combination primarily in high-tech fields (Blomqvist et al. 2005; Rothschild and Darr, 2005) and within regional economic development activities.

The five theories of the firms mentioned here, RBV, LO, IT, ANT, and SC all utilise the firm as the foundational basis to explain the phenomenon of innovation. Another approach to studying innovation has used the process of innovation as a foundational basis to search for theoretical commonalities.

#### *Innovation process theories*

The innovation diffusion theory (ID) is a process theory related to ANT, that looks at innovation practices on a micro-level by building on the underlying assumptions about actors in ANT and describing how actors' interests can be addressed in the special circumstance of innovation (Harrisson et al. 2001). This theory proposes that innovation diffuses among members of a social system through the construction of consent, rather than through coercion, using a two-step process of "interessement" and "enrolment" (Harrison and Laberge, 2002). Within customer groups, individuals go through a new product or service adoption process that begins with a similar process of developing awareness, proceeding to interest, which is followed by evaluation, trial, and adoption (Kotler and Turner, 1981). In a different setting, a study of innovation diffusion in the treatment of individual substance abusers restates the innovation adoption process as knowledge, persuasion, decision, implementation, and finally adoption (Hubbard and Hayashi, 2003). Whether the adoption process is a two-step or a five-step process, the concept remains consistent in that it is directed toward satisfying the individual or group actor's interests.



The concept of enrolment adds the influence of networks to the decision-making process. As members of the network enrol in the new network being constructed as the result of the innovation, the remaining non-adopting members of the network feel peer pressure building to join the 'new normal'. On an individual level, an example would be the decision that a drug abuser would face when his/her partner in drug abuse activity decides to join a treatment programme. The abuser must decide whether to join his/her partner or seek out new partners for their drug abuse activity. It presents a decision point where the drug abuser will feel pressure to join old network partners in the 'new normal'. Holdout members or holdout groups feel similar pressures when innovations are being adopted. In a thorough case study of the introduction of a series of innovations into the metal manufacturing sector in Quebec, Canada, these same pressures were noted for hold out groups whether they were union or management (Harrison and Laberge, 2002)

On a more macro basis, another process approach to examining innovation borrows from the concept of the product life cycle. Extensive industry-level case-study research projects examined similar products offered by a group of competitors over a long period of time and has claimed to have discerned a pattern of innovation that repeats itself for assembled products (Tushman and Anderson, 1986; Utterback, 1996). Innovation of products was found to begin primarily with a variety of designs that offered differing features. Over time, the design settles out to a 'dominant design' of the most highly valued features, at which point innovation migrates towards process innovations aimed at satisfying shifts in buying criterion toward improved quality and reduced cost. Firm size and behaviour is somewhat related to these activities, as the case studies suggest a parallel migration takes place from small technology-based product-innovation focused entrepreneurial firms to larger volume-based process-innovation focused bureaucratic firms. Innovation activity associated with beginning and ending stages of the innovation life cycle moves from cost target uncertainty and technical uncertainty to cost target certainty and a stable product design.

These micro- and macro-based theoretical innovation process-based approaches and the theory of the firm-based approaches to the study of innovation have developed in the wake of earlier economics-based approaches to the topic mentioned in the introductory section of this thesis.

When a context is defined for the aforementioned theoretical perspective work, the most common setting for the research is within large organisations. Several authors have taken specific aim at SMEs as the context for their theories.

#### *SME based theoretical work*

Edwards et al (2005) argued that Strategic Choice, a process theory closely aligned to IT is the most appropriate theory basis for SMEs and that research into innovation within SMEs would be best served by researching the processes of innovation within these firms. These authors argue that strategic choice describes the management process of “ensuring stability in existing practices while managing the unpredictability of innovation” (Edwards et al. 2005) and that this ‘control’ and ‘appropriation’ by actors is influenced by existing internal structures and routines, and external barriers and opportunities offered by the firm’s environment. Given that both ANT and IT are also process theories, it is questionable as to what concrete advantages the addition of a slightly varied third process theory offers.

Research in the late 1970s suggests that small fluid, flexible companies play a vital role in the process of the development of “dominant designs” (Abernathy and Utterback, 1978). Their role was to provide a number of iterations of product features that through evolutionary customer selection resulted in a dominant design that propelled these companies into larger companies that then shift their focus to economies of scale and process innovation targets. In a later article (Utterback, 1996) suggests that, “dominant design” development stems from entrepreneurial firms (not necessarily small firms) that then shift their behaviour to bureaucratic as they move to focusing on process innovation. This shift was found to be most pronounced within assembled products industries.

Based on a Spanish technological development database which included small firms from multiple sectors, work was carried out to assess the role of internal factors on the types of innovative behaviours exhibited by the firms (Galende and de la Fuente, 2003). This work on defining different types of innovative behaviour arose as the result of the authors’ review of multiple theoretical perspectives including transaction cost economics, positive theory of agency, evolutionary theory, and the resource-based view of the firm. A model was proposed based on the conjunction of these theoretical perspectives and the subsequent testing of the model suggested that significant

innovative behaviours (including within the small firms) could be categorized as either 1) internally generated innovations as the result of close connections with customers, (similar to Rothwell's technology need-pull model) or, 2) science-based innovations generated by internal R&D departments (similar to Rothwell's technology push model) or (3) based on an internal bias towards the need to continuously develop new products. Their findings indicated a weak correlation between size of firm and type of behaviour with much stronger associations based on the sector in which the firm found itself.

### *Summary*

Much of the preceding discussion of theoretical perspectives is drawn from work that does not specify a particular context as the espoused theory is suggested to be a representative set of fundamentals that apply to innovation in all settings. Other articles buttress their arguments with empirical examples drawn mostly from the context of large organisations. Very little work has been done to specifically address theoretical perspectives for small firms and for particular theories, with good reason. For example, by definition, the small relative size of SMEs reduces the quantity of resources the firm has to work with to sustain competitive advantage and according to the definition of the Resource-Based View (RBV), should render small firms less competitive than their large firm counterparts. Yet we know that small firms can compete successfully in certain contexts with larger firms, so this serves to raise doubts about the appropriateness of using the RBV as the theoretical basis for the small firm.

In a likewise fashion, the learning organisation model (LO) is best suited to large organisational settings wherein structured knowledge management practices are needed to deal with the number of interactions required to communicate between large numbers of employees. Organisational strengths of SMEs include an ease of communication due to the smaller number of interactions required (Tidd et al. 1997). This means that they do not need the formal strategies that are used in large firms and that are described as being characteristic of an LO.

The other branches of theoretical work that seem to offer application to the SME context are the process theories. The Innovation Diffusion (ID) and Actor Network Theory (Verganti, 1999) take into account the documented behaviours during the process of specific innovations and this degree of specificity is not materially affected by the size of the firm in which the innovation takes place. This research will follow up

on the promise of the process theories by documenting both individual and overall innovation processes inside SMEs.

## **2.4 Barriers to innovation**

Any description of the innovation literature would be incomplete if it did not include an enumeration of the wide variety of barriers to innovation within existing organisations. It is highly improbable that any firm or idea under consideration would be faced with all of these barriers but it is also unlikely that any firm is able to innovate without facing at least some of the barriers identified herein. Barriers that start-up companies face are outside of the intended scope of this discussion. Some of the previous work to identify barriers to innovation within organisations may have limited relevance as most of the research has been done in the context of large, highly structured and formalized firms and the firms constituting this research context are smaller and less structured. This section begins by describing barriers that appear to be broadly applicable to the entire innovation process followed by a tabulation of barriers that seem to specifically affect particular stages of the innovation process. The concluding portion of this section describes specific research efforts to identify barriers that affect SMEs and the resultant gaps in knowledge about barriers to innovation for the chosen research context.

Barriers that affect the entire innovation process can broadly be categorized as 1) stemming from the participants involved with the innovation process, 2) the previously established routines and structures that make up the organisation, and 3) the innovation-related directions (or lack thereof) provided by senior management.

The actor-network theory of the firm provides a fundamental foundation for a number of barriers to innovation as innovation participants (i.e. actors) are a required ingredient throughout the process. To briefly recap, according to this theory, actors act in their own interest while they are affected by and are affecting the social, economic and technical network around them (i.e. the firm and its network of customers, suppliers and competitors). Actors block innovation when the “highly ambiguous venture” (Van de Ven et al. 1999, p.44) that often characterizes innovation takes them away from “preferred comfortable routines” (Van de Ven et al. 1999, p.13) and challenges their limited capability to handle complexity and maintain focus on complex subjects while changes are occurring in their group and organisational norms. In addition, actors have been found to be reluctant to support changes or innovations that do not offer identities

based on autonomy, socialization and solidarity (Harrison and Laberge, 2002, p.515). One glaring symptom of the problems created by resistant actors is the resulting restrictive control on sharing of knowledge useful for problem solving and decision making (Scholl, 1999; Hickins, 1999). Other symptoms reveal themselves in the organisational politics when the relative personal attractiveness of a particular idea to the innovation participants plays a role in determining their level of formal support for the idea.

This is well illustrated in the case of major technological discontinuities that requires actors to “deal with a considerable amount of ambiguity and uncertainty as they struggle to comprehend and master both the new technology and new competitive environment” (Tushman and Anderson, 1986, p.460) in a setting where the control of these discontinuities can significantly affect the ultimate distribution of power within the firm. One example of this was highlighted in a case study of a large telecommunications corporation wherein managers suggested that the process of innovation “is intertwined with power relations” (Salaman and Storey, 2002, p.162) and could be described as a series of “tensions and paradoxes” (Salaman and Storey, 2002, p.160) and that innovation is affected by the “way in which managers and other influential players in organisations perceive and understand the issue” (Salaman and Storey, 2002, p.148) . In addition to these barriers influenced by potential power redistribution brought about by particular innovations, innovation within organisations inevitably involves change in some form or another and all the hurdles attached to the process of change. Sampling of the extensive change literature identifies a number of barriers to change. Catalogued barriers include the actor’s fear of new ways of doing things and their insecurity about what the change entails (Bates et al. 1996).

Actors operating in their own self-interest also extends to the self-interest of groups within networks as evidenced by the behaviour of strategic business units (SBU) that have been known to limit their support for particular innovations to the detriment of the overall corporation while delivering advantage to the particular SBU (Prahalad and Hamel, 1990), and to entire industrial networks that resist innovations to avoid upsetting their highly valued interdependent relationships (Sebora et al. 1994).

In addition to the barriers that begin with the innovation participants, barriers to innovation have been found that stem from an organisation’s pre-innovation structure

and routines. This is not surprising given that the purpose of creating organisations is to complete repetitive tasks more efficiently than their competitors. Organisations do this by channelling individual actions to predictable routines (Levitt, 2002) and reinforcing the resulting structures by conferring power and status upon those individuals that efficiently deliver results (Storey, 2000). By definition, innovation challenges structures, routines, power, and status such that the initial logical reaction to an idea is to try to deflect or stop the challenge.

A commonly used tool for deflecting the challenge includes the project approval practices that value bureaucratic comprehensiveness over focus on marketing and technical issues (Salaman and Storey, 2002). The resulting bureaucratic delays and associated cost inflation for trials of new ideas thereby increases the attached risk sometimes resulting in premature termination of innovative ideas (Quinn, 1986). An increased number of management layers also has been shown to be effective in stifling innovation as a long(er) chain of ‘yeses’ are required for innovations to proceed, but only one ‘no’ is required to kill a project (Quinn, 1986; Pearson, 2002). An additional structural barrier stems from internal competition for resources that exist in profit-centred and/or functionally structured organisations as the characteristics of the internal competition can create information pathologies which impedes cross-functional work (Scholl, 1999).

Related literature refers to these pre-innovation factors as forming a “path dependency” found in the domains of “technology as hardware”, “knowledge base” and “routines” (Coombs and Hull, 1998, p.242) with the endowments of each domain being somewhat ‘sticky’ in that they are difficult to change and take lengthy periods of time to change (Teece et al. 1997, p.514). A related concept suggests that the core competencies of firms become “core rigidities” when innovation presents a challenge to the status quo (Daneels, 2002, p.1096).

Another related barrier to innovation is the ongoing pressure to deliver established products and services and meet operational challenges and deliver short term financial results (aka ‘mainstream’ activities) on a day-to-day basis. Members of some organisations find themselves so preoccupied with the mainstream activities that they do not have any time or energy left over to pursue fuzzy and uncertain activities like

innovation (aka 'newstream' activities) (Lawson and Samson, 2001; Amabile, 1988; Kanter, 1989; Friedmann and Maurer, 2003).

An implicit acknowledgment of the innovation blocking effectiveness of these actor-based, structure-based and routine-based barriers is carried in the project champion literature that found that their presence or lack thereof has a significant impact on the likelihood of innovation success (Jones and Stevens, 1999; Slappendel, 1996; Leifer et al. 2001). These individuals perform a vital role in shepherding innovation to overcome the inertia inherent in the organisation's efforts to deliver their products and services as efficiently and routinely as possible.

Given the comprehensiveness of the barriers to innovation, countervailing forces are required or the barriers will block every innovation attempt. In addition to supporting the presence of project champions by tolerance of their penchant for disobeying organisational rules (Jones and Stevens, 1999), senior management located close enough to operations and their customers (Kerssens-van Drongelen and Weerd-Nederhof, 1999) can provide much of the impetus for innovation by repeated indications of the requirement for personnel to pursue innovation to ensure organisational health (Kanter, 1997; Amabile and Whitney, 1997; Lawson and Samson, 2001). When this consistent message is missing, potential innovation participants question why they should risk their support for new approaches (Amabile, 1988; Salaman and Storey, 2002; Zahra and Nash, 1995) resulting in innovation projects which lose support. This direction also goes missing when the organisation is not sure where they want to go or how to get there, resulting in management not knowing how to react to novel unstructured ideas. Commitment to proposed changes is also reduced by any lack of faith in the capabilities of the change leader and concern by the recipients whether they are being told the whole change story (Wynne et al. 1989).

In addition to the aforementioned barriers which are broadly applicable throughout the innovation process, there are barriers that have particular effects on the specific stages of innovation. Table 2.1 offers a sampling of these barriers as well as the stage in the innovation process during which the barriers manifest themselves. The innovation stages have been broken into the idea acquisition, idea evaluation, and idea implementation phases of the innovation process. The following descriptions review barriers to innovation which affect the entire innovation process and stage-specific

Table 2.1 Barriers to innovation

|                                  |  | INNOVATION STAGE  |   |
|----------------------------------|--|---|---|
| BARRIER                          | Idea acquisition   | Idea evaluation   | Idea implementation   |
| <i>Mixed messages</i>            | <p><b>Inappropriate incentives</b><br/>                     - Pay-for-performance focuses efforts on existing money-makers, while in house rhetoric encourages innovation (Quinn, 1986)<br/>                     - Individual pay-for performance places competition above collaboration, undermining teamwork necessary for innovation (Farson and Keyes, 2002)</p> <p><b>Idea generation short-circuited</b><br/>                     - Second-guessing of ideas before development even started, even while CEOs speak about need to innovate (Pearson, 2002)</p> | <p><b>CEO messages not backed up with action</b><br/>                     - Speeches by the CEO that espouse innovative behaviour but blame seeking, second-guessing, short term oriented actions often contradict message, thereby affecting risk profile of idea evaluators (Pearson, 2002)</p> | <p><b>We need to pursue development but...</b><br/>                     - Despite the compelling logic of the corporate line on innovation, the day-to-day priorities continue to emphasize traditional attitudes and ways of doing things (Salaman and Storey, 2002)</p> <p><b>Incentive construction is difficult</b><br/>                     - Pay-for-performance incentives are difficult to set-up for innovative activities as the outcomes are unknown in the beginning. The easy choice is to reject new ideas and retreat to behaviour with known rewards (Chandler et al. 2000)</p> |
| <i>Decision-making processes</i> |  | <p><b>Paralysis by analysis</b><br/>                     - Detailed analysis in advance of resource commitments. In one company the list of required analyses is ten pages long (Kanter, 1989)</p>  | <p><b>Roadblocks from 'Corporate'</b><br/>                     - Innovation project leaders complain that the rest of the organisation does not understand them, does not cooperate, moves too slowly, stifles their initiative, encumbers them with unnecessary and overly costly procedures, and charges them for services or benefits they would not rather receive (Kanter, 1989)<br/>                     - Onerous reporting requirements that get in way of creative work (Kanter, 1989)</p>   |



Table 2.1 (cont'd)

|   |   |  |   |
|---|---|--|---|
| <p><b>Resource allocation criterion</b></p> | <p><b>What about the next quarter?</b><br/>         -Excessive focus on next quarter's results short circuits all but the least expensive ideas (Sutton, 2002b)</p> | <p><b>Does it pay enough fast enough?</b><br/>         - Proposed innovation must meet material revenue and return expectations that matter to the corporation and deliver these with enough certainty to compete for resources. (Kanter, 1989)<br/>         - The need for quarterly profits conflicts with the extended periods an innovation normally requires to provide returns (Quinn, 1986)<br/> <b>Accepted corporate accounting methods used to evaluate all ideas</b><br/>         - Incremental and much riskier radical innovations evaluated using the same methods (Salaman and Storey, 2002)<br/> <b>Technology is risky, market expansion is not</b><br/>         -Financially-oriented managers perceive more risk with technical innovation resulting in a requirement to meet an elevated hurdle rate (Quinn, 1986)</p> | <p><b>Corporate vs. needed overheads</b><br/>         - By assessing against a project all of its direct, indirect, overhead, overtime and service costs, large corporations have much higher development expenses compared with entrepreneurs working in garages (Quinn, 1989)<br/> <b>Mismatch of financing requirements</b><br/>         - Short term bias of publicly owned corporations favours quick marketing fixes, cost cutting and acquisition strategies to longer term developments (Quinn, 1986; Morrissey, 2000)<br/> <b>Too much, too soon</b><br/>         -To do list of innovation projects overwhelms time availability for personnel, resulting in few innovation projects being completed correctly (Friedmann and Maurer, 2003)</p> |
| <p><b>Lack of metrics /definitions</b></p>  |   | <p><b>We do not measure so how can we know whether we've been successful?</b><br/>         -Disagreement on definitions, priority and expected consequences of innovation among managers makes commitment of resources uncomfortable (Griffin and Page, 1993; Storey, 2000; Barnett and Storey, 2001)</p>  | <p><b>Who gets blamed?</b><br/>         -No one is held accountable for results because we do not measure results, makes avoiding responsibility for failure less obvious (Griffin and Page, 1993)</p>  |

Table 2.1 (cont'd)

|   |  |   |   |
|---|--|---|---|
| <p><b>Sociological/political Issues</b></p>             | <p><b>Not invented here syndrome</b><br/>- Can not be any good because its not invented here (Pearson, 2002)</p> | <p><b>Just like last time we tried, it will not work</b><br/>- Previous unsuccessful change attempts impair credibility of project champions a second time around, (Axelrod, 2001)</p>  | <p><b>Whose budget line?</b><br/>- Mainstream budgets, schedules and expectations conflict with the need for new stream activities to shed the burdens of the past (Kanter, 1989)<br/><b>Meeting 'plan' is difficult at best</b><br/>- High-level signoff on a plan and agreement to a series of procedures or steps with the expectation that they will be followed without deviation. (Kanter, 1989)<br/>- Adherence to plan is a common measure of managerial performance in project-based firms (Keegan and Turner, 2002)<br/><b>Sponsors and champions move on</b><br/>- Promotion processes make innovation management transient and create delays (Kanter, 1989)<br/><b>It is too big to turn quickly</b><br/>- Sheer size of organisations creates large constituencies that do not participate in change decision-making (Axelrod, 2001)</p> |
| <p><b>Characteristics of disruptive innovations</b></p> |  | <p><b>Will we not be just hurting ourselves?</b><br/>-Delay of next generation products justified based on potential l for cannibalization of existing activities (Christensen, 1997)<br/>-Product architecture change requires change in organisational architecture, thereby increasing change costs and attracting resistance (Henderson and Clark, 1990)<br/><b>What is the ROI?</b><br/>-Disruptive innovations often require creation of a market as opposed to exploiting current markets, making hurdle rate calculations guesswork at best (Christensen, 1997p.77)</p> | <p><b>Leap of faith required results in ongoing uncertainty</b><br/>- Insecure project participants absorb precious personnel resources by needing to be continually 'resold' on the idea(Christensen, 1997)<br/><b>Problems encountered are more novel</b><br/>-When problems arise during development there is not a pre-existing well-ordered body of knowledge to turn to for advice. Consequently, roadblocks are likely to be more permanent. (O'Connor and Rice, 2001)</p>   |

barriers. These barriers have been identified primarily from research conducted in larger firms.

There have been some targeted attempts to identify barriers to innovation within MechSMEs. In a review of metalworking companies of up to 500 employees (Shapira, 1990), technology upgrading was found to be problematic due to the lack the cash or credit to upgrade, and because their personnel are often unaware of newer technologies as they are not able to get their internal people the necessary hands-on training with new technologies. In addition, this author found that owners and managers may be unable to dedicate the time required to properly implement new technologies. A survey of 238 manufacturing SMEs of less than 250 employees (Freel, 2000) was undertaken utilizing a postal survey of single individuals that was taken as a proxy for the view of the entire firm. The findings identified specific barriers to new product development including lack of technically qualified labour, poor use of external information and expertise, difficulty in attracting capital to spread risk, unsuitability of technical entrepreneurs as managers and high regulation costs within the firms. A sampling of small manufacturers (median number of employees was 31, with sampled firms ranging in size from 2 to 1150 employees) (Chandler et al. 2000) studied the development of innovation-supportive culture within these firms. The barriers to the development of such a culture within this group included work-load pressures, difficulty in assembling incentive systems for innovative activities, and the presence of formalized human resource practices.

This previous work on identifying barriers to innovation within MechSMEs should prove useful even though there are significant concerns with the methodologies employed. For example, Chandler, Keller, and Lyon's work (2000) used innovation-supportive culture as a questionable proxy for innovation. (Shapira, 2001) synthesized large scale surveys to identify the magnitude of the technology uptake problem among small manufacturers and hypothesized what the barriers were to technology uptake within the firm without testing their validity. One of the goals of this research project will be to address the lack of literature describing barriers as they directly relate to innovation by asking multiple respondents within the same organisation about the barriers as they see them. Repetition of these case studies should reveal whether any patterns in barriers to innovation exist for this context of mechanically-based SMEs.

## 2.5 Externally-sourced innovation enablers

The preceding section described barriers to innovation that principally stem from factors internal to the organisation. Enablers on the other hand stem from both internal characteristics of the firm (which are described under the organisational factors section) and the firm's environment. This section will review the literature describing the latter and is organized into those enablers stemming from the macro- and then micro-economic environments of the firm.

### *Macro-based Enablers*

A broad perspective of the economics of innovation was originally described in the seminal works of Schumpeter (Schumpeter, 1939; Schumpeter, 1942). Economists built on Schumpeter's work as they assessed economic history and found that economic growth derives primarily from technological change (Solow, 1988) (Lipsey, 1996). Lipsey observed, "Long term growth is driven by technological change – that is, by changes in the goods and services that we produce and changes in the way we produce them" (Lipsey, 1996, p.30) and Solow found that gross output per hour of work in the US economy doubled between 1909 and 1949 with seven-eighth's of this increase directly attributable to technological change. Governments of all levels have reacted to these and other related findings by supporting innovative activities with a multitude of programmes. A brief review of government websites describing innovation support programmes accessible to Canadian firms shows that multiple generic programmes exist from federal, provincial, regional, and municipal levels of government. From some of these levels of government, additional support exists for specific forms of innovation for particular industries. It is beyond the scope of this thesis to address the diffusion and impact on rates of innovation of this very long list of programmes as any reasonable treatment would require an inordinate portion of the thesis and would not support the objectives of focusing on internal manageable processes.

One long-tenured government programme that was designed to directly impact manufacturers and specifically created to support innovation is the patent system. An evaluation of the impact of the patent system using a broad cross-industry survey found that managers considered patents to be a broadly ineffective method of intellectual

property protection (Zahra and Nash, 1995; Taylor, 1973). Comparison of patenting practices by industry (von Hippel, 1998) found that the value of patent protection varies with industry with efficacy being high for chemically-based industries and low for mechanically-based industries. In short, for the context of this research this foundational attempt by government to support innovation is not an effective enabler.

Business history also teaches lessons about innovation as long-term business performance has taught managers of firms that they cannot sit still, or they will get run over. For example, in a review of the 1985 Fortune 500 list, Brown et al (Brown et al. 2000) found that less than half remained in the list ten years later. Foster (Foster, 1986) found that major paradigm shifts (technological dislocations) often result in a replacement of the industry leaders. For whatever reason, 7 out of 10 times the leaders miss the 'next wave'. To some, the message received by managers becomes 'innovate or die'. On the other hand, empirical research into firm valuations has suggested that innovative firms are more profitable and valued at a premium by the share market relative to their less innovative counterparts (Figg, 2000; Roberts et al. 1989). The message managers receive is that innovation is required to prosper. These 'carrot' and 'stick' lessons of business history act to keep innovation as a top-of-mind concern for managers.

During the last decade, arguably the most pervasive change of the way managers perform their tasks has been the development and diffusion of the Internet. During idea implementation, using the Internet as a tool assists innovators in searching for solutions to innovation development problems, assessing and accessing markets for innovations and copying competitor's innovations. Customers are able to focus their product searches more tightly resulting in increased numbers of niches requiring more targeted designs of products and services. The need for a greater number of focused product/service offerings, the decreased time required to complete innovations and the shortened timeframes for competitive response has resulted in an accelerated rate of change (Kanter, 1998) that requires firms to innovate more often and with reduced time-to-market in order to survive (Landry, 2002). In short, even outside of the digital world, the development of the Internet has stimulated innovation. The Internet is also an "enabling technology" (Moore and Starr, 2006) that supports the creation of associated innovations. The innovation represented by electronic banking would not exist in its current form without the supporting infrastructure of the Internet. Within mechanical

machining industries, the introduction of CAD/CAM methods and the associated improvements in quality and cost reductions would not have been possible without the introduction of computers and before that the invention of the transistor. Each enabling innovation can create radical shifts in methods and other technologies (Lipsey, 1996) and act as a platform for multiple spin-off innovations. Within the mechanically-based manufacturing industry a wide range of enabling technologies (e.g., new materials (Beard, 1997), new processes for physically altering materials (Christner, 2003), knowledge management (McMahon et al. 2004), photonics, nanotechnology (Suhir, 2004) all may play a role in future spin-off mechanically-based innovations.

#### *Micro-based Enablers*

In addition to the enablers that stimulate innovation from the broader environment, enablers within each firm's micro-economic sphere made up of customers, competitors suppliers and other members of their networks can provide the stimulus for innovation.

Firms that have followed the advice of staying close to their markets are often confronted with changing customer needs and responding to these needs is cited as a stimulus for innovation (Zhang and Sharifi, 2000). Close connection to their most profitable customers and their resulting significant influence on a firm's innovation direction is cited as one of the factors which set up firms to be blind-sided by disruptive innovations that arise from outside the established supplier-customer dyads (Christensen, 1997). Pressure to match or exceed feature enhancements and price reductions offered by competitors are also often cited as a significant stimulus to pursue innovations (Coombs and Thomlinson, 1998; Covin and Slevin, 1991; Brown et al. 2000; Pearson, 2002; Kim and Mauborgne, 1999; Pavitt, 1990). Suppliers to firms have been found to play an important role in knowledge transfer (Kotabe et al. 2003) as it results in improvement in product and process design.

Co-location and clustering of firms has been hypothesized as being important enablers of innovation with mixed results as to their importance. An assessment of isolation's effects on a group of British rural SMEs found no isolation disadvantage existed with respect to innovation (North and Smallbone, 2000), whereas studies of Silicon Valley (Edwards et al. 2005) suggested that the common cross-organisational forums that take place in the valley are important enablers of innovation. This is yet another example of innovation appearing to be a context-specific phenomenon.

Each of the aforementioned enablers has broad application across firms of all sizes and none of the literature reviewed suggests any of them serve to specifically enable innovation within SMEs. One of the objectives for this research is to assess the role of external enablers as perceived by the respondent firms.

## **2.6 Organisational factors in innovation**

This section reviews the literature describing the effects on innovation of firm size, the firm's operating strategy, organisational structure, and culture. Each of these organisational factors shapes and/or is shaped by the innovation practices that are chosen or that develop within the firm. A more detailed look at literature focused on innovation processes is carried in the next Chapter.

### *Firm Size*

The debate about the effects of firm size on innovation developed from Schumpeter's early assertions (Schumpeter, 1942) that large firms were best suited to the creation of innovations. Over the intervening years, the question appears to have evolved to a realization that both large and small firms enjoy advantages and suffer from disadvantages with respect to innovation and that neither group is seen to be better at innovation, but that each group has different characteristics which affect innovation (Vossen, 1998; Rothwell, 1991; Acs and Audretsch, 1990b; Baldwin and Gellatly, 2003).

There are several factors that are self-evidently affected by firm size that could prove important to innovativeness. Firm size affects

- the physical and organisational distance between members of cross-functional teams (Christensen, 1997);
- the quantity of inter-personnel communication interchanges;
- the number of bureaucratic levels which affects trialling costs (Quinn, 1986);
- the average time that senior managers can devote to each individual employee and to each individual customer (Sebora et al. 1994);
- the number of personnel that have learned to work with the existing practices of the firm;

- the number of specialist personnel that can be supported and the risk associated with losing their tacit knowledge (Barnett and Storey, 2000) and the number of functions personnel must fulfil;
- the absolute amounts of capital available for innovation. The result being that smaller firms can only pursue smaller innovations or must be willing to risk more of their firm in order to pursue similar innovations to those pursued by much larger firms (Pavitt, 1990);
- the scale of the idea on which senior managers can effectively focus (Christensen, 1997);
- the history of entrenched practices as firms take time to grow, and younger, smaller, firms may have had less time to entrench barriers and enablers affecting innovation.

On average, these factors should provide smaller firms with advantages in terms of more comprehensive firm-level teamwork, more willingness to pursue ‘smaller’ innovations, deeper understanding of customer issues by senior managers, fewer resistors to change and less history to overcome when change is needed. On the other hand, less specialist talent is likely to be available to solve specific problems and the available capital to tackle innovation projects is smaller. Considering the other literature reviewed throughout this thesis, these issues are all seen as important to a firm’s innovativeness.

Using an industry-level unit of analysis, other firm-size related research has reported findings that the growth of small firms is diminished in industries with high levels of capital-intensity, advertising intensity, unionization, and relatively low levels of human capital (Acs and Audretsch, 1990b).

A firm-level case study of lessons learned by 3M, a firm which is often cited for their firm innovativeness, stated that firm size does matter and that innovation is more prevalent and successful when divisions are small (Bartlett and Mohammed, 1995). Other firm-level analyses of the effects of size found that for a sample of firms introducing statistical process control as a process innovation, there were more differences in methods used between hierarchical and non-hierarchical organisations than there were between large and small firms (Roberts et al. 1989). Bessant et al. (2001, p.32) carry this argument a step further by saying that “what distinguishes a firm



and gives it competitive advantage is not so much its size or position, but rather its ability to respond and lead in the continually shifting environment". While firm size might lead to this ability in some circumstances, in other contexts it may very well hamper it. In a quantitative analysis of the perception of an innovation supportive culture within 23 manufacturing companies in Utah, increases in firm size were found to result in the use of more formalized human resources practices which were shown to be negatively correlated to the perception of the presence of an innovation-supportive culture (Chandler et al. 2000).

Analysis at the specific innovation level of the effects of firms size carried out within the SAPPHO projects compared 29 successful/unsuccessful pairs of innovations launched within the chemical and scientific instrument industries (Rothwell et al. 1974). Although a number of factors were found to affect innovativeness, firm size was specifically found not to impact the success for the individual innovations selected for study.

In summary, an early suggestion that large firms are better suited to innovativeness has migrated to strong arguments that the advantages of small firm size does affect the way innovation happened for some situations, yet other studies have not found that firm size affects some important dimensions of innovation. This disagreement on the importance of size seems to indicate that firm size is yet another variable that seems to be context-specific with respect to its effect on innovation.

### *Operating strategies*

Multiple authors have documented a variety of strategic options that firms pursue with far-reaching implications for innovation within these firms. Macro-level strategic choices between pursuit of low cost or product differentiation as the firm's basis for competition (Porter, 1980) have significant impacts on the proportion of process and product innovation practiced by the firm and the resulting innovation structures, personnel and methods. Strategic choices that are based on opportunities spotted using value-chain analysis are driven by the characteristics of the industries served by the firm (Porter, 1980) and by the expectations of economic rent that potential innovations can deliver within the chosen industry (von Hippel, 1998). The types and methods of innovation pursued by the firm as a consequence of either of these industry level approaches are driven by the industry context.

Firm-level bases for strategic choices can stem from decisions around core competencies (Prahalad and Hamel, 1990) and the path dependencies (Coombs and Hull, 1998) that block exploration of new first-order competencies required to address new markets or create new products (Daneels, 2002). Any decision to pursue novelty in either products and/or markets influences the nature of the practices required to pursue the individual innovations and over time, the construction of a capacity for ongoing innovation of a particular type.

A third framework of strategic choice stems from the management of technology literature wherein the merits of industry leadership in terms of technology strategy is discussed. Strategic options offered here include “leading edge” or “fast follower” (Oliver, 2002, p.6) or “science-based product innovators”, “entrepreneurial fast-track experimenters”, “global cost leaders”, “lethargic reliance on information technology”, and “process adaptors” (Miller and Blais, 1992, p.363) with each option requiring different innovation personnel and methods to exploit the strategic choice. Each of the three aforementioned frameworks for making strategic choice imply that senior management of firms make conscious selections of direction as opposed to the “logical incrementalism” approach (Quinn, 1989, p.46) wherein a strategy for the firm develops from the collection of previous operational decisions and business events. The timing and method of strategy selection does not alter the required innovation practices to carry out the chosen business strategy but may have an impact on the path dependencies (Coombs and Hull, 1998) and core rigidities (Daneels, 2002; Tidd et al. 1997) that innovation efforts must accommodate.

An empirical study of the performance of firms (Olson et al. 2005) against organisational fit for firms exercising one of four generic strategies (“prospectors” or “analyzers” or “low-cost defenders” or “differentiated defenders”) found that fit between strategy and innovation orientation was a significant contributor towards increased performance for a limited set of strategic choices. For example, the highest ranking firms utilizing a “prospecting” strategy had a statistically significant orientation towards product development. On the other hand, an orientation towards product innovation was found to negatively impact the performance of the highest ranking “analyzers” that focused on only pursuing potentially successful product imitation introductions while defending core markets. A similar negative impact of product

innovation was found to apply for the highest ranked “low cost defenders”. For the highest ranked “low cost defenders”, as expected, an internal/cost orientation (process innovation) was shown to have a statistically significant positive impact on performance. For “differentiated defenders” that defend selected market niches, the effect of orientation towards either of product or process innovation was found to have no statistically significant effect on the performance of the highest ranking firms that pursue this strategy.

This empirical study was conducted within firms with more than five hundred employees across a broad sample of industries contained within twenty different two-digit Standardized Identification Codes (SIC) with senior marketing managers acting as the respondents for each of their firms. If these findings can be generalized to the industry context of manufacturing (which were part of the SIC classes studied) then managers can conclude that in order to deliver the best firm performance, the strategic orientation requires complementing innovation structures, personnel and methods.

### *Structure*

A number of the barriers to innovation identified earlier in the thesis, stem from organisational structures (for example, layers of bureaucracy that must be satisfied before innovative ideas get the go-ahead, and profit centres that have a disincentive to cooperate to be successful in the internal competition for resources). The potential of innovation to redistribute power within the organisation (Salaman and Storey, 2002; Collinson, 1999) serves to potentiate the impacts of these structures and potential changes in structures.

Various organisational structures are proposed to assist in the innovation process by seeking to reduce these structure-sourced barriers. Less conventional arrangements including skunk works, (Kanter, 1989; 2000a) innovation hubs (Leifer et al. 2001), starburst arrangements (Quinn and Anderson, 1996), building of networks to enable outsourcing of everything but core competencies (Quinn, 2000), keeping innovation in-house to leverage integration advantages (Chesbrough and Teece, 2002), sharing of risk and innovation-aiding resources through joint ventures (Coombs et al. 1996; Collinson, 1999) and venture capital funding arrangements (Christensen, 1997; Kanter, 2002) have all been found to be effective at supporting innovation in selected contexts.

In the same empirical study that measured the effects of orientation toward product and process innovation on the performance of firms selecting particular strategic postures (Olson et al. 2005), it was found that organisational structure needed to fit the chosen strategy in order to deliver higher firm performance. Whether organisational structure preceded innovation orientation or vice-versa was not evaluated, but on the face of it there did seem to be consistent direction of effects on firm performance. For example, the results show that “prospectors” focusing on new markets and new products are best served by a decentralized and specialised organisational structure that should result in more sources for ideas, more ability to exploit ideas and a product innovation orientation. A summary of their findings of the effect of structure and innovation orientation on firm performance is contained in Table 2.2

*Table 2.2 Effect of structural characteristics and innovation orientation on firm performance for chosen strategy*

|                                   |                     | <b>Chosen strategy</b> |                             |                                   |
|-----------------------------------|---------------------|------------------------|-----------------------------|-----------------------------------|
|                                   | <b>“Prospector”</b> | <b>“Analyzers”</b>     | <b>“Low-cost defenders”</b> | <b>“Differentiated defenders”</b> |
| <b>Structural Characteristics</b> |                     |                        |                             |                                   |
| <i>Decentralization</i>           | Positive            | Insignificant          | Positive                    | Insignificant                     |
| <i>Specialization</i>             | Positive            | Insignificant          | Insignificant               | Insignificant                     |
| <i>Formalization</i>              | Insignificant       | Insignificant          | Insignificant               | Positive                          |
| <b>Innovation Orientation</b>     |                     |                        |                             |                                   |
| <i>Product Innovation</i>         | Positive            | Negative               | Negative                    | Insignificant                     |
| <i>Process innovation</i>         | Insignificant       | Insignificant          | Positive                    | Insignificant                     |

Other empirical research has focused on the character of the managers involved with the innovation. In the aforementioned SAPPHO studies (Rothwell et al. 1974), success was more likely when the responsible individuals came from the ranks of senior management. Using historical ratios of R&D expenditures/sales as a proxy for innovativeness, senior management groups that contained higher levels of technical qualifications were found to support more R&D expenditures (Daellenbach and McCarthy, 1999). If the proxy assumption holds, then increased technical qualifications should lead to greater innovativeness for the firm.

Economics-based theoretical arguments have been made about preferred organisational structures for innovation. A proposal has been made to eliminate the barriers to innovation between departments by eliminating departments and by organizing only by process (Johannessen et al. 1997). The proposed benefits of this arrangement, (including

fewer department agendas getting in the way of communication, and ‘ownership’ of project success as opposed to defence of departmental position) may prove useful for innovation, but wholly ignores the benefits of functional departments to efficiently produce existing products and services. In the unlikely event that firms wish to jettison all existing business, then this proposal may have merit, otherwise it is likely unworkable.

Case studies of two US-based corporations recognized for their innovativeness, Xerox (Brown, 2002) and Rubbermaid (Amabile and Whitney, 1997), document the advantages of the particular structures in use. In the case of Xerox, the potential benefits of continuing organisation-wide innovation were seen to be sufficiently important such that the objectives of the R&D department were shifting toward enabling an innovation agenda throughout the organisation rather than keeping it for themselves. For Rubbermaid, their structural template utilizing cross-functional Business Teams stemmed from their early cross-functional team successes. These Business Teams are assigned written objectives, have their innovation performance measured and are coached and overseen by senior managers. Team chemistry is seen as more important than technical expertise. At the time of the study, this structure was seen to be an important contributor to a product innovation track record that resulted in one thousand new products being introduced within the preceding three years.

One of the important conclusions that can be drawn from this previous work is that it appears that no one structure is best for all innovation situations, so that the design of the organisational structure for innovation needs to be managed for each situation. Previous efforts have focused on removing barriers to innovation through organisational redesign, enabling innovation by creation of structures to leverage tacit knowledge (e.g. cross-functional teams) and support of strategic objectives with structures that deliver the types of innovation required by the strategy. Organisational culture is yet another variable that affects innovation and that can be influenced by structure or lead to the development of particular structures. The next section explores the literature on the impact of organisational culture on innovation.

### *Culture*

Like so many other variables associated with innovation, organisational structure and culture simultaneously affect each other. Descriptions of these effects are found in an

comparison of the selection of change management practices between hierarchical and non-hierarchical organisations (Rothwell et al. 1974) and in a similar comparison between formal and informal organisations and the impact on knowledge management practices, the transfer of tacit knowledge and the effects on knowledge and learning, teamwork, trust, motivation and creativity (Lemon and Sahota, 2004). Their parallel findings suggested that reduced hierarchy and greater informality led to higher levels of knowledge transfer, teamwork, trust and creativity.

For the front-end idea generation process, research focused on assessing the factors behind the creativity of R&D scientists, marketers and financial personnel (Amabile, 1988) found that motivation of the idea generator was the single largest determinant of creativity and that freedom and the resources to create were important motivators. Social Capital is proposed as another culture-based explanation for what motivates employees to share tacit knowledge that can translate into intellectual capital and innovation inside the firm (Nahapiet and Ghoshal, 1998). This proposed concept suggests that Social Capital for employees assembles via three constructs, structural (social systems and networks), cognitive (shared ideas and common goal), and relational (personal relationships and trust). In a broadly confirmatory study (Mascitelli, 2000), found that idea generation is enabled by a corporate culture that is based on a strong sense of personal belonging from all team members and focuses on creating a common vision that facilitates and encourages idea exploration through the concept of learning by doing. This is consistent with the reactions by personnel to these types of cultures that are forecast by the actor-network theoretical perspective, wherein networks and personal self-interests are seen to intersect and affect decision-making in the innovation context (Harrison et al. 2001; Kanter, 2002).

Related research into the phenomenon of creativity in organisations suggests that managers play a key role in motivating the generation of ideas by creating an internal culture that encourages employees to try new things (Kanter, 2000b; Chandler et al. 2000) and tolerates failure as a regularly expected outcome of innovation efforts (Farson and Keyes, 2002; Bartlett and Mohammed, 1995; Kanter, 2002). These findings are buttressed by findings that when management mixes messages about their support for innovation it presents a significant barrier to innovation (Quinn, 1986; Farson and Keyes, 2002).

Other authors have suggested that management's role in supporting innovation needs to go beyond creation of a fertile atmosphere for organic growth of ideas to the level of demanding that innovation occur (Amabile, 1988) including the creation of structures to support innovation, especially when radical innovations are the targeted outcomes (Leifer et al. 2001).

The combination of the structures affecting culture, and the practices required to ensure employees are motivated to generate and pursue ideas, has led several authors to attempt to describe the culture necessary for innovation. In-depth case studies of 18 business units from 12 U.S. and Japanese companies (Khurana and Rosenthal, 1998) leads to advice to holistically manage the idea generation phase of innovation while seeking to link business strategy, product strategy and product-specific decisions. Key idea generation personnel are encouraged to remain focused on broad topics such as "business vision, technical feasibility, customer focus, schedule, resources and coordination" (Khurana and Rosenthal, 1998). Exploratory case study research (Zien and Buckler, 1997) within companies that were widely acknowledged as innovation leaders at the time of the study (3M, Hewlett-Packard, Polaroid and Sony) suggested seven common principles that describe their organisational culture. These principles were described as (1) sustaining faith and treasuring identity as an innovative company, (2) being truly experimental in all functions especially in the front end of the innovation process, (3) creating interdependence between functions so that personnel develop genuine relationships, (4) developing a deep understanding of current and future customer needs, (5) engaging the whole organisation in a community of innovation, (6) keeping the fun and rewards in innovation for individual personnel and finally (7) reinforcing this culture with the retelling of stories that confirm the culture of the organisation and their status as an innovative organisation.

Much of the aforementioned research has taken place in the context of very large organisations that struggle with difficulties in preserving firm-wide or even division-wide informal communications which are so important to the development of the components of Social Capital for employees. Informal communications and structures that characterize many small firms should assist in the development of motivation for employees. The relative proximity of senior management to the employees should facilitate encouragement of trying new ideas. This seems to be borne out by economics

and strategy-based arguments (Vossen, 1998; Covin and Slevin, 1991) and exploration of these concepts is one of the targets of this thesis.

## **2.7 Practitioner context**

The remaining portions of this Chapter take an alternate approach to the topic by reviewing the body of literature that views innovation from the situational complexity perspective that confronts practitioners. Rather than trying to isolate single variables or groups of variables to explain innovation, this literature recognizes the degree of complexities that practitioners of innovation management must confront and attempts to derive patterns of management practices that the researchers perceive to be successful from the experiences gathered from previous innovation projects. These portions begin with a separate section reviewing the literature on change management which is primarily associated with first order competencies of innovation management. This is followed by sections organized into schools of thought around best practices and documentation of innovation processes in use. These two sections describe how practitioners manage innovation utilizing both first-order competencies (execution of individual projects) and second-order competencies (management of a programme of innovation).

### **2.7.1 Change management**

One of the fundamental challenges to innovative activities is to manage innovative projects to a point of resolution (Atherton and Hannon, 2000). Without exception, innovation cannot occur without some disturbance in the status quo and so it is inevitable that managers of innovation find themselves also to be managers of change (Storey, 2000). In addition, innovation presents a special case to these managers because of the variety and power of the problems that can accompany innovative changes. For example, innovation has the potential to change many aspects of the working environment, including the tangible (e.g. new methods of production and new uses of technology), and the intangible, (e.g. social infrastructure and internal political norms can be disturbed by new structures and new personnel) (Geels, 2004).

A review of the ‘innovation problem’ identified in Britain during the 1990s (Storey, 2000) illustrates the close alignment between change management and innovation. This



case study research that was carried out in different sized firms in a number of sectors, sought clarity as to what managers perceived to be the innovation problem. The research findings suggested that managers' perceptions were that the problem stemmed from disagreements between managers on the meaning and priority of innovation and disagreement on the amount and type of resources that should be dedicated towards achieving innovation. Implicit explanations drawn out of the case study narratives indicated that important change management concepts of top management support (Oke, 2004) and an awareness of need for change (John Sinclair and Sinclair, 1994) were prerequisites for innovation success, and that managers felt that innovations are all about how they feel change management should be done.

A comprehensive review of literature describing change management practices is beyond the scope of this thesis and it would duplicate many of the concepts covered in the review of the main body of innovation literature. On the other hand, some particular issues identified in the change management literature (such as different sources of resistance to change and change management methods) have particular application to the management of innovations.

Managing change commonly involves work to reduce and/or eliminate resistances to proposed changes. Innovation is a particularly rich wellspring of the documented sources of change resistance such as:

- Fear of the unknown - All innovations move from uncertainty towards certainty during its life. During the uncertainty stage, the associated insecurity can generate a resistance to change (Benson and Dundis, 2003).
- Fear of failure - Innovations require personnel to perform tasks that they have not done before and this can lead to a fear of failure that motivates the participants towards resistance of the proposed change (Farson and Keyes, 2002; Chandler et al. 2000)
- Disruption of existing routines and methods - Innovations can require personnel to alter past practices that they have learned to do well and that they enjoy. As a consequence, they will resist efforts to change their routines (Storey, 2000).
- Self-interests not served - Innovation participants (or actors) that do not see any self-interest being served by a proposed innovation are not likely to endorse the proposal (Harrison and Laberge, 2002; Storey, 2000) resulting in passive resistance at best.

- Disruption of existing groups – Innovations that require changes in work groups can disrupt established social relationships and participants that wish to maintain the status quo will resist such changes (Geels, 2004).
- Micro-politics – In a detailed case study of a failed innovation authored by one of the protagonists (Jones and Stevens, 1999) a very strong argument is made that micro-politics involved in a change absolutely must be considered as part of any review of new product development. This is because micro-politics play a critical role in determining the ability of an organisation to change.

The effect of each of these sources of resistance is leveraged by the potential for innovation to alter organisational power positions within the firm (Tushman and Anderson, 1986; Vieitez et al. 2001; Salaman and Storey, 2002). Participants are often aware of anecdotal histories of innovation that have created major shifts in power and position, and as a consequence, they are alerted to possible shifts whenever an innovation is proposed within their organisation.

Within the field of change management, an extensive menu of alternative methods has developed to accommodate resistances like these (project management (Ruta, 2005; Crawford and Di Benedetto, 2006; Tidd and Bodley, 2002) (Keegan and Turner, 2002), knowledge management (Nonaka and Takeuchi, 1996) (Axelrod, 2001; Fischer, 1991), use of project champions, (Markham and Griffin, 1998; Markham, 1998; Howell and Shea, 2001) and change agents, (Kanter, 1999) managers of innovation can modify them as required to accommodate the special circumstances of the contemplated innovation.

In summary, the change management literature cannot be ignored in any review of innovation, because all innovation involves change in one form or another and managers of innovation find themselves to be managers of change at least to some degree. Some useful lessons can be drawn from the change management literature around the various sources of resistance to change that can apply to innovation, the classic literature on motivation which details some enabling characteristics of innovation, some change process issues on the benefits of shared changes and the related lessons learned about project managers, managers of change and innovation champions.

The overwhelming majority of the works cited in this section has not taken place in the context of smaller to medium-sized firms but have taken place in the context of larger organisations from both the profit and non-profit sector. While substantial portions of the change resistance and motivational literature likely applies in the MechSME context, it is questionable whether the remaining issues are likely to have the same application in a context that experiences more interaction and closer ties between involved parties purely because of the reduced number of personnel involved. Determining whether the findings of these related bodies of literature have broad application within MechSMEs is another objective of this research effort.

### **2.7.2 Schools of thought**

An objective analysis of the innovation literature reviewed to this point in the thesis would have to conclude that the sources and findings of the extant innovation literature are highly variable, highly fragmented and sometimes contradictory. The number of academic disciplines which provide insights into the complexities of innovation on their own is impressive. One method which has been utilized by a number of disciplines to combat information overload for practitioners is to integrate concepts into useful descriptions known as schools of thought (e.g. communism, socialism, and capitalism within economics and political philosophy (Levin, 2003), Freudian and Jungian analysis within psychotherapy (Ekstrom, 2004).

Within the first Chapter of this thesis, six schools of thought as to how to manage innovation were offered for the reader's consideration. Briefly, these were:

- a) *Innovate in order to learn to innovate*
- b) *New economy model*
- c) *Intrapreneurship can solve everything*
- d) *Organic*
- e) *Disciplined*
- f) *Organic then Disciplined*

A summary of the previous research that supports each school of thought is carried in Table 2.3.

Table 2.3 Schools of thought, particular issue and supporting references

| <b>School of Thought</b>                      | <b>Particular Issue</b>   | <b>References</b>  |
|---|---|--|
| <i>Innovate in order to learn to innovate</i> | Knowledge leads to innovation   | (Nonaka and Takeuchi, 1996; Kanter, 2000b; Kanter, 2000c; Coombs and Hull, 1998; Hauschild et al. 2001)                          |
|   | Learn through quick cheap prototyping   | (Schaffer, 2002; Farson and Keyes, 2002; Schaffer, 2002)   |
|   | Plan and forecast thoroughly  | (Cooper, 1990)   |
|   | Management should focus on building core competencies   | (Daneels, 2002; Pavitt, 1990; Quinn and Anderson, 1996)  |
|   | Create environments to facilitate sharing of tacit knowledge  | (Nahapiet and Ghoshal, 1998; Kotabe et al. 2003; Collinson, 1999; Scholl, 1999; Johannessen et al. 1997)                         |
|   | Build capacity to absorb knowledge  | (Cohen and Levinthal, 1990)  |
|   | Construction of and renewal of operating routines permits firms to survive a changing environment   | (Nelson and Winter, 2002; Becker et al. 2005; Dosi et al. 2000)  |
| <i>New economy model</i>                      | Market leaders are vulnerable to disruptive innovations that are difficult to implement internally  | (Coombs and Hull, 1998; O'Connor and Rice, 2001; Christensen, 1997; Kanter, 1989; Normann, 1971)                                 |
|   | Disruptive innovations can be implemented with some organisational redesign   | (Quinn, 1986; Veryzer Jr., 1998; Leifer et al. 2001; Von Hippel et al. 1999; O'Connor and Rice, 2001)                            |
|   | Disruptive innovations can create substantially different technical trajectories for an industry  | (Utterback, 1994)  |
| <i>Intrapreneurship can solve everything</i>  | Champions overcome barriers to innovation through effort and perseverance   | (Van de Ven et al. 2000; Cooper and Kleinschmidt, 1995; Leifer et al. 2001)  |
|   | Champions disrespect for organisational 'rules' should be tolerated   | (Howell et al. 2005; Robinson, 2001; Nijhof et al. 2002)   |
|   | Entrepreneurship required for hostile and dynamic market environments   | (Covin and Slevin, 1991; Nijhof et al. 2002)   |
|   | Encouragement to try is a key management task   | (Schaffer, 2002)   |
| <i>Organic</i>                                | Everyone in an organisation should be encouraged to 'think outside the box'   | (Kanter, 1998; Amabile, 1988; Kanter, 2000a; Sutton, 2002a; Kanter, 2000c; 2002)   |
|   | Hostile and dynamic market environments require creativity throughout organisation  | (Covin and Slevin, 1989; Kidder, 1981; Lipman-Blumen, 1999)  |
| <i>Disciplined</i>                            | Environmental scanning should be focused  | (Pearson, 2002; Drucker, 2002; Levitt, 2002)   |
|   | Innovation processes should follow a proscribed pattern   | (Cooper and Kleinschmidt, 1995; Cooper, 1990)  |
| <i>Organic then disciplined</i>               | Different modes of management are required for idea generation and idea implementation phases   | (Verganti, 1999; Brown and Eisenhardt, 1997; Kanter, 2002; Khurana and Rosenthal, 1998; Quinn, 1989; LaBarre, 2002; Quinn, 1986) |
|   | Upper management should control direction of innovation but provide structure and support to encourage organic processes inside development teams | (Bonner et al. 2002)   |

Macro-level analysis of this table suggests that within the overall body of innovation literature (which has been taken primarily from the contexts of large and high technology organisations) there are substantial levels of support for each of the schools of thought. What is of primary interest though, is how these schools of thought might apply to the research context for this thesis. Accordingly, the following comments can be made about each school of thought in turn as they might apply to MechSMEs.

*Innovate to order to learn to innovate*

Within this school of thought, learning as a means to build core competences and create intellectual property is seen as a key strategy to innovate successfully. Active management of the transfer of both formal and tacit knowledge along with the corresponding investments and structures required to make it happen are seen as prerequisites for innovation.

Three factors need to be kept in mind when assessing this school of thought for MechSMEs:

1. The reduced number of interpersonal contacts within smaller organisations means more informal information sharing occurs within a greater portion of the organisation (Vossen, 1998; Rothwell and Zegveld, 1985).
2. The problems associated with multiple strategic business units with differing objectives within the same organisation (Prahalad and Hamel, 1990) often do not exist as the firms are commonly single-site, single-industry organisations.
3. For mechanically-based firms intellectual property protection is seen to be very weak (Taylor, 1973 cited in von Hippel, 1998, p.47) and management has learned that construction of a comprehensive intellectual property position is unlikely and of questionable utility.

The net effect of combining these factors is a reduced need for managers to invest in structures to support formal knowledge transfer and to commit knowledge to a formal written configuration. On the other hand, the behavioural advantages stemming from smaller numbers of more frequent interpersonal contacts assist the transfer of tacit knowledge (Rothwell and Zegveld, 1985; Kotabe et al. 2003; Scholl, 1999) which should result in more flexible and effective responses to customer requests and a greater

knowledge of core competencies throughout the firm. In summary, only portions of this school of thought are expected to be found to be supported within the respondent firms.

#### *New economy model*

In a similar way the recently developed, influential model associated with disruptive innovations is not likely to apply in a significant way to MechSMEs. The rationale for this hypothesis is as follows.

With a few exceptions, much of the genesis of the new economy model has resulted from industry-level studies of discontinuous, radical or disruptive innovations as they apply within industries that are easily scalable and based on core technologies or methods. For example, studies of the computer memory, steel mini-mills, and retailing industries (Christensen, 1997), and replacement of the ice industry with refrigeration and the introduction of float glass into the plate glass industries (Utterback, 1994) identify single innovations which set these industries onto new trajectories. Each of these industries is scalable with the quickest changes occurring in those industries for innovations that require a smaller amount of new physical infrastructure and small numbers of personnel that require extensive training in the new methods. The electronic distribution of recorded music is an example of a very quick change in an industry that occurred because of a file sharing software innovation that was highly scalable. It required virtually no physical infrastructure and very little training and its adoption was very rapid.

On the other hand, at the macro level, mechanically-based manufacturing is a mature, highly fragmented industry with a long history and a requirement for significant physical infrastructure (e.g. machine tools.) operated by trades people that rely on a number of skills, both manual and intellectual. In short, the distribution of any single innovation is not easily scalable and hence MechSMEs are unlikely to undergo many of the rapid changes identified within the school of thought based on the new economy model. While industry-wide new economy-based changes are not likely to sweep the MechSME industry, parts of the industry are being affected by the replacement of some mechanical components (e.g. actuators and sensors) with electronic versions that perform the same function. In terms of organisational behaviour inside affected firms, the “disruptive” effects of these mechanical product replacements are likely to be found.

### *Intrapreneurship can solve everything*

Within this school of thought, intrapreneurship as a solution refers to the behaviour of personnel inside a firm when they are confronted with barriers to innovation. The classic function of these intrapreneurs, also known as project champions, is to overcome the barriers to innovation that exist for the particular innovation they are championing (Robinson, 2001). The organisational level of the champion determines which of these barriers they can address. For the owner/manager there are few restrictions on the barriers they can address. On the other hand, a champion situated at a lower level within the firm is not likely to address issues associated with difficult access to capital or the development of incentives to support innovation. They are however, likely to be able to impact work load pressures and time to implement ideas by working longer hours and convincing other members of the firm to set aside day-to-day work and work longer than normal hours to advance projects of interest to the champion (Kidder, 1981).

Another important consideration that impacts this school of thought as it applies to mechanical manufacturing is that the barriers to entry are quite low for the industry as evidenced by the high rates of entry (e.g. in Canada between 1998 and 2003, the number of establishments in NAICS sectors 332, 333, 336 and 339 increased by 67.7% for a net growth of 842 establishments (Statistics Canada, 2003). In addition, the increased frequency of informal interactions that characterize the behaviour within SMEs (Vossen, 1998; Rothwell and Zegveld, 1985) makes tolerance of an organisational 'rule-breaker', seen as being required for intrapreneurship to flourish (Howell et al. 2005) more difficult to accept. This is likely to be the case for SMEs because of the higher relative profile any culturally abnormal rule-breaking activities are likely to have within the smaller community of actors within the firm. The combination of the restricted number of opportunities for promotion associated with the small size of SMEs, the expectations of decreased tolerance for rule breaking and the industry's low barriers to entry likely means that few champions with sustained ambition are likely to be found inside SMEs. Ambitious champions are more likely to leave the organisation to start their own organisation rather than continue a long term effort to overcome whatever organisational inertia exists. As a consequence, over the long term it likely is difficult to develop skill sets that support championing (Robinson, 2001) within significant portions of the SME's workforce.

### *Organic*

Within this school of thought managers are encouraged to manage organically using egalitarian approaches while performing broad environmental scans to produce large numbers of ideas that may or may not be related to their existing business. The bulk of the research that supports this school of thought has been performed in either internet-based environments (Kanter, 1998) or within large (Amabile, 1988; Kanter, 2000c) or “world-class” organisations (Kanter, 2000b, p.1). Key differences between these research settings and MechSMEs include decreased product scalability, increased difficulty in accessing capital so that riskier proposals are more difficult to finance (Freel, 2000), and a lesser ability to defend their intellectual property protection resulting in reduced expectations of economic rent from successful innovations (von Hippel, 1998; Zahra and Nash, 1995). In short, it is not likely that management methods aimed at producing quantities of ideas aimed at unrelated business areas find favour within MechSMEs.

### *Disciplined*

This school of thought suggests that management should be mechanistic and scanning for ideas should be performed only in areas related to existing businesses (Pearson, 2002; Drucker, 2002; Levitt, 2002). Once ideas survive initial screening then extensive formalized project planning and evaluation of the proposed new product or service is suggested (Cooper, 1990). All of these activities are oriented to reducing the risk attached to the inherently uncertain activity of innovation.

With respect to MechSMEs, the primary activity of this industry is to produce tangible goods by altering materials through a combination of physical and thermal forces. The personnel that design and produce these goods are trained to apply these physical and thermal forces to produce highly reproducible results without surprises. They are trained and continue to work toward eliminating uncertainty in the results of their work. When choosing a method to pursue inherently uncertain innovation, it is likely that these personnel will continue to try to eliminate uncertainty and as a consequence will find the disciplined approach to innovation to be very appealing.

### *Organic then Disciplined*

This school of thought attempts to borrow from the strengths of the two previous schools of thought and seems to have appeal on its face as a method for managing



innovation. The problems that arise from this school of thought are in the details, are not immaterial and should be examined in light of the characteristics of MechSMEs.

The extant literature recognizes the difficulty in switching between organic and disciplined modes of innovation management and some scholars have suggested alternate arrangements to access the benefits. Planning and designing new products simultaneously based on several temporal modes, (including current thinking to keep the project advancing, at launch, during production, as part of a sequence of new products, and during disposal) is suggested as a useful method to anticipate future problems while designs can still be altered (Verganti, 1999).

Other work has identified innovation management methods that function based on more control over the direction of innovation projects being exercised by senior managers while organic internal team processes are encouraged to meet the challenges laid out by senior management. These include

- structural rearrangements that create innovation-specific groupings (such as skunk works, venture capital arrangements) which then strive to meet the challenges set out by senior managers (Quinn, 1986);
- fairly fluid semi-structures oriented around meetings, schedule updates, and ongoing inexpensive testing of concepts for future product plans (Brown and Eisenhardt, 1997);
- formal signing of ‘contract books’ by employees recruited by managers to create the deliverables for the project in question (Kidder, 1981); and
- the metaphor of improvisational theatre wherein innovators ‘perform’ about a ‘theme’ set by senior management in front of ‘live’ customers (Kanter, 2002).

In all cases, organic internal team processes are controlled to a purposefully limited degree by the overall structure that is set by senior management.

The problem of switching between organic and disciplined innovation management goes to the matter of when or where this switch should occur. For example, when should the control attached to disciplined innovation management methods be enforced and who should be controlled or do the controlling? Is it possible for a senior manager who must be part of the innovation team because of his/her skills to divorce himself/herself sufficiently from the team to provide credible discipline to the overall

process? These power-related questions become particularly troubling in MechSMEs characterized by small management groups and among personnel whose first reaction is to embrace certainty over uncertainty.

Managing innovation according to this school of thought also requires that the senior manager(s) do situational management without reference to an innovation framework (such as stage-gate) to advise them when to initiate the not insignificant task of applying disciplined, mechanistic management methods to a project that has succeeded until then using organic methods. On its own, the cultural shift inside the innovation team that is required is significant. An additional barrier to effectively managing this switch inside MechSMEs goes to the unsuitability of technical entrepreneurs as managers (Freel, 2000).

Given these constraints imposed by the characteristics of MechSMEs it is likely that a switching process is not used very often within this context and this is confirmed by the data gathered from MechSMEs in a study focused on new product development methods among manufacturers of varying sizes (Verganti, 1999) . Most of the research previously mentioned does not address these questions within the framework of MechSMEs so this is an area of exploratory interest for this research project.

The previous sections of this thesis have reviewed the innovation-related literature which focuses on particular aspects of innovation. Much of this literature has attempted to assess whether correlations exist between the particular aspect in question (e.g. firm size, culture, structure, operating strategy) and the difficult-to-define dependent variables of innovation or innovativeness. The sometimes contradictory results that arise when findings from one context are tested for replication in another context, has led some researchers to suggest that innovation is context-specific.

### **2.7.3 Innovation processes**

These disappointing conclusions have led other researchers to taking a more holistic approach to the topic by empirically assessing the processes of innovation in a number of different contexts. As illustrated by the listing of the results of these efforts in Table 2.4, the bulk of the innovation process research has taken place within large firms.

The aforementioned SAPPHO project is an early example of research into innovation practices. This was a retrospective analysis comparing the practices used to create pairs of innovations within the chemical and scientific instrument industries (Rothwell et al. 1974). The practices used to produce the innovations were found to have statistically significant effects on the commercial success of the innovation in question. The limitations of retrospective analysis were addressed through a comprehensive longitudinal study of 14 diverse innovations during the '80s and '90s (Van de Ven et al. 2000). This study found that the management of the process of innovation was just a method of improving the chances of success, but they did not find any methods that guaranteed innovation success although there seemed to be certain elements that appeared to add to the likelihood of success. Table 2.4 provides details of these findings.

At about the same time as these longitudinal studies were taking place, the concept of stage-gate systems for NPD was being developed (Cooper, 1990). This system offered the attraction to managers that they could inject some certainty into the mysterious NPD process as long as they worked assiduously to plan and control the process, set the targets for the process and control the resources attached to particular projects. Several survey-based studies have focused on using the disciplined iterative step-wise, hands-on approach to innovation as their benchmark for effective innovation management (Cooper and Kleinschmidt, 1995; Griffin, 1997; Brown and Eisenhardt, 1995; Tidd and Bodley, 2002). Critics of this approach suggest that the efforts required by innovation team members to acquire resources to move to the next step are wasted and serve to delay project completions (Anderson, 1996). Other authors have conducted research using a comprehensive longitudinal case study method to follow innovation projects that require high levels of technical expertise. They found that management is better to set the objectives for the work and then adopt a hands-off approach to allow a variety of organic internal team practices develop to achieve these objectives (Kidder, 1981; Johannessen et al. 1997). What is not clear is whether the findings that hands-on management works in one context and hands-off management works in another context is because of the differences in requirements for technical expertise or is the result of the methodology used by the researchers. The difference in the findings serves to further illustrate why there is conflicting schools of thought on the right amount of management discipline to use for effective innovation management.

Table 2.4 Descriptions of empirical research of innovation processes

| Type of IP described   | Empirical Research type   | Size of firms studied                                    | Industry context   | Author                          | Principal finding(s) in brief  |
|--|---|--|--|---------------------------------|--|
| <i>Large firm innovation processes</i>   |   |  |  |                                 |  |
| Comparison of use of stage gate systems to success measures of innovation programme  | Large <i>n</i> survey of new product development (NPD) practices in use | Large  | Mfrs of chemicals, electronics, mechanical products and food           | (Cooper and Kleinschmidt, 1995) | Key drivers of innovation performance in order of importance are 1) a high-quality new product process, 2) a clear well-communicated product strategy, 3) adequate resources for NPD, 4) sr. management commitment to NPD, and 5) an entrepreneurial climate for product innovation.   |
| Innovation described as nine step process, 1) product line planning 2) strategy development 3) concept generation 4) concept screening 5) business analysis 6) development 7) test and validation 8) mfg. development 9) commercialization | Large <i>n</i> survey of NPD practices in use                           | 72% large, 28% SMEs                                      | Mostly goods manufacturers that are PDMA members and interested in NPD | (Griffin, 1997)                 | Overall, best practices are evolving. Most respondent firms use stage gate processes, best practice firms are more thorough in use of NPD process. Innovations are moving towards incremental as opposed to radical. More ideas are being screened out earlier in the process without affecting overall success rates. On average, firms use multiple organisational structures for NPD with appointed project manager predominating. Rewards are predominantly in-firm recognition-based, not explicitly financial. |
| Step-wise, iterative product development vs. shared and compressed product development   | Quantitative, sampling of 72 product development projects in 36 firms   | Large  | Global computer industry   | (Eisenhardt and Tabrizi, 1995)  | When responsibilities were shared among multiple innovation teams working in parallel on parts of the development within hostile environments, this method was faster to deliver product innovation than compressed step-wise progression throughout the innovation process. For benign environments, compression is more effective. Schedule incentives aren't significant contributors.  |
| Innovation practices for routine and novel NPD projects compared   | Survey of 50 projects in 25 firms                                       | Not described but given descriptions likely fairly large | Chemicals, pharm'cals, consumer durables and food                      | (Tidd and Bodley, 2002)         | Cross-functional team use is common, increased novelty used more market research and more steps in process.  |

Table 2.4 (cont'd)

|  |   |  |                                       |                        |   |
|--|---|--|---------------------------------------|------------------------|---|
| Comparison of step-wise stage-gate type development practices to development practices focused on acquiring required knowledge when it is needed | Combination of comprehensive case studies and industry examples   | Large  | Aircraft, automobile, and electronics | (Anderson, 1996)       | Both integrated product development (IPD) and phased product development (PPD) are better than laissez-faire approaches to NPD. PPD systems should be utilized as an entry-level method for NPD, but as sophistication and experience increases, organisations should move towards IPD.   |
| Methods to increase creativity of innovation teams   | Surveys of project managers   | Not specified                                  | Consumer products                     | (Sethi et al. 2002)    | Innovations teams have highest levels of creativity when degrees of cross-functionality and group cohesion are moderate. Too much cohesion stifles candid debate and too little results in replacement of group goals with other goals.   |
| Technological pioneering   | Survey of managers and case studies   | Not specified                                  | Not specified                         | (Zahra and Nash, 1995) | Successful technological pioneering requires senior management involvement, formation of complementary strategies and organisational structures. On average, incumbent sales begin to drop 14 years after new technology introduced. Patents/copyrights found to be ineffective protection of intellectual property. Technological pioneering found to be quite risky but can rewrite the rules of competition to the advantage of the pioneers. Pioneering within established technology supplier requires duality of administration that supports old and new technologies. |
| Evaluation of roles of market research, R&D, integration of innovation processes for two industries  | Case studies of paired comparisons of innovation practices for 29 success/failure pairs in two industries | Large for chemical, some small for instruments | Chemical and scientific instruments   | (Rothwell et al. 1974) | The SAPPHO project found binomial statistical support to state that the following factors increase the chances of a creating a commercially successful innovation. <ul style="list-style-type: none"> <li>1) thorough understanding of user's needs,</li> <li>2) efficient but not necessarily quick development</li> <li>3) presence of an effective project champion</li> <li>4) effective internal and external communications</li> <li>5) level of marketing and sales efforts</li> </ul>   |

Table 2.4 (cont'd)

|   |  |                    |  |                                  |  |
|---|--|--------------------|--|----------------------------------|--|
| Project management  | Essay and 5 case studies   | Large              | Construction project management vs. IT system implementation | (Sauer et al. 2001)              | Purchasers of new IT systems for financial services organisations could learn from high levels of support for project management provided in construction industry.  |
| Heavyweight, lightweight, functional and autonomous development teams   | Case studies of innovation team structures   | Large              | Telecom and automotive                                       | (Clark and Wheelwright, 1992)    | Innovation teams with heavyweight leaders are smaller and more efficient than teams with functional leaders. Heavyweight leader's role is to override resistance within functional groups whose services are required to complete the innovation project. Heavyweight led teams require a project charter described in a contract book. Heavyweight leaders should be co-located with team and have career responsibilities for team members. High turnover rate after project finishes. |
| Cross-functional business process teams that had both NPD and profitability responsibility for particular markets | Case study of Rubbermaid corporation in mid-'90s   | Large              | Mfrs of injection moulded plastic products                   | (Amabile and Whitney, 1997-)     | Cross-functional entrepreneurial team of executives had extensive history of success within the firm. Growth required replication of team at lower management levels. Results were varied with some variance attributed to conflicts with functional structure. Team chemistry, written objectives, innovation metrics and top management support are more important than expertise of team members.   |
| Examination of collaboration in NPD   | Grounded theory qualitative study consisting of interviews of R&D, production and marketing managers | Mid to large sized | High technology  | (Jassawalla and Sashittal, 1998) | Degrees of collaboration that results in cross-functional teams is affected by 1) equitable levels of interest in the outcomes by team members, 2) transparency of knowledge between team members, and 3) constant mindfulness of the broader picture that affects the firm. Synergy should result from higher levels of collaboration.  |

Table 2.4 (cont'd)

|  |  |                     |   |                                  |  |
|--|--|---------------------|---|----------------------------------|--|
| <p>Creation of project charter by management, recruiting and signing on of key players to meet challenge, internal project team dynamics</p>   | <p>Extensive longitudinal case study of programme of major technological innovations</p> | <p>Large</p>        | <p>Computers</p>  | <p>(Kidder, 1981)</p>            | <p>Within this industry, the challenge of the work and competition to be the best problem solver on the team drives personnel to extraordinary levels of effort. Effective management requires that 1) the bar is set and kept high enough to challenge participants, 2) management allows internal team dynamics to develop without interference, and 3) loose HR practices are important to allow dynamics to develop. Other findings include that once the challenge is completed team member turnover is difficult to prevent as these members actively seek out the next challenge.</p>   |
| <p>Process teams, innovative output and their impact on productivity</p>   | <p>Comprehensive case study of one firm over four years</p>                              | <p>Large</p>        | <p>Shipbuilding</p>                                       | <p>(Johannessen et al. 1997)</p> | <p>Teams organized around their 'ownership' of an important process within the firm were found to create process improvements at a high rate. Productivity improvements were substantial. The authors extended their findings to an unsubstantiated opinion that invisible tacit knowledge assets embedded within personnel are the only source of competitive advantage that can be sustained over time.</p>  |
| <p>Three phases consisting of idea generation (induced by a discontinuity) development and rollout. IP is seen as a multiple start and stop process with a changing cast of characters</p> | <p>Long term longitudinal study following 14 innovations</p>                             | <p>Mostly large</p> | <p>Medical, electronics, not-for-profit organisations</p> | <p>(Van de Ven et al. 2000)</p>  | <p>IP team members use different metrics than investors, and metrics used shift over life of project. Good IP management increases odds of success but does not guarantee innovation success. Preferred IP management utilizes project champions, is flexible and uses peer pressure to meet deadlines. Typical emotional states of team members transition from an excited beginning to a concerned and sometimes depressed middle and finishing with an ending of shooting the culprits or honouring the heroes. Individuals often have troubles dealing with withdrawal after innovation becomes normal business. Corporate promotion practices deny project champion continuity within innovation teams resulting in project delays.</p> |

Table 2.4 (cont'd)

| <b><i>SME innovation processes</i></b>   |   |                                  |  |                             |   |
|--|---|----------------------------------|--|-----------------------------|---|
| Product and process innovation. Applying lessons learned from SME high-tech innovation literature to other industry contexts                                   | Survey of executives                                    | SMEs                             | Mfg., construction, communication and transport    | (Motwani et al. 1999)       | Executive's satisfaction with innovative actions measured against a number of IP factors. Found that factors positively related to process innovation are 1) actions for continuous improvement, 2) sector innovativeness, 3) internal management systems, and 4) structure for managing innovation<br>Product/service innovations were positively related to 1) sector innovativeness, 2) internal management systems and 3) structure for managing innovation. No causality claimed, suggested interviewing of managers is required to begin seeking out causalities. |
| Alignment with and servicing of principal customer/partner needs, through development of internal skill sets   | Case studies – 50 managers inside 5 manufacturers       | SME-sized firms                  | Mechanical and electronic tangible goods producers | (Barnett and Storey, 2000)  | These firms reacted to innovation demands of outside firm. Comprehensive linkages with outside firms seen as key enabler.   |
| Problem solving process is followed by entrenchment of solution as normal practice. Problem-solving process is aided by enhancement of innovative capabilities | Case studies of 5 firms. Interviews with owner/managers | Micro to medium-sized businesses | Both product and service providers                 | (Atherton and Hannon, 2000) | Innovation process model should be 1) build innovative capability (Olson et al. 2005), 2) solve problems using innovation, 3) lock-in new way quickly.  |



Other examples of innovation process-based research has used intrapreneurship and the presence and power of project champions as the basis for assessing the process (Amabile and Whitney, 1997-; Clark and Wheelwright, 1992) while others have focused more of their work and findings on the motivational aspects of the process (Sethi and Nicholson, 2001; Jassawalla and Sashittal, 1998). With respect to the SME-based work, the goals of these research projects appear to be to simplification of the innovation process into a limited number of guiding principles for managers (Atherton and Hannon, 2000).

*Table 2.5 List of opinions about preferred innovation practices*

| <b>Basis for opinion</b>  | <b>Examples used</b>        | <b>Size of firms</b> | <b>Industry context</b> | <b>Author</b>                | <b>Opinion offered</b>  |
|---|-----------------------------|----------------------|-------------------------|------------------------------|---|
| All companies must innovate or they will die. Personnel create enough ideas, but corporate culture stifles too many ideas.  | Hewlett-Packard, 3M, Dupont | Large                | Varied                  | (Kanter, 1997)               | Upper management must create culture and invest resources to provide encouragement to try for personnel. Firms must take chances with new ideas and new practices, some of which will inevitably fail, but this is the only way to fill the new product development funnel with enough ideas to survive.  |
| Literature review of organisation-oriented innovation management research. Areas assessed include rational planning, communication web and disciplined problem solving. | Multiple                    | Varied               | Varied                  | (Brown and Eisenhardt, 1995) | Integration of three streams of research results in a single graphical model which represent the factors distilled from the previous research that assists product development. The broad factors proposed which lead to financially successful innovation include 1) team structure and leadership affects innovation process performance, and 2) team leadership, customers and senior management affect effectiveness of new product design. Finally the authors propose a combination of efficient innovation process performance, effective product design and a munificent market shape the financial success of the new product. |

Table 2.5 (cont'd)

|   |                                      |   |                                   |                    |   |
|---|--------------------------------------|---|-----------------------------------|--------------------|---|
| Innovation is linked to competitive advantage and to manage innovation it requires integration of technological, market and organisation change | Multiple                             | Mostly large                                | Multiple                          | (Tidd et al. 1997) | Systematic approach to innovation is more productive than laissez-faire approach. Suggests that managing innovation should focus on recognizing and understanding what makes innovation routines effective, then building and improving them.   |
| Results derived by example firms when they impose tight deadlines and expectations of innovative approaches on groups of managers               | Zurich UK, Siemens, General Electric | Large                                       | Insurance, Equipment              | (Schaffer, 2002)   | Factors which contribute to success of this approach to IP are 1) time resources devoted to innovation challenge combined with requirement by senior management that something happens – unstated but clearly understood preferences by senior management for failed trials over no trials, 2) iterative learning that results from quick cheap trials, (even the ones that fail), 3) clearly stated objectives for exercise that challenge the teams and 4) cross-functional team structure. |
| There must be some characteristics of large innovating firms which allow them to survive multiple waves of change.                              | Multiple                             | Primarily large but SMEs used as a contrast | Varied goods producing industries | (Pavitt, 1990)     | Long-term successful innovation programme management has the following characteristics: 1) the range of technology options depend upon accumulated competences, 2) methods are employed to achieve cross functional integration during the innovation process, 3) accumulated competences require learning, and 4) resource allocation decision accounts for potential learning outcomes.   |

In addition to these empirical studies of innovation processes in a variety of contexts, there is a notable body of literature that offers opinions about preferred innovation practices. A listing of these publications makes up Table 2.5. As the reader can see from the table,

almost without exception these articles are oriented toward helping large firms to effectively manage innovation and their suggestions for innovation practices mirror the debates among the various schools of thought on how best to manage innovation. The holistic approach to seek out some commonalities in innovation by focusing on innovation processes has provided further evidence of the disagreements in the literature about the details of how innovation happens inside large firms and of the gaps in the literature for MechSMEs. On the other hand, this holistic approach has identified some major elements of innovation that do appear to be in common, namely that innovations start as an idea, evaluations of the merits of each idea occurs from a number of different perspectives and that ideas undergo a transformative process to a state of usefulness before they are considered to have completed the innovation journey (Van de Ven et al. 1999). These three elements appear to be common across industry and firm size settings and are a robust place to begin to fill in the gaps in the literature surrounding innovation inside MechSMEs.

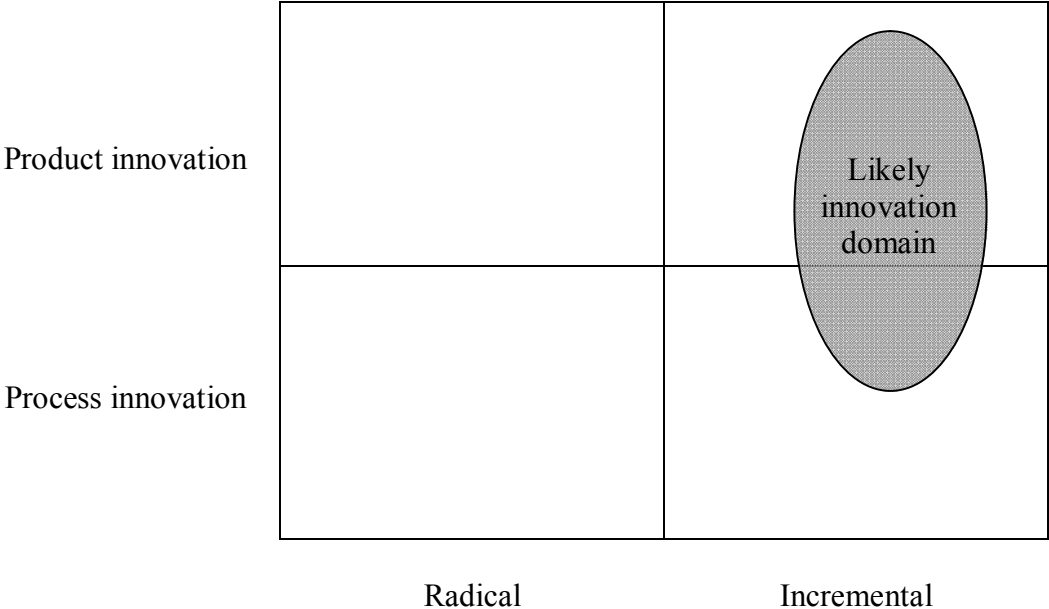
## **2.8 Summary**

In addition to the review of innovation definitions and metrics, this Chapter reviewed literature that focused on academic efforts to detail the presence, or lack thereof, of particular individual elements or sets of elements affecting innovation. Throughout the Chapter there are descriptions of focused work undertaken to describe innovation elements, or innovation practices, affecting specific competencies of the first order (e.g. technical, marketing or administrative expertise required for individual innovations) and descriptions of previous research focused on second order competencies involving building the ability to improve entire programmes of innovation (Daneels, 2002). In each case, the efforts have been focused around identifying variables of importance. While some have been identified for particular contexts, for the context of this research, a great deal remains unknown with supposedly ‘known’ facts disputed by other ‘known’ facts. In short, a great deal of confusion remains around the ‘silver bullet’ variables for innovation within SMEs. This Chapter also has described the body of innovation literature that approaches the innovation problem from the complex perspective that faces practitioners of innovation. Foci of this literature have included change management, and process studies of previous innovations.

To help make sense of the conflicts in the overall body of literature, six competing schools of thought about how to best manage innovation have been described. With respect to the applicability of these schools of thought to MechSMEs, each section contains comments on how the characteristics of MechSMEs may affect the fit of each school. The schools of thought oriented around knowledge management, new economy/disruptive innovation, organic innovation practices, and organic switched to disciplined innovation practices, are all discounted as being unlikely to be used within MechSMEs. Intrapreneurship in combination with disciplined innovation practices managed through a series of change management methods are all expected to be found in MechSMEs given their particular characteristics.

Additionally, the broadly based SME work of Baldwin and Gellatly (2003), the industry structure-based literature of Von Hippel (1998) and innovation dynamics literature of Utterback (1994) suggests that because MechSMEs are manufacturers of mechanically-based assembled products, they are most likely to be found pursuing a mix of incremental product and process innovations with more of an emphasis on product innovation. For a graphical representation of the expected area of study for this context, see Figure 2.1.

*Figure 2.1 Expected innovation domain for MechSMEs*



In terms of innovation practices, a generic but robust finding that innovation has at least the three elements of idea generation, idea evaluation and idea implementation is a good place to start to begin documenting innovation practices within MechSMEs.

## **Chapter 3 Research Question and Methodology**

This Chapter begins by synthesizing the literature reviews from the theoretical and practitioner contexts by briefly restating the gaps identified by other authors as it applies to SMEs and by describing other authors' comments about the state of contradictory arguments in the overall body of innovation literature. These comments are then connected to the rationale for focusing research on innovation processes and individual innovation practices inside MechSMEs and the research question that emerges to begin addressing the gaps and confusion in the extant literature. With the research question established, the ensuing discussion describes the rationale used by the author to select the primary research methodology.

### **3.1 Summarizing description of innovation literature**

Gaps in our understanding of the definitions of innovation, change management practices and innovation metrics within SMEs exist primarily because the literature in these topic areas have utilized larger organisations as their principal research context. Attempts have been made to utilise these results by direct transference into SME-based research (Motwani et al. 1999) with questionable results. For example, the innovation metrics research conducted by the PDMA (Griffin and Page, 1996) samples firms that are very focused on new product development performance and using these metrics inside SMEs has questionable merit when other literature has found that owners of SMEs (Chandler and Hanks, 1993) do not use any measures for innovation performance as part of their ongoing evaluation of how their business is performing. Similar transference problems between contexts are described in the preceding discussions of generic theories of the firm, with the resource-based view and learning organisation models appearing to be particularly inappropriate for use in the context of SMEs.

Very few efforts have been undertaken to describe innovation inside traditional craft-based SMEs such as MechSMEs, and this gap in the literature seems illogical to the author given

the economic importance of the sector. Other scholars have recognized this gap and that SMEs present unique characteristics for the challenge of innovation, and have called for additional research among traditional SMEs (Hoffman et al. 1998; Tidd et al. 1997; Edwards et al. 2005). Some attempts have been made to address these gaps and the calls for more research in the SME context. Unfortunately the work that has been done inside SMEs has mostly focused on new technology-based firms (Hoffman et al. 1998). The few exceptions that have focused their research inside manufacturing SMEs have attempted to begin addressing these issues, but each study has shortcomings.

For example, the findings from the large sample cross-contextual work in Canada (Baldwin and Gellatly, 2003) are diluted by the broad nature of the sample to the point of limited usefulness within MechSMEs. The French efforts (Motwani et al. 1999) used very small sample sizes (87 firms across four sectors) and a single respondent from each firm and normative-functional studies based on variance methods to test models developed within high technology firms. The questionable accuracy of single respondent data compounds the problems of the small manufacturing sample size bringing into question whether the findings are useful. Using a different approach, multiple respondent data was gathered from a larger manufacturing sample size in a study based in Utah (Chandler et al. 2000) and produced findings as they relate to the creation of an innovation-supportive culture. Unfortunately, the findings included that perception of such an internal culture is not a necessary condition to help grow the firm financially (Chandler et al. 2000) except in hostile and dynamic business environments. This limits the utility of the finding to those situations which fit the specified environment. British case study work (Barnett and Storey, 2000) focuses on firms that have formed comprehensive relationships (e.g. interlocking ownership, and joint ventures) with customers. Unfortunately, these special cases are not likely to be representative of SMEs in general and MechSMEs in particular and as a consequence, do not address the author's interest in learning about how innovation happens inside traditional MechSMEs.

Refocusing the lens onto the larger body of innovation literature displays a great deal of disagreement between scholars as to how innovation happens or even what it is (Drazin and Schoonhoven, 1996; Edwards et al. 2005). This "wealth of contradictions" (Friedmann and Maurer, 2003, p.1) has led these authors to observe that the state of the literature describing

the management of innovation practices is much less mature than for other management practices (e.g. total quality management, and Six Sigma). Similar comments reflecting on the state of confusion are echoed by researchers within the NPD community (Brown and Eisenhardt, 1995; Maidique and Zirger, 1985). Other articles researching the relationship between innovation and profitability have brought into question the broader ‘innovate or die’ mantra that is prevalent throughout the innovation literature. For example, the work on the relationship between profitability, market niche, organisational structure and innovation orientation (Olson et al. 2005) found that for certain settings (i.e. firms competing based on being low-cost producers) product innovation harms profitability.

In summary, it would be difficult to argue objectively that there is significant agreement within the literature about how innovation happens within SMEs and that a previously agreed-to model could be tested within the more defined framework of MechSMEs. As a consequence, any research done in this operating context must be exploratory at least to some degree.

### **3.2 Rationale for studying overall innovation processes and individual innovation practices.**

Once the gaps in the literature surrounding innovation in SMEs were identified, this raised the question of what approach to use to begin filling these gaps most effectively. The chosen approach needed to be broad enough to capture all of the material innovation practices and cope with an extensive SME innovation knowledge gap. An additional requirement was that the approach must be able to deal with the multi-dimensional characteristic and temporally dynamic nature of innovation (Van de Ven et al. 2000; Edwards et al. 2005) and the mutual simultaneous shaping of the process variables that occurs during the innovation process.

Researching the processes involved with innovation offers this breadth of approach and its longitudinal nature allows for documentation of changes in the innovation practices as the process unfolds. Also, basing innovation research on the processes involved is a well-established approach to studying innovation (Rothwell et al. 1974; Kidder, 1981; Cooper,



1990; Sebra et al. 1994; Coughlan and Brady, 1995; Anderson, 1996; Cusumano, 1997; Johannessen et al. 1997; Jones and Stevens, 1999; Van de Ven et al. 1999; Van de Ven et al. 2000; Verganti, 1999; Von Hippel et al. 1999; Barnett and Storey, 2000; Hargadon and Sutton, 2000; O'Connor and Rice, 2001; Keegan and Turner, 2002) and satisfies the recent call for innovation process-based research within SMEs (Edwards et al. 2005). Using the processes of innovation also offers flexibility as they play a role in all of the known types of innovation, including product, process, and service, so that any management prescriptions developed are more likely to become generically useful within firms with similar characteristics. In addition, researching of innovation processes provides a unifying theme to draw together the extensive but fragmented literature. Finally, research into innovation processes offers a useful comparison point for both micro and macro research in other sectors.

In order to improve the utility of these process findings for practitioners, it is important to consider their frame of reference and note that previous research has found that managers do not manage overall innovation processes at the programme level (Griffin and Page, 1993; 1996). As a consequence, they are not likely to be well-versed in thinking in terms of innovation processes. Alternative terms offered in the extant literature include 'routines' (Nelson and Winter, 2002), 'capabilities' (Dosi et al. 2000; Lawson and Samson, 2001) and 'innovation practices' (Brown and Maylor, 2005). Each of these in turn offers a slightly different unit of analysis to describe the same general area of management. For example, routines imply sets of repetitive activities; capabilities refer to abilities as opposed to a set of activities and innovation practices refer to either sets of activities or individual activities.

To facilitate transference of these findings to practitioners it is important to frame at least the prescriptive findings in terms of the smallest, most manageable portions of the innovation process. Using innovation practices as the unit of analysis offers the lowest level of abstraction and stating the prescriptive findings in these terms is the likely the most effective method to offer accessible language to practitioners.

### **3.3 Research question**

Earlier in this thesis, the principal objectives of this work were identified as informing the ongoing debate about key factors for firm innovativeness and providing specific practice prescriptions for managers of SMEs. After reviewing the broad and varied body of innovation literature, a number of important knowledge gaps about innovation in SMEs have been catalogued. Finally, an argument has been made to address these knowledge gaps through innovation process research within a context that should be a particularly rich source for studying innovation practices over which managers have primary control. The synthesis of the research objectives, the scanning of the existing knowledge base and a thoughtful approach towards how to fill these gaps results in the following research questions:

*Within mechanically-based SMEs, what innovation practices are used and how do the various members within the firm evaluate their innovation performance? Are there any common elements that seem to be important to contributing to their firm's innovativeness?*

Answering these questions should begin to address the author's objectives for this thesis. The knowledge gained should provide a useful empirical background to comment on the utility of the competing schools of thought and provide the raw materials to begin building useful management prescriptions for managers within this particular context.

Consideration of which methodology should be used to assess the research question begins with an assessment of the variety of methods previously used within the body of the innovation literature.

### **3.4 Previous innovation research methodologies**

There is ample evidence of a variety of methods being used to conduct research in the body of innovation literature (see Table 3.1). The methods have ranged from exclusively quantitative, large sample cross-contextual surveys to innovation-specific case studies. The existing literature also suggests differing approaches for determining the appropriate level for the research. For example, multiple authors have suggested that best practices for

*Table 3.1 Sampling of previous work that have used particular research methodologies*

| <b>Methodology</b>   | <b>Previous work</b>  |
|--|---|
| Cross-contextual, large sample size quantitative surveys       | (Miller and Blais, 1990; Chandler and Hanks, 1993; Cooper et al. 2000; Griffin and Page, 1993; 1996; Seborá et al. 1994; Coombs and Thomlinson, 1998; Daellenbach and McCarthy, 1999; Motwani et al. 1999; Bharadwaj and Menon, 2000; Chandler et al. 2000; Stewart, 2000a; Bonner et al. 2002; Baldwin and Gellatly, 2003) |
| Case studies at industry-level                                 | (Christensen, 1997; Kerssens-van Drongelen and Weerd-Nederhof, 1999; Barnett and Storey, 2000; O'Connor and Rice, 2001)   |
| Case studies at firm-level                                     | (Coughlan and Brady, 1995; Cusumano, 1997; Amabile and Whitney, 1997-; Collinson, 1999; Jones and Stevens, 1999; Von Hippel et al. 1999; Hargadon and Sutton, 2000; Salaman and Storey, 2002)   |
| Case studies of individual innovations or pairs of innovations | (Rothwell et al. 1974; Fischer, 1991; Van de Ven et al. 1999; 2000; Barnett and Storey, 2001; Harrison et al. 2001; Nijhof et al. 2002; Hubbard and Hayashi, 2003)  |

innovation are firm-specific (Teece et al. 1997; Coombs and Hull, 1998; Brown, 2000; Daneels, 2002; Edwards et al. 2005) suggesting that any attempts at generalization of innovation research results are doomed to failure. More optimistic findings suggest that best practices are industry-specific (Seborá et al. 1994; Baldwin and Gellatly, 2003).

On the other hand, a meta-analysis of 47 new product development studies (Montoya-Weiss and Calantone, 1994, p 398) within a variety of operating contexts resulted in their statement that “There is remarkable consistency in the results despite highly variable data sets, methodologies and operationalizations”. The consistent factors identified as being useful were paraphrased as: “Successful firms developed a superior product that is attuned to customers’ wants and needs and they have strong marketing and technical knowledge and skills to develop and launch the product” (Montoya-Weiss and Calantone, 1994, p. 407). The lack of specific advice for managers to account for differences in strategic positioning and industries (e.g. technical knowledge levels are significantly different for biotechnology firms than they would need to be for a commodity reseller) limits the utility of these broad targets for managers facing their own particular set of circumstances.

The author has opted to explore the middle ground between the beliefs that all innovation is firm-specific and cannot be generalized and the belief that the innovation puzzle has been solved and is generalizable (at least for new product development). This middle ground is aimed toward exploring whether specific useful innovation practices are shared by multiple firms within the same particular operating context. This multi-firm approach explores the firm-specificity issues while ‘controlling’ for industry-specific issues by studying firms who share a similar operating context. The degree of commonality of the findings among similar firms in similar situations should help to advance the discussion around the ability to generalize the findings of innovation research. This approach also satisfies a further objective to begin the identification of advice whose usefulness may prove useful for at least some practitioners. Whether the findings of this exploration later prove to be extensible to other operating contexts could be the topic for future research projects.

While the lack of a commonly preferred methodological approach in the extant literature does not provide guidance for the methodological choice, it does provide an opportunity to focus the thesis to answer the question at hand. The research questions focus on finding out *what* innovation practices are used, *how* innovation is measured and whether any innovation practices *seem to be important* contributors to firm innovativeness. The documentation of practices required to answer the *what* and *how* questions suggests some form of open-ended questioning to record the amount of common use among respondents. Use of previously-developed descriptors to form these questions, provides an opportunity to compare the results to previous research focused on similar research questions.

For the final portion of the research question, the objective of the question begins to approach an attempt to determine causal links between common innovation elements and firm innovativeness. The absence of agreement on any particular model to test and absence of agreement on the definition of potential dependent variables of innovation or firm innovativeness makes use of a deductive positivist approach to determine causalities difficult. This challenge however does not preclude the interest in beginning exploration of potential links between innovation practices and firm innovativeness.

Given the high levels of uncertainty in the existing body of literature, the significant gaps associated with innovation in SMEs, the need to address this gap of knowledge using

temporally dynamic innovation processes as the framework, and considering that questions exist as to whether innovation best practices can be usefully generalized, all confirms the appropriateness of using an inductive study to try to answer the research question. In the sections that follow, arguments are laid out for this thesis to be based on a methodology utilizing embedded case studies and why sampled firms have been chosen with a view towards demonstrating a point of redundancy in the findings. Finally, this Chapter concludes with a discussion of the operationalization of the case studies and the summarizing framework of typologies which informs the questions employed within the case studies.

### **3.5 Rationale for using case studies**

The justification for using case studies for this inductive study is grounded in three arguments beginning with a response to calls by other researchers for more case study-based research in the area. The second argument stems from the ability of case studies to cope with multiple levels of analysis. The final justification stems from an assessment of fit of the research questions with positivistic and naturalistic paradigms and an associated justification based on the situational characteristics of performing innovation process research inside MechSMEs

Firstly, numerous other researchers have called for more case studies in innovation research (Normann, 1971; Hoffman et al. 1998; Jones and Stevens, 1999; Barnett and Storey, 2001; Edwards et al. 2005) as they have speculated that internal organisational issues (e.g. path dependencies, resource allocation processes, and the requirement for innovation champions to overcome organisational politics-based inertia) are important factors affecting innovation that have been mostly missed by previous broad but necessarily shallow, quantitative research efforts.

Secondly, from a situational perspective, the influential methodology scholar Yin (Yin, 1981, p. 59) proposes that qualitative research is effective for “investigating a contemporary phenomenon within its real life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used”. The objectives of this research seem to fit both the category of “an arena of

complex research” and “a contemporary phenomenon within real life” and “in which multiple sources of evidence are used”. A wide scope of potential, holistically constructed theories has been suggested as the result of previous work, so the methodology must approach the problem with an ability to consider a wide scope. Qualitative, in-depth case study research has this capability. It also makes intuitive sense that in-depth case studies are more likely to unravel materially critical, internal socio-political issues (Hoffman et al. 1998; Jones and Stevens, 1999) and how the innovation practices affect firm innovativeness.

In his case study research design and methods text, Yin (Yin, 1989, p. 17) reviewed five different research strategies (experiment, survey, archival analysis, history and case study) against the form of research question and whether contemporary or historical events were being studied and whether control is required over behavioural events. He argues that using the case study approach is appropriate when the questions asked are *how*, *what* and *why*, and no control is required over behavioural events (i.e. no proactive experiment is being conducted) and the research focuses on contemporary events. For this research the questions broadly fit, as no behavioural control is required and the events being studied are broadly contemporary.

An additional consideration which supports the selection of the case study method are the previous findings which suggest that innovation processes are temporally dynamic (Cusumano, 1997; Van de Ven et al. 1999; Barnett and Storey, 2001; Edwards et al. 2005) and dynamic processes can be studied either using longitudinal design or by accessing respondent’s memories of events. While the latter approach carries with it a concern about potential for revisionism by respondents, it offers the advantage of research efficiency and the development of respondent’s perspective of historical events. Embedded case studies offer the opportunity to explore multiple temporal levels of analysis (Montoya-Weiss and Calantone, 1994) which adds to the richness and thoroughness of the understanding of innovation processes. In terms of this research, this operationalizes to questions about a recently completed innovation, a recently terminated innovation and an ongoing innovation. In addition, within case study methodology the ability exists to look at overall innovation policies and practices within the SME and to verify them against snapshot descriptions of recent innovation events and an ongoing innovation process. In summary, case studies are a

wholly appropriate method to learn about innovation practices inside SMEs and what role these practices might play in firm innovativeness.

Finally, from a philosophical perspective, the positivist paradigm suggests that reality is single, tangible and fragmentable, that time and context-free generalizations and nomothetic statements are possible and that there are real causes, temporally precedent to or simultaneous with their effects (from Table 2, (Bidgood, 1999)). The naturalistic inquiry paradigm offers another approach. This paradigm suggests that realities are multiple, constructed and holistic, that only time and context-bound working hypotheses are possible and that all entities are in a state of “mutual simultaneous shaping, so that it is impossible to distinguish causes from effects” (Lincoln and Guba, 1985, p. 37). As discussed in earlier sections, multiple previous innovation research efforts (many of which used a positivist approach) have concluded that innovation is context-bound at one level or another and that the research method used should include the ability to capture the temporally dynamic and multi-characteristic nature of innovation. In short, there is not a clear match within the positivist paradigm as an appropriate philosophical basis to study the phenomenon of innovation but there does appear to be a closer match to naturalistic inquiry. Case studies are one of the well-accepted methods of operationalizing naturalistic inquiry.

### **3.6 Analytic techniques**

Five alternative approaches are offered for analyzing data based on the research paradigm underpinning the inquiry (Lincoln and Guba, 1985). In order, the approaches offered include a) analytic induction, b) constant comparative method, c) typological analysis, d) enumerative systems and e) standardized observational protocols and their use is advocated across the continuum ranging from naturalistic towards the positivistic paradigm. Typological analysis is the selected approach and the rationale for this choice concludes this section. The shortcomings of the other approaches for this research project are described to begin this section.

The analytic induction method is a process wherein the researcher approaches the initial case without any preconceived assumptions and documents practices, events and comments. Out of this purposefully unfocused initial enquiry, the researcher suggests individual typologies that appear to arise and then modifies and refines these typologies

with subsequent cases. Part of the process in the subsequent case studies includes seeking negative incidents to confirm the presence/absence of proposed typologies. This method has not been selected as its inherent assumption is that any typologies developed in previous innovation work are completely useless and have no possible application to MechSMEs. It seems obvious that this assumption is nonsensical.

The constant comparative method is a similar process (it is basically a holistic version of the analytic induction method) wherein the researcher seeks to observe emerging typologies by simultaneous consideration of social incidents. “Thus, the discovery of relationships, that is, hypothesis generation, begins with the analysis of initial observations, undergoes continuous refinement through the data collection and analysis process, and continuously feeds back into the process of category coding. As events are constantly compared with previous events, new typological dimensions, as well as new relationships, may be discovered” (Lincoln and Guba, 1985, p.335).. This method is rejected for similar reasons as it is not a matter of a lack of innovation typologies, but more so finding which previously described typologies seem to apply for this context.

With an objective of providing benchmarks for managers in similar settings, the enumerative approach entails the counting of practices, events and comments to compare levels of use between firms with varying levels of firm innovativeness. While straight counts of innovation events (e.g. ideas generated, patents granted, etc.) or the R&D funds invested, or numbers of personnel supporting or resisting innovations, or innovation practices, may tell us something about the symptoms of innovation within the studied firm, the fact that the definitions and objective measures of innovation have not been widely accepted to the point it can be used as a dependent variable, means that the researcher cannot establish the optimum levels for each of the counted components of innovation. Even if benchmarks could be established, the presence of these objectives for managers does not include advice on achieving these objectives. Information about the management actions that result in the underlying innovation process that develops these numbers is much more immediate and useful. The lack of accepted definitions of innovation also causes uncertainty as to whether the metrics used are consistent.



The use of standardized observational protocols calls for the recording of well-accepted metrics by some combination of observation and participation in a longitudinal study of the process. Previous innovation process work ( Kidder, 1981; Jassawalla and Sashittal, 1998; Van de Ven et al. 1999; Tidd and Bodley, 2002;) details why the observational approach would be problematic from a logistical perspective as it describes how the innovation process takes place among an ever changing cast of characters in a variety of settings and often during unplanned events. These problems would argue for participation in the process to improve the coverage of events, however, this would still not accommodate comprehensive recording of the events given the multiple location nature of the process. In addition to these logistical problems, this method suggests that the observer/participant should record the occurrence of events that fit previously well-accepted innovation metrics. As has been stated earlier these do not exist. Even if well-accepted metrics did exist, they may have questionable utility. For example, if you consider that a benchmark ‘time to market’ for a new drug is established, this is probably two to three times longer than a benchmark ‘time to market’ for a new automobile. Clearly what might pass as exceptional performance for the latter would be disastrous performance for the former and standardization of any protocols by industry, or company size, or geographic location would be a patchwork system at best and it is questionable whether this would meet the test of being standardized.

Unlike the other suggested approaches, typological analysis offers a good fit with the state of the extant literature and the research question. It offers the advantage of using previous innovation-related findings that are likely to have utility inside MechSMEs. The developer of this method (Burawoy, 1991:26 from Daneels, 2002) made this observation: “The generation of theory from the ground up was perhaps imperative at the beginning of the sociological enterprise, but with the proliferation of theories reconstruction becomes ever more urgent. Rather than always starting from scratch and developing new theories, we should try to consolidate and develop what we have already produced.” This type of analysis has also been described as a process wherein “The researcher examines the literature relevant to his/her problem area, and employs the empirical data to fill in its gaps, reveal its flaws, elaborate its meaning, and extend its coverage” (Daneels, 2002). These advantages can be realized by the use of previously identified typologies as the source for the foci of the inquiry and when used in conjunction with a case study that employs both

these focused questions and open-ended questions, also offers the opportunity for new concepts to arise. Another benefit of using previously identified typologies centres around making dissemination of results more effective as communication with readers will use language they already understand.

In this research inquiry, the majority of the typologies that questioning was focused around were the robust generic innovation process typologies that included idea generation, idea evaluation, idea implementation, innovation enablers, and barriers to innovation. For a more detailed description of the typologies utilized see Section 3.8.1 on the operationalization of the typological case analysis and Appendix A for the list of questions used.

Finally, the use of typological analysis has another benefit in that will permit reflection on the earlier work (Nelson and Winter, 1982) that hypothesizes that routines of processes and practices that develop inside firms are the determining factors in the firm's continued survival in a changing environment. By focusing on typologies that include both innovation processes and practices, comment can be made on the existence and importance of routines within the respondent firms.

### **3.7 Sampling options**

Once the decision was made to perform an inductive study to engage in the theory-building process of what innovation practices are used, how they are measured and how they seem to contribute to firm innovativeness, the next question to be addressed is which firms should be sampled within the chosen context (MechSMEs) and how should these firms be selected for study. Three different approaches are suggested, purposive sampling, emergent sampling and sampling to the point of redundancy (Lincoln and Guba, 1985). The next paragraphs describe the strengths and weaknesses for applying each of the methods for this thesis. The conclusion of these arguments indicates that for typological analysis, sampling to the point of redundancy is the method that offers the best fit.

In the ideal situation, a list of firms within the MechSME context ranked by their relative innovativeness would suggest which firms should be studied. Using purposive sampling

based on a well-defined dependent variable of innovativeness, case studies of the innovation practices used by the most innovative firms would highlight practices that seem to aid innovation and the absence of these practices could be verified inside firms that were placed at the bottom end of the innovativeness table. As stated elsewhere, widely accepted definitions of innovation, or for that matter, innovativeness do not exist and no list exists from which the research targets can be chosen. This has not stopped other scholars from attempting to characterize the relative innovativeness of firms. A notable example of these efforts (Cobbenhagen, 2000) involved comprehensive canvassing of external industry experts for their opinions of innovativeness based on their own heuristic criterion (which varied by sector) among the potential target firms with the goal being to classify them as “front-runners or pack-members” (Cobbenhagen, 2000, p.70). These efforts were then triangulated for confirmation with researcher opinions and the opinion of the CEO or general manager. The Cronbach’s alpha of .67 for all three opinions marginally validated the dichotomous innovativeness rating, but surprisingly, there was a greater validity by dropping the inputs of the CEOs (Cronbach’s alpha =.72) indicating that firms seen by others as pack-members were often seen by their CEOs as front-runners.

The results of this study found of the fourteen hypotheses that were tested, seven hypotheses were not supported by the findings or were found to have opposite relationships to those postulated. Given these unexpected results and the individual heuristics used by the external experts and the disagreement with the CEOs who possess significantly more knowledge of their firms, raises the question as to whether the dichotomous innovation classification was accurate or even valid.

Given this uncertainty after this exhaustive effort to classify firm innovativeness was undertaken, leads to the conclusion that the creation of more useful multi-level firm innovativeness rankings would be a very difficult task to perform in a defensible manner. This uncertainty is consistent with the difficulties scholars and practitioners have had in getting agreement on innovation metrics described in Section 1.3. In conclusion, this suggests that the theoretically attractive practice of purposive sampling can not be carried out in a defensible manner.

The next sampling option offered is emergent sampling design (Lincoln and Guba, 1985) wherein the findings of one case study are used to assess which firms to target for the next case study with intent to build on the findings of the firm previously studied. This sampling method would be consistent with a grounded theory approach to building theory from scratch and this method is not consistent with the typological approach which aims to reconstruct and expand the coverage of previously described typologies. In addition, emergent sampling design for innovation case studies suffers from the possibility that the authors that believe innovation is firm-specific (Teece et al. 1997; Coombs and Hull, 1998; Brown, 2000; Daneels, 2002; Edwards et al. 2005; Baldwin and Gellatly, 2003) are correct. If this is so, then an emergent sampling design will be influenced to a great degree by the initial firms selected, and under the emergent approach, the initial firm selected is done at random. The net result is likely to be an unfocused study that may or may not answer the research question.

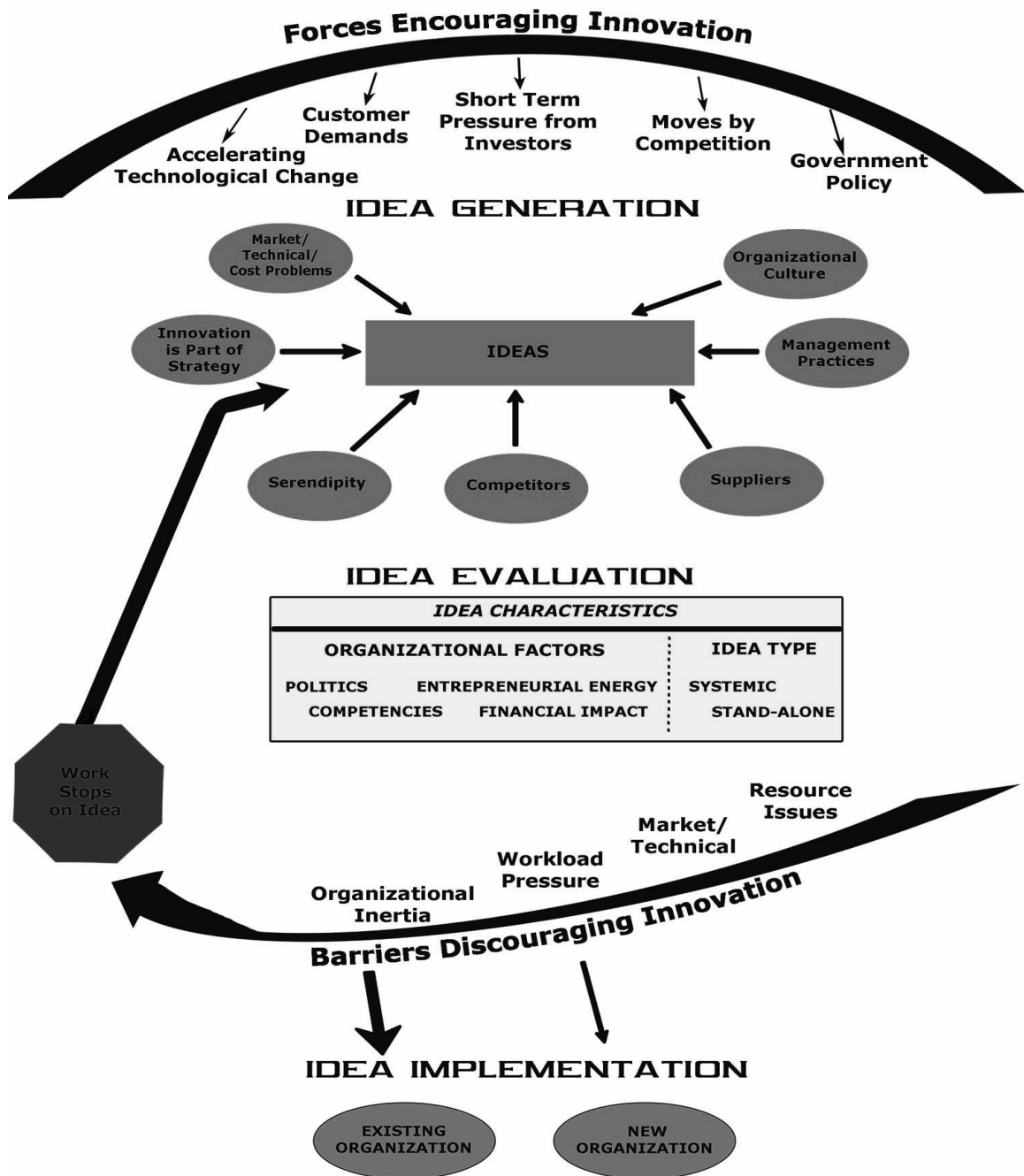
The final option offered is sampling towards the point of redundancy (Lincoln and Guba, 1985). In this method, sampling of firms goes on until no new substantial findings are being generated with additional case studies. For research using the typological approach, at the very least, this means that no new information appears to be arising for the previously identified typologies. In the best case scenario, any new typologies or theories that develop as the result of the series of case studies would also become redundant findings for all the case studies. This objective of redundant findings adds an additional filter to the sample description carried in Section 1.5 describing the rationale for selection of MechSMEs for study. Because these firms are assembled products manufacturers that compete principally on product differentiation, and as a result, customers are likely to have significant influence on design and innovation within the firm, only firms wherein no single customers made up more than thirty percent of their business were studied. Thirty percent was chosen as a limit as a practical compromise between limiting the number of firms available for study and limiting single customer influence). This was intended to limit the study to the internal innovation practices generated by the management of the similar firms, and to preclude the study of firms whose innovation practices were those of some single customer imposing their own criteria.

### **3.8 Operationalizing typological case study analysis**

Having chosen embedded case studies of selected firms as the most appropriate method, the next step involved operationalizing the process with a series of questions that would be asked of all firms. Reduction of the number of typologies to be asked about was the first task as the holistic nature of innovation has led to innovation-related typologies stemming from every functional business research area as well as from fields as diverse as psychology and neuroscience. Using a list of questions focused on the typologies of interest, and a format of semi-structured interviews that provide the opportunity for other concepts to arise, ensured that important concepts were not missed.

In order to bring some focus to the typologies to be explored, a summarizing typological framework was constructed that was used as a reference for interview questions to ensure no significant concepts have been missed. The elements of the framework were selected based on a criterion combining the frequency which they are mentioned in the literature and the author's assessment of the likelihood of application to this particular research context. Included in this summarizing framework were concepts arising from the theoretical paradigms, empirical observations and the literature organized around schools of thought about innovation. Review of the extant literature identified some major elements of innovation that do appear to be in common, namely that innovations start as an idea, evaluations of the merits of each idea occurs from a number of different perspectives and that ideas undergo a transformative process to a state of usefulness before they are considered to have completed the innovation journey (Van de Ven et al. 1999). These three elements appear to be common across industry and firm-size settings and are a robust place to begin to fill in the gaps in the literature surrounding innovation inside MechSMEs. This is an approach common with a number of other innovation research efforts (Van de Ven et al. 1999) wherein the research describes innovation as a process (Van de Ven et al. 2000; Edwards et al. 2005; Barnett and Storey, 2000; Cooper, 1990; Amabile and Whitney, 1997; Griffin, 1997; Coughlan and Brady, 1995; Clark and Wheelwright, 1992; Kanter, 1997; Tidd et al. 1997; Cooper and Kleinschmidt, 1995; Johannessen et al. 1997).

Figure 3.1 Overall innovation process



The resulting typological framework that follows separates the innovation process into three sub-processes, beginning with idea generation (either by creation or acquisition from others), followed by an evaluation sub-process that each idea must survive before it becomes subjected to the concluding development sub-process. Although the three sub-processes can be iterative and/or combined, these sub-processes have been set out from

each other for purposes of individual illustration. See Figure 3.1 for the graphical representation of the overall innovation process that has been used to ensure questioning is thorough during the interviews.

### 3.8.1 Idea generation

Figure 3.2 lays out the various practices and enablers of purposeful idea generation that have been most commonly identified in the literature.

*Figure 3.2 Purposeful idea generation*

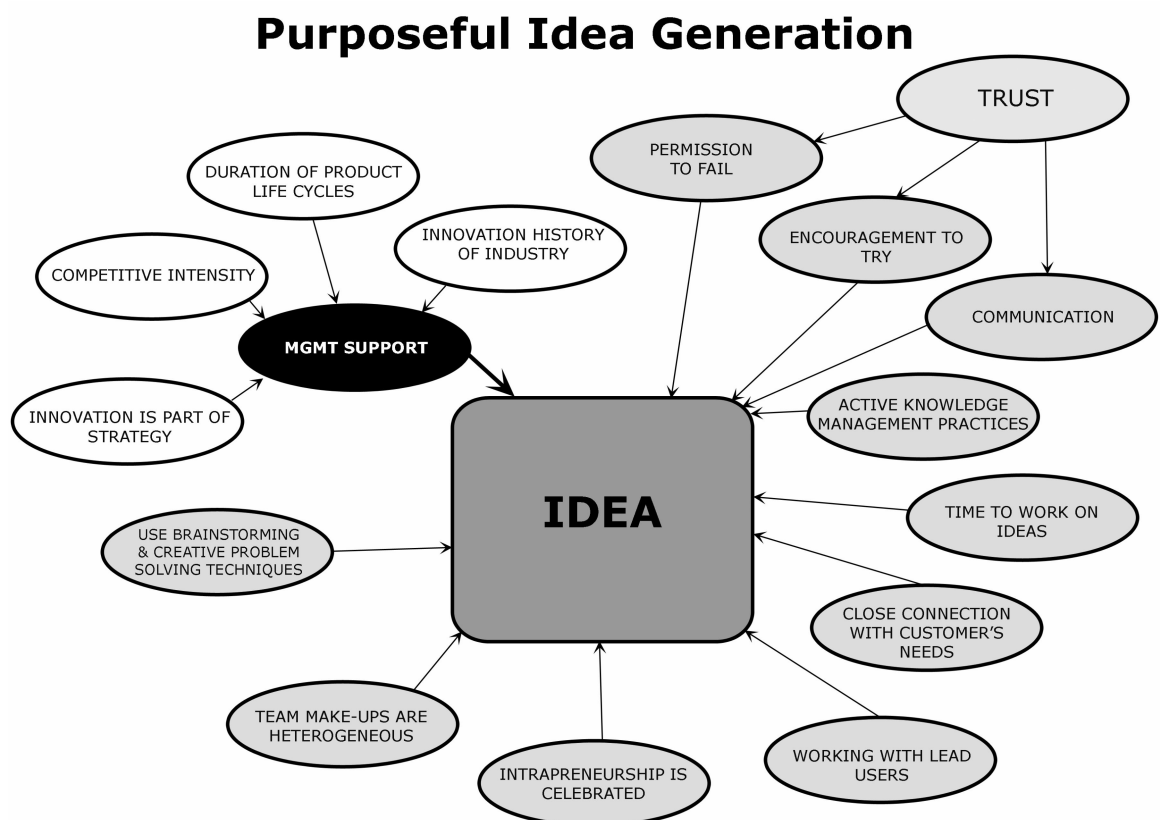


Table 3.2 provides a list of references from which the concepts of the Figure 3.2 are based.

### 3.8.2 Idea evaluation

Once an idea is created (and sometimes simultaneously to its creation), it undergoes an evaluation process by the involved parties. At times the practices used are formal and may follow a portion of the stage-gate process similar to that identified by Cooper (Cooper, 1990). In other circumstances, the parties make a very quick judgment and subconsciously

*Table 3.2 Antecedent and independent variable path references for Figure 3.2 Purposeful Idea Generation*

| <b>Antecedent Variable</b>              | <b>Independent Variable</b>                               | <b>References</b>   |
|---|---|---|
| Innovation history of industry          | Management support  | (Covin and Slevin, 2000; Chandler et al. 2000)  |
| Duration of product life cycles         | Management support  | (Kanter, 1998; Covin and Slevin, 2000)  |
| Competitive intensity                   | Management support  | (Montoya-Weiss and Calantone, 1994; Chiesa et al. 1996)   |
| Innovation is explicit part of strategy | Management support  | (Rothwell and Zegveld, 1985; Miller and Blais, 1990; Quinn, 1992; Zahra and Nash, 1995; Amabile and Whitney, 1997-; Kanter, 1997; 1998; Kerssens-van Drongelen and Weerd-Nederhof, 1999; Kim and Mauborgne, 1999; Lawson and Samson, 2001; Salaman and Storey, 2002)                            |
| Trust                                   | Permission to fail  | (Christensen, 1997; Brown, 2000; Chandler et al. 2000; Drucker, 2002; Farson and Keyes, 2002; LaBarre, 2002; Stein, 2000)   |
| Trust                                   | Encouragement to try                                      | (Kanter, 1997; 1998; 2000c; Chandler et al. 2000; Harrison and Laberge, 2002)   |
| Trust                                   | Communication   | (Kanter, 1989; Fischer, 1991; Damanpour, 1991; Bartlett and Mohammed, 1995; Brown and Eisenhardt, 1995; Brown and Eisenhardt, 1997; Chiesa et al. 1996; Scholl, 1999; Quinn, 2000; Farson and Keyes, 2002; Harrison and Laberge, 2002; Keegan and Turner, 2002; Galende and de la Fuente, 2003) |
|   | Active knowledge management practices                     | (Hargadon and Sutton, 1997; Coombs and Hull, 1998; Collinson, 1999; Hickins, 1999; Stewart, 2000b)  |
|   | Time to work on ideas                                     | (Amabile et al. 2002; Pearson, 2002)  |
|   | Close connection with customers' needs                    | (Quinn, 1986; Covin and Slevin, 2000; Bartlett and Mohammed, 1995; Teece et al. 1997; Amabile and Whitney, 1997-; Brown, 2000; Chesbrough and Teece, 2002; Pearson, 2002)   |
|   | Working with lead users                                   | (Von Hippel et al. 1999)  |
|   | Intrapreneurship is celebrated                            | (Bartlett and Mohammed, 1995; Covin and Slevin, 2000; Brown, 2000; Drucker, 2002)   |
|   | Team make-ups are heterogeneous                           | (Cooper, 1990; Anderson, 1996; Hargadon and Sutton, 1997; Johannessen et al. 1997; Kanter, 1998; Von Hippel et al. 1999; Pearson, 2002)   |
|   | Use brainstorming and creative problem solving techniques | (Kanter, 1989; 2000c; Hargadon and Sutton, 1997; Scholl, 1999)  |

evaluate the idea across many different parameters. In many cases, the literature suggests that the characteristics of the idea are measured along the continuum of at least the five dimensions shown in Figure 3.3. Regardless of the level of the formality of the evaluation, the characteristics of the idea determine the probable path for any further development of the idea as shown in Figure 3.3 below.



Figure 3.3 Idea Evaluation and Probable Destination

## Evaluation of Idea and Probable Destination

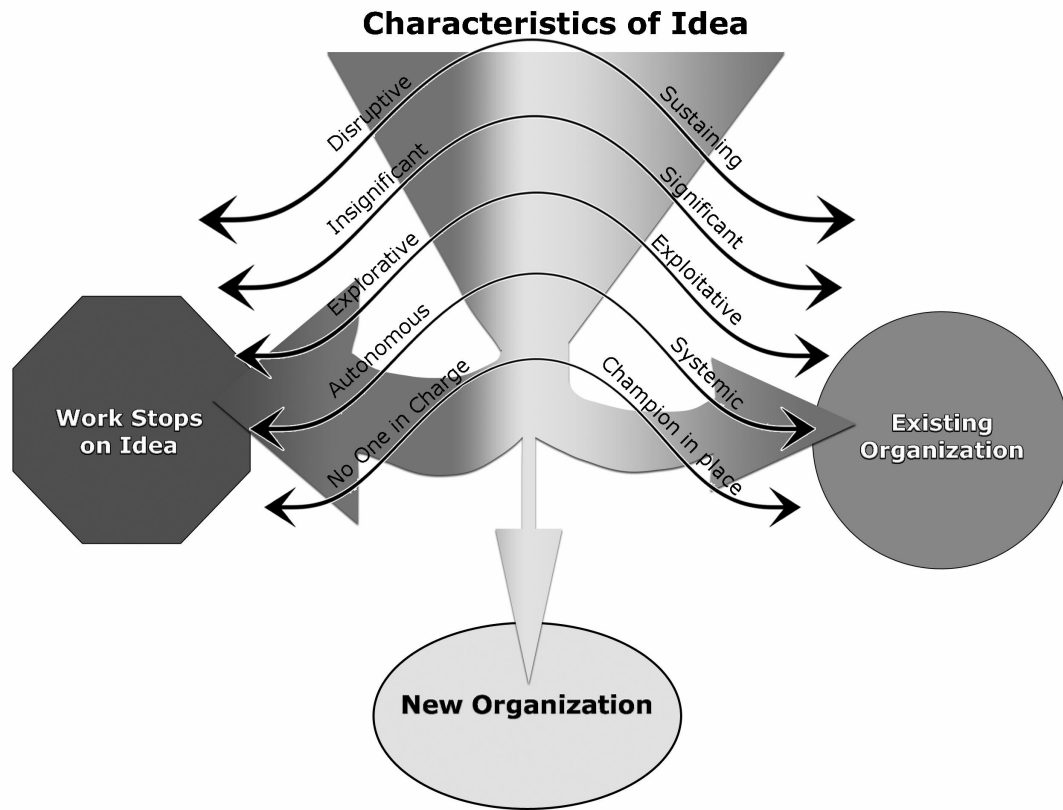


Table 3.3 References for Figure 3.3

| Idea Characteristics  | References   |
|---|--|
| Ranging between politically sustaining and politically disruptive ideas                       | (Christensen, 1997; Kanter, 2000b; Stewart, 2000a-)  |
| Ranging between financially significant and financially insignificant ideas                   | (Bartlett and Mohammed, 1995; Galende and de la Fuente, 2003; Kanter, 1989; O'Connor and Rice, 2001; Wolpert, 2002)  |
| Ranging from exploiting current competencies to requiring the exploration of new competencies | (Chesbrough and Teece, 2002; Daneels, 2002; Galende and de la Fuente, 2003; Quinn, 1989; Teece et al. 1997; Tushman and Anderson, 1986; Sutton, 2002b; Salaman and Storey, 2002) |
| Ranging from systemic to autonomous ideas   | (Chesbrough and Teece, 2002; Teece et al. 1997)  |
| Ranging between a champion promoting the idea to no one assuming responsibility for the idea  | (Leifer et al. 2001; O'Connor and Rice, 2001; Pearson, 2002; Quinn, 1986)  |

### 3.8.3 Idea implementation

As noted earlier, the implementation sub-processes are iterative and ongoing throughout the overall innovation process. A series of conditional approvals for continuing the development work on ideas are required to complete the transition from idea to innovation.

The literature describes the following characteristics as being typical of implementation practices:

- The work performed engenders a higher level of uncertainty than routine work (Cooper, 1990; Brown and Eisenhardt, 1995; Verganti, 1999; Turner and Muller, 2003),
- Any team or organisational structure created to perform the work is temporary and will not exist in that form once the innovation work is complete, (Cusumano, 1997; Khurana and Rosenthal, 1998; Turner and Muller, 2003) and,
- New ideas are linked to specific targets, either product/process/service targets or business targets (Khurana and Rosenthal, 1998; Turner and Muller, 2003).

A number of approaches have been observed that move ideas towards innovations. These include stage-gate practices (Cooper, 1990; Anderson, 1996), project management approaches (Cusumano, 1997; Keegan and Turner, 2002; Turner and Muller, 2003), planned flexibility approaches (Verganti, 1999) and organic management approaches (Khurana and Rosenthal, 1998; Kanter, 2000b). As the question framework is intended to provide a common question reference for research on innovation practices inside organisations, it is important that any subsidiary model is able to capture the common elements of the implementation steps in use. Given the variety of approaches used it is impossible to provide a detailed step-by-step implementation model that captures the variety of approaches, however it is still possible and useful to describe the common elements between the various approaches.

Without exception, all of the approaches begin with high tolerances for ambiguity, (Rothwell and Zegveld, 1985) significant flexibility in design and a willingness to work with ideas that are perceived as riskier than the norm by the value network of the firm. The

implementation practices then iteratively work towards reducing the perceived risk by increasing the firm's knowledge in the area of the idea, reducing the number of design options, (both of which address the fear of the unknown) and increasing the political investment by key organisational actors (as evidenced by approvals for financial

commitments to the idea). Another common element of all implementation approaches is that senior management plays a key role as a gatekeeper and/or cheerleader for the innovation in question. See Figure 3.4 for a graphical representation of the idea implementation process.

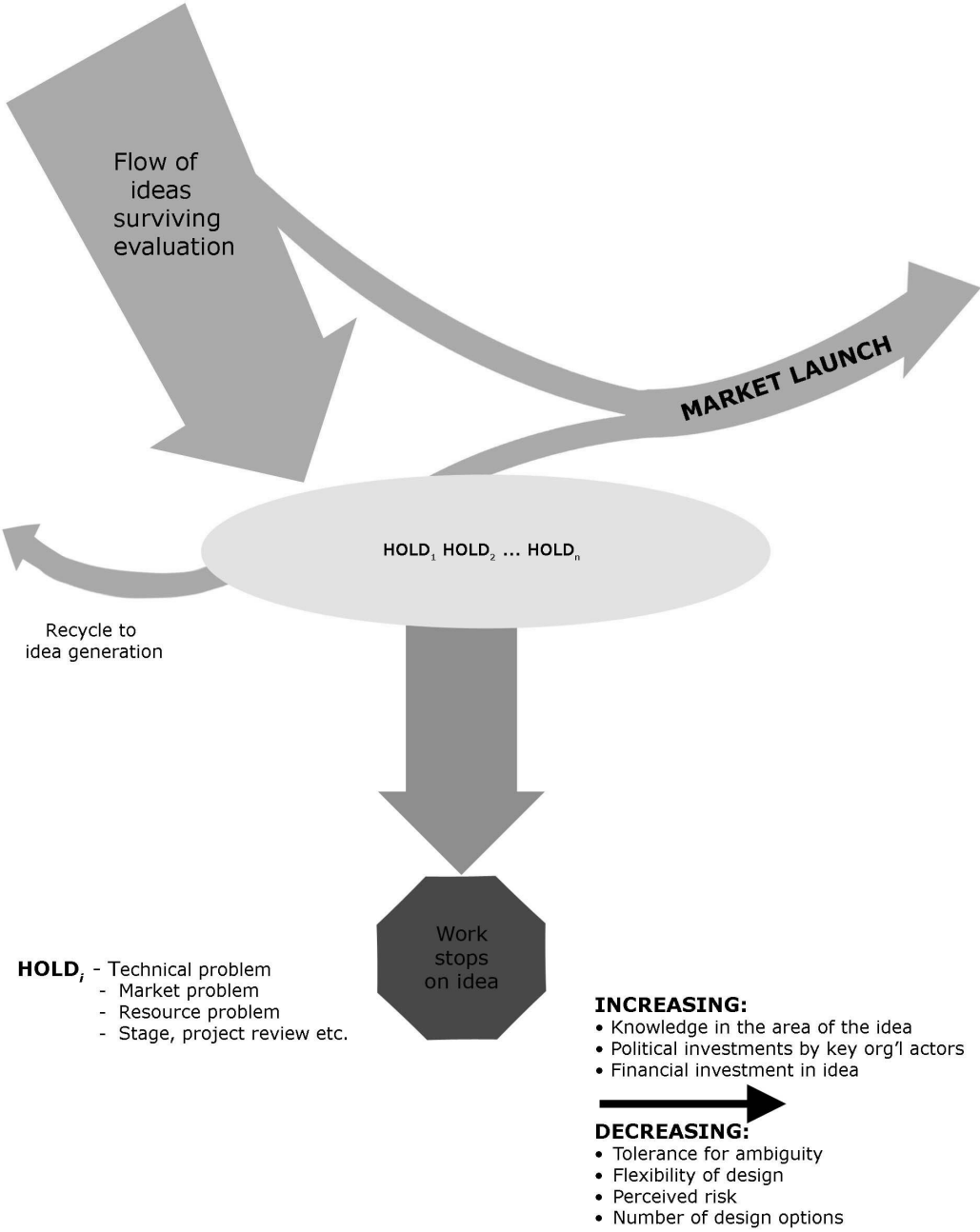
### **3.8.4 Linkages of question framework to theoretical paradigms**

The resource-based view of the firm and the learning organisation views of the firm are linked and combined within the framework. Knowledge management practices, as well as knowledge and existing competencies of the firm are all linked to learning organisation theory (Cohen and Levinthal, 1990; Collinson, 1999; Barringer and Harrison, 2000), but they also can all be labelled as a resource for the innovating firm (Quinn, 1986; Hargadon and Sutton, 2000). These resources are particularly important during the idea generation stage of the process, as part of the evaluation phase when new ideas are considered with respect to existing competencies and any additional competencies the new idea requires, and finally, as part of the implementation phase wherein experience with project management practices can be considered a resource.

On the other hand, the previous learning and resulting routines developed within the firm can act as barriers to the innovation as described in the knowledge-path dependency literature (Coombs and Hull, 1998; Daneels, 2002). Actor-network theory is the other major theoretical paradigm that is cited in the literature (Scholl, 1999; Storey, 2000; Harrison et al. 2001), and is utilized in the framework throughout all the major phases. The primary use is during the idea generation stage and the evaluation stage. During the idea generation phase, employees' self-interests can be satisfied if the management takes on some of the risks inherent to innovative thinking by ameliorating the risk of failure for the employees and truly valuing anything learned from the innovative effort. The result is that more ideas will surface. Actor-network theory is also relevant in the evaluation portion of the framework when an idea is evaluated for its effect on internal politics and the value network of the existing organisation. If the particular innovation in question does not satisfy all of the powerful actors' interests, then the innovation is very likely to be stopped.

Figure 3.4 Idea Implementation

# IDEA IMPLEMENTATION



Similarly if the network's social parameters are potentially disturbed by the idea being evaluated, then the innovation is likely to be stopped. Hence, actor-network theory plays a significant role in the barriers to innovation as well.

### **3.8.5 Limitations of the typological innovation process framework**

This framework is a visual summary of the innovation literature that is useful for focusing interview questions and ensuring that no material concepts are missed during the interview phase (see Appendix A for the list of questions asked). No firms are likely to enjoy all of the innovation enablers described or suffer from all the innovation barriers that have been outlined and the framework is too generic to be accurate for all innovation cases. Despite these weaknesses, the framework remains a useful tool to establish the context of the exploratory innovation research that the proposed research is directed towards.

## **3.9 Protocol for multi-firm case study**

The foregoing methodological discussion supports the use of typologically-based embedded case studies of firms that are MechSMEs that have been selected to realize an objective of achieving a redundancy of findings. The protocol employed for these case studies is similar to others previously used within the wider innovation field (Brown and Eisenhardt, 1997) and consists of the following steps;

### *Preparation*

- Review of the body of innovation literature with particular focus on previous innovation research inside small firms.
- Identification of lack of agreement in literature and gaps in literature for MechSMEs.
- Identification of typologies that should be explored using a summarizing framework as a check list.
- Preparation of a master question list to explore these key concepts. Open-ended questions added to allow for a balance of replication and openness to new concepts.

### *Identification of units of analysis/sampled firms/respondents*

- Sourcing of companies was based on personal contacts within SME-sized companies that produce mechanically-based, standardized goods located in the same provincial jurisdiction. (Note: Personal contacts were needed to acquire necessary time commitment to complete data acquisition. To acquire four case study firms, twelve firms were visited in person and another fifteen firms were contacted by telephone).
- Screening of firms was conducted based on whether a) the skill base as the bulk of employees was predominantly mechanical in nature, b) the firm was within the SME size range for this location (50-500 employees), and c) that no more than 30% of volume was sold to one customer (to ensure sources and effects of innovation are spread comprehensively throughout the firm and that they reflected management's objectives as opposed to those of an overly influential customer).
- A preliminary meeting was conducted with the senior manager to identify what he saw as being the three innovations that were 'most typical' of his firm. In order to capture the different innovation phases, managers were asked to identify their 'most typical' innovation that was recently completed (RC), another that was currently ongoing (OI), and an innovation that had been recently terminated (RT).
- The senior manager was then asked to identify the knowledgeable respondents by naming the functional managers most affected by innovation, first line supervisor(s) and members of the OI, RC and RT teams.
- Research permissions were sought from all respondents with a letter requesting their participation. This letter contained an approved endorsement of the research process from the senior manager. A sample copy of this letter is enclosed as Appendix B

### *Data acquisition from each firm*

- Arrangements were made for a site visit and for provision of a confidential location such as an internal office or boardroom to conduct the interviews.
- Customized questionnaires were created for each respondent based upon responsibility/knowledge level and involvement with particular innovation(s) and knowledge of overall innovation policies (e.g. the first level supervisor was not

asked about overall innovation budgets, but the senior on-site managers were). Key typologies were explored with most respondents, but were not questioned if it was not likely for the particular respondent to be well-informed about the concept in question (e.g. a member of the RC may not know anything other than rumour as to why the RT was terminated, so questions about the RT would not be included in their questionnaire). If they did know something about a particular typology that was material that was not included in their questionnaire, the open-ended questions offered an opportunity for the respondent to raise the issue.

- Interviews were conducted in a random order of respondents with each respondent being asked to not discuss the interview with other respondents until all the interviews were completed to avoid biasing of the data.
- Interviews began with the respondent being asked to confirm their consent including their willingness to have the interview video-recorded (Video recording was used with a view to use in a future research project). All respondents except one indicated their consent, with the exception withholding consent to be recorded. For this respondent, diligent note taking was used as a proxy for recording the interview.
- After consent was given, the questioning began by starting the recording, and opening with a series of relatively innocuous questions to put the respondent at ease. A typical opening question was: ‘Broadly speaking, what percentage of your time would you say you spend coming up with or developing innovations?’
- During the time the respondent was answering, summary notes were taken as a backup data source in case technical problems precluded use of the recordings.
- When a topic of interest arose, additional questions were asked around this interest area. In some cases, this portion of the interviews took on the flavour of a conversation about an innovation topic of mutual interest.

#### *Data analysis for each company*

- Upon return to the office, audio tapes were generated from the videotapes.
- Audio tapes were then transcribed into text in a tabular form suitable for sorting analysis. The previously described additional questions and ‘conversations’ were

also recorded as part of the transcription. For the four firms, these transcriptions resulted in approximately twelve hundred pages of text.

- Each individual respondent's response to each individual question was paraphrased with the objective of reducing the amount of data while maintaining the essence of the response. For those few responses where the meaning was not clear from the transcription of the text, the audio tape and video tape was used to assist clear interpretation of the response.
- Paraphrasing of individual questions was collated into typologies (including barriers and metrics) and firm-wide interpretation of paraphrased responses was undertaken.
- Iterations of each firm-specific report were written to ensure the accuracy of the contents of the report as verified during e-mail and telephone conversations with the senior manager.
- A copy of the firm-specific reports was mailed to all the firm's respondents.
- A site visit within 7-10 days of the report mailing took place to present the results of the report. This visit included discussions with respondents to seek out any discrepancies in results. No significant material errors in interpretation of how innovation happened within the firm were found.

#### *Analysis of overall findings*

- Summary statistics of innovation characteristics have been collated:
  - average core team size for each innovation,
  - distribution of product and process innovations,
  - average innovation duration in months for each category of OI, RC, RT, and overall innovations,
  - average investment as a % of sales for each category of OI, RC, RT, and overall innovations,
- The firm-specific paraphrased and sorted transcriptions were collected into a single document suitable for sorting. This was then sorted according to typologies (including barriers and metrics) and assessments were made for degrees of commonality of particular innovation practices as they pertained to the particular typologies. This completes the connective evidence chain to the typologies sourced originally during the literature review.



- Performance characteristics (profit growth last three years, sales growth last three years, % of sales from products introduced last three years, employment growth last three years) were tabulated by firm.
- A subjective assessment of firm innovativeness based on heuristic criteria (see Chapter 5 for discussion) and performance over last three years was completed. Major differences and similarities in innovation practices were highlighted to discuss potential linkages to individual firm performance.
- Discussion with senior managers of each firm took place to gather their reactions to overall findings and the proposed theories.

The trustworthiness of this case study was supported by video recording and transcription of interviews that provides an evidence chain connecting answers given with questions asked. In addition, a research journal recording theoretical developments and methodological concerns as they occurred, served to document theory induction and refinement of methodology as the study progressed. This mechanism for reflections on the developing theories serves to boost the dependability and confirmability of the findings.

### **3.10 Case study trustworthiness**

As with conventional quantitative inquiry, when considering the role of a qualitative case study researcher the author confronted the issue of how could his audiences be persuaded that the findings of an inquiry are worth their attention. The questions the audience raises include: Are the findings correct for the sample studied? Do the findings have application in any other setting? Are the findings repeatable and therefore dependable? Were the results objectively obtained or were they driven by the researcher's agenda? Within quantitative research, meeting these tests usually means employing statistical methods to test the internal and external validity, reliability, and objectivity of the results.

For quantitative research two similar approaches for testing the quality of the results were developed in parallel throughout the 1980s and 1990s. A specific approach for case study-based research (Yin, 1994), involved performance of qualitative versions of each of the quantitative tests. An alternate approach to assessing research quality within case study research was also developed as part of the thinking behind the naturalistic inquiry

paradigm (Lincoln and Guba, 1985) of which case study research is seen to be a valid part. For this paradigm, the tests of research quality have been renamed trustworthiness and it has been broken down into analogues of conventional inquiry that align credibility with internal validity, transferability with external validity, dependability with reliability and confirmability with objectivity.

These two approaches and descriptions of how this thesis has addressed each of the quality concerns are collected in Table 3.4. Comments on the concerns about the quality of the results mentioned by these authors that have not been addressed, and additional quality concerns not mentioned by these authors that have been addressed, and the rationale for the methodological decisions that were taken, conclude the discussion on the methodology employed for the thesis.

Three design tactics suggested to test naturalistic inquiry that were not followed by this research were persistent observation, prolonged engagement, and step-wise replication by two research teams (Lincoln and Guba, 1985). All three of these tactics were suggested to support grounded-theory development based on an emergent research design and do not apply to the typologically-based research approach used here. With respect to persistent observation, an additional argument can be made that this approach would be nearly logistically impossible. As earlier innovation process research has found, the innovation process occurs often in an unplanned manner in multiple locations simultaneously and it involves multiple personnel (Van de Ven et al. 1999). Logistically, the unplanned nature alone would make persistent observation difficult if not impossible unless multiple researchers were embedded throughout the firm. Given that it would require multiple researchers to accomplish persistent observation, the potential for errors in communication between researchers is also a consideration that would need to be accommodated in any research design. On balance, the potential to improve the perceived credibility/internal validity of the research was not adjudged to be sufficient to overcome the problems created by the required use of multiple observers.

The choice to not perform prolonged engagement stemmed from a similar balancing of

Table 3.4 Tests of quality of research results for case study research

| Quality tests – Yin, 1994 | Case study research design tactic - Yin   | Lincoln & Guba analogues to quality tests | Case study research design tactic – Lincoln and Guba, 1985   | Tests/research design employed as part of the case study protocol for this thesis   |
|---------------------------|---|---|--|---|
| <b>Construct validity</b> | <ul style="list-style-type: none"> <li>-use multiple sources of evidence</li> <li>-establish chain of evidence</li> <li>-have key informant review draft case study report</li> </ul> |   |  | <ul style="list-style-type: none"> <li>- data triangulation using confirmatory document analysis, multiple respondents for each unit of analysis, multiple innovations, multiple firms</li> <li>-chain of evidence used that starts with prepared questions, video recording of interviews, assembly of paraphrases all supported by transcribed data for each answer</li> <li>-for every firm the senior manager reviewed their report in draft form to identify any changes, if required. Final versions were negotiated with senior manager to ensure accuracy</li> </ul>  |
| <b>Internal validity</b>  | <ul style="list-style-type: none"> <li>-do pattern matching</li> <li>-do explanation building</li> <li>-do time-series analysis</li> </ul>  | Credibility                               | <ul style="list-style-type: none"> <li>-prolonged engagement</li> <li>-persistent observation</li> <li>-triangulation</li> </ul> | <ul style="list-style-type: none"> <li>-cross-case analysis to check for relatedness among the identified constructs</li> <li>--similar questions around key typologies (e.g. barriers, metrics) that make up important, likely repetitive patterns were asked within each firm along with checks with respondents to ensure adequacy/accuracy of theoretical constructs for their firm and explanation building carried out during discussion of the results</li> <li>-time series accommodated by embedded case design that for each firm studied two past innovation activities, one current innovation activity and questions around history of overall innovation practices within the firm</li> <li>-for prolonged engagement and persistent observation, see end of this section</li> <li>- data triangulation using confirmatory document analysis, multiple respondents for each unit of analysis, multiple innovations, multiple firms</li> </ul> |
| <b>External validity</b>  | <ul style="list-style-type: none"> <li>-use replication logic in multiple-case studies</li> </ul>   | Transferability                           | <ul style="list-style-type: none"> <li>-thick descriptions to help users assess transferability to their situation</li> </ul>    | <ul style="list-style-type: none"> <li>-use of screening criterion for case study targets (employment between 50 and 500 employees, no more than 30% of sales to one customer, majority of employees work is based on mechanical skills) reduces number of contextual variables within the sample to facilitate replication</li> <li>- thick descriptions of the case study firms (transcriptions averaged 300 pages for each firm) help readers assess transferability to their particular contexts.</li> </ul>  |

Table 3.4 (cont'd)

|                    |   |                                |   |  |
|--------------------|---|--------------------------------|---|--|
| <b>Reliability</b> | -use case study protocol<br>-develop case study data base | Dependability                  | -proven credibility delivers dependability<br>-stepwise replication by two research teams including ongoing communication between the teams | - see Section 3.6<br>- pattern-finding analysis of transcriptions was done using a sortable database of questions and responses coded by typology (e.g. barriers, metrics)<br>-see credibility above<br>-for step-wise replication, see end of this section  |
|                    |   | Objectivity/<br>Confirmability | -testing for presence of bias in questioning, answers and data analysis   | - repeated use of pilot-tested questions reduced any interviewer-generated firm-to-firm bias. Original interviewer bias is inherent in methodological and sampling design and is difficult to test for or isolate without another researcher repeating the entire study<br>- questions surrounding innovation processes have the potential to threaten the respondent's organisational formal or informal position. As a consequence, some respondents may bias their responses. Questioning of multiple respondents per innovation and checking that corresponding documents confirm or deny responses served to identify if and when respondent bias occurred.<br>-coding bias was assessed for one of the case studies and no coding bias was found. See letter in Appendix C |
|                    |   | All of the above               | -journal of researcher's reflections on methodology development   | -reflection on methodological adequacy in a journal kept by the researcher   |

(Four left-hand columns taken from *Designing Case Studies*, Robert K. Yin Figure 2.3 page 33 and from Lincoln and Guba pages 301 to 328)

potential to improve perceived credibility with the problems this approach would create. Prolonged engagement by a single researcher trying to meet the logistical challenges of being where and when the innovation process was occurring would preclude the study of more than one firm at a time. This would raise questions about the redundancy and credibility of the findings as no comparatives would be available. Prolonged engagement could also require very lengthy periods of observation to complete the longitudinal tracking of innovations as they occur. For example, Van de Ven et al., (1999) found that some innovation processes took as long as fourteen years to be concluded. Research carried out over this period would certainly be subject to maturation concerns (Babbie, 1998) likely affecting the internal validity of the findings.

Step-wise replication by two research teams is suggested as a case-study research design tactic to ensure dependability (Lincoln and Guba, 1985). This tactic originates from the quantitative ‘split-half’ mode of determining test reliability and the concerns attached to emergent research design wherein naturalistic inquiry researchers follow the research design that the data leads them towards. The expressed concern is that the researcher’s inherent biases may affect the way they operationalize the data gathering which in turn could influence the results. Step-wise replication by two teams is suggested as a tactic to neutralize this concern and ongoing methodological discussions between teams is suggested as the method to ensure data gathering approaches are aligned. In this case, the design of the typological embedded case studies was completed before the majority of the data was gathered. Even though a pilot study did influence the questions asked in subsequent firms, no material alterations were made to the research design throughout the course of the project. As a consequence, this research should not be considered to use emergent design and as a consequence should not suffer from emergent design dependability concerns. In addition to the concerns about research quality expressed by the aforementioned research design scholars, there are issues with respect to respondent memory, respondent self-interest, test-retest and split-half analysis that have been addressed within this research design. See Table 3.5 for more details.

Table 3.5 Additional research quality concerns accommodated within the research design

| Concern                  | Comment   |
|--------------------------|---|
| Respondent memory        | Respondents are interviewed about overall, ongoing and recent innovation processes. Memories of past innovation processes have the most likelihood of being subject to memory loss of actual events – interviewing of multiple members within the same organisation fills in the blanks that some respondents do not remember.  |
| Respondent self-interest | The potential that certain innovations have to alter the respondent's power within their organisation may lead to respondents being circumspect in their answers. Once this becomes obvious, the interviewer reassures the respondent about the confidentiality and anonymity provisions of the research and repeats the question. Analysis of responses from multiple respondents within the firm serve to reveal any misstatements by other respondents and provide confirmation as to a more accurate answer to the question posed.                      |
| Test-retest              | The extensive amount of respondent time required to complete the interviews restricts the respondent's availability for retesting. It is also expected that the Hawthorne effect will play a role in these companies as just the act of interviewing multiple respondents about the topic of innovation is bound to at least temporarily raise the profile of innovation within the organisation and as a consequence, change the attitudes of respondents to the topic. This effect serves to invalidate test-retest as a method to measure dependability. |
| Split half               | Within the set of questions posed to each respondent there are overlapping questions that attempt to get at similar data. A comparison of the data gathered provides a form of split-half reliability.  |

### 3.11 Summary

This Chapter has described the author's rationale for choosing multi-firm, embedded case studies using typological analysis to answer the research questions that developed as the result of the literature review and the author's objective of making a contribution to the innovation management literature.

The driving reasons for choosing this methodology were:

- a) That *innovation* or *innovativeness* has not been accepted as an objective well-accepted dependent variable, thereby making researching of and establishment of causal links difficult,
- b) That previous quantitative attempts to isolate 'silver bullet' variables for successful innovation have not been successful and in fact significant disagreement exists in the innovation literature,
- c) That significant previous efforts have been made to document innovation typologies and that certainly some of these are valid for MechSMEs, and

- d) That to be useful to managers in the absence of ‘silver bullet’ advice, the results of this exercise needs to be written in language that they understand and the study of management practices and metrics certainly fills this requirement.

The next Chapter presents the results of the case studies on a firm-by-firm basis. This is followed by Chapter 5 wherein the discussion of the agglomerated findings, their relationship to the literature and the conclusions are stated.

## **Chapter 4 Case studies of MechSMEs**

### *Introduction*

This Chapter discusses the firm-specific case studies. Innovation practices are described within two firms supplying goods and services to different portions of the hard rock mining industry, followed by descriptions of innovation practices within two firms that provide two different types of packaging equipment to a variety of packaged goods manufacturers. Each of these case studies has involved interviews of a broad cross section of respondents from different organisational levels about multiple innovation processes and used questions that were structured according to the typologies identified as a result of the literature review. This set of findings has been reported around the elements of innovation (i.e. idea generation, evaluation and implementation and innovation barriers and enablers) with the express purpose of detecting patterns in the practices involved with these innovation elements. Compilation of the quantitative results for all the cases and cross-case analysis follow in Chapter 5.

### **4.1 Atlas Copco Exploration Products**

The following case study is the result of the analysis arising from two days of interviews conducted in the spring of 2005 with a total of eight personnel from the Exploration Products division of Atlas Copco located in North Bay, Ontario, Canada (ACEP). An organisation chart is included later in Appendix D to identify the interviewed personnel and their roles.

#### **4.1.1 Brief overview of plant**

Atlas Copco is a global group of companies headquartered in Stockholm, Sweden, that manufactures industrial products at 49 production sites in 16 countries on five continents. Their primary products include air compressors, construction and mining equipment, electric and pneumatic tools, assembly systems and motion control products. Atlas Copco was founded in 1873 and employed over 25,000 people in 2005. Revenues for 2004 were



over \$6 billion US, with 65% of this coming from outside of Europe. Corporate operating margins were approximately 13% for fiscal 2004. The products are sold and rented under more than 20 brand names through a worldwide sales and service network reaching 150 countries, half of which are served by wholly or partly-owned sales companies. Each production division, like the site in North Bay, is specialised within a product area and has total responsibility for product development, manufacturing, and sales and service operations in order to give each product the best chance to satisfy customer needs for their particular market (Source: Atlas Copco company information).

In terms of industry niche and strategy selection, ACEP chose to service the exploration sector of the hard-rock mining industry which is subject to significant variance within the business cycle. To service this sector they chose to focus on three principal products with significantly different product life cycles (diamond drill bits – 2-3 years, drill rods- 4-6 years and drills, 8-10 years). Design of the bits and drill rods require material science expertise and the drills require mechanical expertise. In terms of competitive position, ACEP was one of two dominant firms in this niche worldwide and they paid very close attention to the other dominant player. These industry level and strategic level decisions resulted in the development of a structure within the site wherein three separate groups assumed responsibility for each of the product types. Drill rods and diamond bits are manufactured on a build-to-inventory basis in relatively large batches whereas drills are assembled on a build-to-order basis (sometimes with some customer-specified components i.e. a particular brand of engine to power the drill is to make up part of the design).

ACEP served mining exploration customers exclusively and provided them with two classes of products, the consumable bits for drilling rock and the mechanized drills and rods which twist them. The consumable bits are manufactured in various sizes and configurations that commonly are structured to support a pattern of synthetic diamonds in a composite substrate material. The mechanized drills utilise a combination of fabrication, engine or electric motor, hydraulic, drill string and flushing technologies to provide the torquing action and downward pressure required for the bit to cut rock. Extreme variations in rock types between drill holes and within drill holes results in operators continuously experimenting with the combination of down pressure, rotation rate and flushing rate to maximize productivity in drilled meters/hour and efficiency metrics in terms of drilled

meters/bit longevity. This ongoing search for more efficient drilling led to longer life bits resulting in decreasing product volumes for the plant.

As of the spring of 2005, the plant was at maximum capacity (production ran 24/7 and physical space for expansion was unavailable). The plant achieved annual sales of approximately \$60 million (50% of which were export sales spread throughout 50 countries), employed about 90 personnel and enjoyed profitability rates of about 14-15% of sales before taxes. Between 2002 and 2005, these sales and employment figures reflected a 12% annualized growth rate (which approximates expenditure growth in the overall Canadian mineral exploration drilling industry) and a turnaround in profitability from a break-even position.

The plant transformed between 1994 and 1998 from one of two Canadian JKS Boyles plants specialising in the provision of surface drilling products, to one of Atlas Copco's production companies offering a much broader production line once two other North American exploration product companies had been acquired by the parent and consolidated into the North Bay location. Prior to 1998, when Atlas Copco acquired JKS Boyles, this plant was part of a leveraged buyout triggered by the need for some financial restructuring resulting from the boom/bust nature of the mining exploration industry.

The history of the plant resulted in an operation that exhibits a combination of behaviours held over from its phase as a major part of a small Canadian corporation, its interim ownership by a financially-focused entrepreneur and finally by its ownership by Atlas Copco. Personnel from each era of the site's development are still involved in the firm, with predominance in terms of numbers being with the company since the JKS Boyles era. Senior management on the other hand, arrived with or since the purchase by Atlas Copco. Formal processes within the site migrated over the last seven years towards adoption of formal Atlas Copco processes.

#### **4.1.2 Industry setting**

The worldwide and Canadian mining exploration drilling supply industry can be characterized as being dominated (80% share) by two major suppliers, Atlas Copco

(approximately 30% share) and Boart Longyear (approximately 50% share). Both of the Canadian plants for these firms are located within 2 km of each other in the town of North Bay, Ontario (population of 55,000).

The typical sales process for this industry follows a pattern starting with a drilling target being identified by geologists. Regardless of whether the geologists are independent prospectors or affiliated with integrated mining corporations, the majority of time a drilling contractor is hired to drill holes to acquire sample cores for metallurgical assay work. The need for ‘drilling off’ targets fluctuates wildly depending upon the state of this commodity-based mining industry. When metal prices are high, mining companies have easy access to capital and they are very motivated to bring additional metal supply on-line as quickly as possible. When commodity prices are low, capital is difficult to access and as exploration is one of the mining company’s largest discretionary expenditures, it is often severely curtailed during times of low metal prices. The consequence for the drilling industry is that they experience extreme volatility. For example, expenditures in the Canadian portion of this industry nearly doubled in the 2001-2004 period and at the time of the research would be considered to be in the boom part of the economic cycle. (Source: Prospectors and Developers Association of Canada (PDAC)).

For the contractors, it is very difficult to hire and support skilled drillers that are interested in investing time and effort in learning about and using complicated technological developments. The challenging employment conditions resulting from the combination of the industry’s boom/bust cycle, the small size and specialised focus of the drilling firms, the remote location of the drilling sites and long periods of isolation required to drill off targets, and the commonplace performance bonuses offered to get targets drilled off as quickly as possible, all serve to pre-empt efforts to develop employee’s skills for longer-term stable employment. The consequence is that the drilling industry’s learning rate is very slow resulting in a very low rate of adoption of complicated technological innovations. Also, given the relatively small size of the drilling industry and the frequent movement of drillers between companies, the resulting close knit community makes word of mouth and reputation key criteria for purchase decisions. This plays an especially important role for consumable bit purchases when a particular bit is found to offer a performance advantage.

### **4.1.3 Context of North Bay site innovation processes**

Atlas Copco created structures and developed themes and compensation schemes for their far-flung corporation that require managers of production divisions to meet annual growth targets. These structures stem from their corporate strategy to grow their businesses organically by development of new offerings based on their core technologies and to grow by increasing the breadth of products that can be offered to existing customers. Atlas Copco developed performance metrics to measure their progress on these themes and to transfer responsibility to deliver them to the product divisions. As a consequence, senior management within the plant feel a responsibility to continue to deliver growth to their top and bottom lines and they see introducing product and service innovations as one of the means to this end. One of the managers offered the following insight on the pressure to innovate:

*“...the management team is charged with that responsibility and our product manager is sort of pushed and you have to innovate if you’re going to grow. So, I guess innovation isn’t a structured thing that happens, it’s got to happen everyday.”*

Within the plant, motivation also appeared to be derived from a subtext of gamesmanship as personnel wish to avoid the one of the worst possible outcomes for them, losing out to their cross-town competitors, Boart Longyear.

### **4.1.4 Innovation practice research methodology**

The General Manager was approached and agreed to participate in this case study. He was asked to identify a recently completed innovation, an ongoing innovation and a recently terminated innovation. Characteristics of the innovations selected by the general manager for study are described in Table 4.1.

Members of these innovation teams as well as the senior managers most affected by innovation and the production managers and R&D personnel were interviewed about the innovation projects they were involved in as well as overall innovation characteristics of the company. As with all of the case studies, these interviews were video recorded, transcribed and analyzed with an overall objective of learning about innovation practices

within the respondent organisations. The firm’s organisation chart details the positions of the individual respondents within the organisation (see Appendix D1).

*Table 4.1 Characteristics of innovations self-selected for study by ACEP-North Bay*

|                                     | <b>Recently completed innovation</b>   | <b>Ongoing innovation</b>   | <b>Recently terminated innovation</b>   |
|-------------------------------------|--|---|---|
| <b>Project name</b>                 | Torpedo V13 Bit  | “Brickwalling” project.   | CS1000 Drill  |
| <b>Time information</b>             | Three months time to market. New bit launched at PDAC convention one month in advance of study | Five months to prepare for launch, two months to rollout to target customers.   | Project started two years ago, Repatriated to Sweden 10 months before study   |
| <b>Innovation type</b>              | Product – consumable   | Process   | Product- capital item   |
| <b>Core innovation group size</b>   | 3  | 3   | 2   |
| <b>Reason cited for development</b> | To meet competitive threat, follow up on customer suggestion                                   | To assure ongoing revenues during bust part of economic cycle and increase customer share by dramatically improving customer service levels | First of new line of drills to deliver increased efficiency for customers by reducing core pulling, setup and dismantle times. Also to add metric drill to product line.            |
| <b>Total investment</b>             | \$15,000   | \$40,000  | \$150,000   |
| <b>Project name</b>                 | Torpedo V13 Bit  | “Brickwalling” project.   | CS1000 Drill  |
| <b>New technology or market</b>     | Existing technology, new performance ability for existing markets                              | Existing for both, but success is opening up possibilities for new markets  | New technology for Atlas Copco to serve existing market   |
| <b>Status</b>                       | Successfully launched  | Successfully launched. Targeted customer share increased, rolling out to other customers  | Project fell behind schedule due to other day-to-day pressures and lack of resources. Corporate decided to locate this core competency in Sweden and is continuing to develop idea. |

#### **4.1.5. Discussion of innovation elements**

##### *Idea generation*

The principal methods for generating ideas identified by the respondents are fourfold:

- 1) Annual multi-personnel, day-long review meetings discussing a comprehensive set of issues with multiple personnel from customer organisations,

- 2) The continuous trialling by customers of different drilling combinations are used as a forum to maintain customer relationships and generate ideas to address customer needs and monitor competitors' activities,
- 3) Hearing about ideas from other divisions within Atlas Copco and,
- 4) Results monitoring to identify problem areas (e.g. to identify productivity bottlenecks, costing increases, and sources of employee dissatisfaction).

Several cultural characteristics of the firm seemed to influence the generation of ideas. A performance measurement culture that engendered a requirement to deliver growth and innovation is seen as one means to this end. The resulting requirement to continue to pursue new ideas is supported by the following:

- The variety of rock types that their customers face resulting in real difficulty in establishing of industry-wide benchmarks and designs with the result that dominant designs are not being established.
- Openness to exploration of new ideas by the senior manager
- The close knit, long-term relationship nature of the industry wherein word of mouth plays a key role and industry participants are hearing about new ideas being tried on an ongoing basis.
- Industry experience is seen as critical by individual personnel and they perceive their industry reputations depend to some degree on their track record with successful innovations,
- Team make-ups are often heterogeneous (cross-functional problem solving teams are used extensively)
- For the most part, open, honest communication patterns take place between various members of the management team

Overall, personnel did not perceive that there was a shortage of ideas to pursue.

#### *Idea evaluation*

Two stages of evaluation appeared to take place within the firm. The first stage is done internally on an ad hoc basis (sometimes by an individual manager and sometimes as part of a group discussion) and it focussed around the questions of – “Will it work technically?”

“Will it pay off?” and, “Does our plant have the resources to complete the innovation?” (including engineering resources, space, and time). This evaluation was done without a formal assigned budget or any formal resources dedicated to the idea. It is a norm for personnel to do this initial evaluation work as an extra function outside of their normal job responsibilities. Sometimes minor design changes will be field-tested by customers as part of the ad hoc technical evaluation process.

In terms of the ad hoc evaluation of the commercial possibilities, due to the relatively small size of the plant’s customers (their largest customer only represents 10% of the plant’s sales), often more than one customer must express interest in an idea before it will be pursued.

Several metrics are used as benchmarks to determine the path of the idea. Ideas requiring a total investment of less than \$20,000Cdn can be handled internally without reference to head office. Ideas that require a second stage formal evaluation by the corporate “Product Board” must be capable of achieving a one year payback, must have at least one endorsing customer (i.e. a “testing partner”) and must have the potential to realize a 10-20% revenue growth for the plant. Successes of the ideas are tracked for the product board’s purposes through a combination of metrics including customer share and market share and a more comprehensive score carding system.

Ideas that survive the informal scrutiny and are large or important enough to warrant the attention of the Product Board are then formally presented for approval utilizing a business plan format. The Product Board consists of 3-4 individuals from the senior and product management ranks from head office in Sweden and several members of the plant’s management team. Once this board grants approval, a formal budget and schedule is struck for the project.

#### *Idea implementation*

Those projects that reach formal status are managed by an administrator (usually from the ranks of engineering or senior management) using generic project management tracking software. Significant projects result in quarterly progress reports to the Product Board which are sometimes accompanied by requests for additional resources. For those smaller

ideas that have been previously endorsed by an evaluation meeting at the plant level, the senior manager uses a variety of tactics to see that the innovation is seen to be moving ahead.

Driving forces for completion of projects includes externally-imposed deadlines such as meeting commitments made to the Product Board, or the need to meet a commitment to customers to address issues raised during the comprehensive meetings with customers, or the need to have new products ready for an important trade show. One of the team members involved in the introduction of the new drilling bit, when discussing this pressure said,

*“..with regards to the time in particular , it needed to get done within a particular timeframe because we were launching a product at an annual convention.”*

Internal deadlines are pursued primarily by the senior manager. One common approach used by the senior manager is by requiring the designated project administrator to report progress to in-plant cross-functional meetings thereby leveraging his pressure with peer pressure. One of the respondents that reflected on the peer pressure mechanism stated that,

*“ ...any projects involving more than one person, which is almost all of them, then you basically have other people’s time being involved in the process and if your not accomplishing your tasks on time then essentially your wasting their time”*

Market launch follows a variety of approaches dependent upon the product or service and timing. Marketing efforts range from direct sales contacts with targeted customers for targeted products or services to more comprehensive promotional campaigns (usually including trade advertising and trade shows) for products with broader application.

#### *Barriers to innovation*

The innovation literature suggests that the most common barriers for SME-sized manufacturers include a lack of access to capital and a lack of exposure to new technologies (Freel, 2000). In the case of this plant, their connection to the corporation seemed to preclude the significance of these barriers. On the other hand, more of the barriers to innovation identified within the large firm innovation literature do seem to be evident. For example:



- the need for bureaucratic comprehensiveness (Kanter, 1989) to acquire Product Board approvals results in bureaucratic delays. The associated cost inflation for trials of new ideas increases the attached risk which can result in premature termination of innovative ideas.
- increased number of management layers have been shown in other firms to be effective in stifling innovation as a longer chain of yeses is required for innovations to proceed, but only one no is required to kill a project (Quinn, 1986; Pearson, 2002). It is likely that this barrier exists for the plant due to the increased number of management layers that is characteristic of the Product Board approval process
- some personnel find themselves so preoccupied with getting product out the door that they do not have any time or energy left over to pursue fuzzy and uncertain activities like innovation (Lawson and Samson, 2001; Amabile, 1988; Kanter, 1989; Friedmann and Maurer, 2003)
- the time and energy costs required to acquire project approvals precludes the pursuit of incremental innovations, other than those trivial innovations that can be implemented quickly by interested personnel

Beyond the aforementioned barriers that are endemic to larger organisations, the plant was also confronted with barriers particular to its situation. Most importantly, the slow pace of change within the exploration drilling industry led to many past innovation failures, and personnel within the management ranks seem to take pride in their abilities to stop ideas based on their industry experience. Respondents described their roles in stopping ideas as follows:

*“.....so then you have to spend more time going through the various options and even though you may know that it’s not going to work very well you know you can’t just reject it out of hand, you have to go through it”* and,

*“...realistic the goals are to see whether you know and I put my two cents in right at the beginning as to say well you know, are you being realistic? I define realistic as based on experiences to whether or not a goal is achievable in a certain amount of time or under certain constraints.”*

They will dismiss ideas if they know about a previous trial failure even when the reason for failure was not technologically-based (e.g. when innovations do not survive through the bust portion of the cycle, the idea may be dismissed for technical reasons that were really

issues of timing). The result of this attitude is that ideas can be dismissed prematurely and opportunities are being missed. They seem to feel the ability to point out potential problems buttresses their reputation as an industry veteran which is commonly acknowledged as a very important prerequisite for any important decision-making role in the industry. One of the managers explained this concept as follows,

*“...we have a mix of very senior competent experienced people and we have some young inexperienced people and so it takes a blend. The mining industry is an industry that’s based on experience and if you don’t have credibility in this industry and if you don’t have experience, then the brightest PHD is not going to sell anything to any mining company or contractor”*

Other situation-specific barriers included a lack of capacity for further growth (both in terms of engineering resources and manufacturing space), significant geographic distance from corporate R&D resources, a seeming reluctance to fully engage manufacturing personnel in innovation processes, and the need for multiple customers to perceive a need before it is seen as valid. Macro-based barriers include the boom/bust nature of the industry that discourages longer term innovations, and the limited technical and business skills of the labour pool of the small city of North Bay.

#### *Outside forces enabling innovation*

Atlas Copco’s clearly stated expectations for growth and turnover of new products (25% of products to be renewed each year) effectively supported with compensation schemes, act as powerful motivators for senior management to keep pushing an agenda for innovation. In addition, the proximity of the plant’s primary competitor and the resulting continuous flow of information about their activities stimulated the plant’s personnel to maintain a pace of innovation that at least matches that of their larger rival. These two factors appear to be the most important forces enabling innovation. Other enablers mentioned by respondents included access to the corporate knowledge sharing intranet as it has been found to be an effective source of ideas and the clustering of other mining suppliers in the region as a source of market intelligence.

#### **4.1.6 ACEP-North Bay summary discussion**

Over the last three years, the plant enjoyed significant growth in sales and employment that mirrored the booming growth in activity of the exploration drilling industry. Profits moved from a breakeven position to slightly exceeding average corporate rates. Sales of new products introduced between 2002 and 2005 fell short of corporate product renewal targets but are still estimated to make up 60% of sales with 40% being realized from new model introductions and the remaining 20% resulting from incremental changes to products. In summary, the plant matched industry growth rates while restoring healthy profit levels.

A strategy of innovating at a rate matching the drilling industry's slow rate of change contributed to maintenance of market share levels and the plant's healthy financial performance during the relatively lucrative boom portion of this economic cycle.

#### **4.2 MTI Equipment Ltd. – Cylinder Division**

The following case study is the result of the analysis arising from interviews beginning in the fall of 2004 with a total of eight personnel from the Cylinder Division of MTI Equipment Ltd., located in North Bay, Ontario, Canada. An organisation chart that identifies the interviewed personnel and their roles is included in the appendices (See Appendix D2).

CylDiv services two parts of the production portion of the hard-rock mining industry, the direct repair and mobile equipment parts business for producing mines in their local service area (approximately a 1000 km radius) and secondly, acting as a manufacturing location for their parent company who then manufactures mobile equipment and services parts needs for their equipment around the world. In the direct service portion of the business, equipment repair makes up a significant portion and a repetitive job shop approach is taken to managing this business. For the parts manufacturing business, CylDiv finds itself competing as a machine shop as many of the products are simple in design and low cost plays an important role in maintaining this business. One of the principal management challenges is trading off within the same shop the long run efficiencies required to compete

on a cost basis with the exigencies required to provide high levels of service to their direct customers. Product life cycles are quite long as the mechanical design of the principal products (hydraulic cylinders and their linking components) have not changed substantially since their original designs in the 1970's. In terms of competitive position, for the service portion of their business CylDiv is the dominant player in their geographic region. For the machine shop business they are one of a great number of firms with comparable capabilities from which the purchasers can select. The competitive advantage that CylDiv relies upon to retain the machine shop business is their extensive database of part number cross-listing, drawings and specifications to ease the purchasing process for customers.

#### **4.2.1 Company history**

The Cylinder Division of MTI Equipment Ltd., (CylDiv) was originally incorporated in 1976 as LHD Equipment Ltd. with a purpose of providing reverse-engineered, machined parts to serve the mobile equipment needs of underground metal mines located in the surrounding region. In 1990, LHD Equipment was sold by its founder to one of its largest customers, Inco Ltd., with a further conveyance to MTI Equipment Ltd., occurring in 1995. MTI Equipment Ltd., is a manufacturer of hard-rock mobile mining equipment (trucks, drills, loaders and other underground mining utility vehicles and equipment) with its head office and principal manufacturing facilities located in Sudbury, 120km west of the CylDiv's North Bay location (see <http://www.mti.ca/> for more information on MTI) .

CylDiv manufactures a wide range of parts, including hydraulic cylinders, pins, bushing, and brackets, for MTI Mining products (designed and sold by the parent company to the mines) as well as parts for competing mining equipment (reverse-engineered by CylDiv and sold directly to the mines). A significant portion of CylDiv's sales and expertise is derived from an extensive and long-established cylinder repair service they provide for mines. In terms of employment, on average, CylDiv employed approximately 70 personnel since the mid 1980s with fluctuations occurring between 50 and 80 employees as dictated by the mines' levels of production. Annual sales for the division are approximately \$CDN 8.5 million which translates to an annualized inflation-adjusted sales growth rate of about .05% since the mid 1980s. No information is available as to how this growth rate compares to other parts suppliers to the underground metal mining industry.

The history of CylDiv results in an operation which exhibits entrepreneurial behaviours held over from its start-up phase (i.e. the ongoing and standardized process of reverse-engineering of parts for equipment installed in mines by others), combined with influences from its history as part of a major multinational mining company and its current owner which is one of the smaller corporate competitors within the global mining equipment market.

#### **4.2.2 Industry context**

The bulk of CylDiv's revenue is derived from the production portion of the underground metal mines industry with the most significant portion derived from mines located within a 1000 km radius of its North Bay location. This sector of the metal mining industry can be characterized as one of the more stable portions of the industry, but it still experiences six-to-ten year long, commodity price-based cycles punctuated by occasional losses of customers as ore bodies are mined out. Within CylDiv's customer bases, only sustained low or high metal prices will result in capacity changes with increases in production capacity taking longer to realize than capacity reductions. During the period research was carried out on CylDiv, the economic conditions for this portion of the industry can be described as very robust.

The innovation stance of the hard rock mining industry casts a large shadow over the innovation efforts of its suppliers as the history of the hard rock mining industry is littered with unsuccessful efforts to use technical advances from other industries. Common reasons given for these failures include a lack of infrastructure near the mines and relatively low education levels of the workforce in mining operations. These problems are then compounded by the nature of the underground mining task which presents significant technical challenges to communication, effective supervision and the survival of equipment. The net result is that small changes can cause significant upsets in routines and the industry has a track record of resisting even minor changes.

### **4.2.3 Innovation practices research methodology**

The General Manager (GM) of the division was approached and agreed to participate in this case study. The GM was asked to identify a recently completed innovation, an ongoing innovation and a recently terminated innovation. Characteristics of the innovations selected by the GM for study are described in Table 4.2. Members of these innovation teams, as well as the senior managers most affected by innovation and the first line shop supervisor, were interviewed about the innovation projects they were involved with as well as overall innovation characteristics of the division. The organisation chart in Appendix D2 details the positions of the individual respondents within the organisation.

### **4.2.4 Overall CylDiv innovation process**

The routine of developing new reverse-engineered products is long-established and standardized within CylDiv. This new product innovation routine is so well entrenched that it is accepted as the normal method of doing business and as such it does not engender significant challenges to manage it. While this established innovation routine is an integral part of CylDiv's activities, it is not likely to be a source for significant potential for improvement. As a result, the research process and the following discussion only apply to those CylDiv innovations which involve substantial management challenges. The innovation process at CylDiv is mostly driven by ongoing problem-solving activities. The principal identifiers of problems are customer complaints and complaints from within the shop when difficulties arise during manufacturing. Opportunities for pro-active innovation steps are identified primarily by interactions with suppliers and by occasional scheduled presentations to the parent company and scanning of competitor's offerings.

Once problems (primarily based on customer complaints) or opportunities are identified, then the GM calls together the involved parties to discuss the issue until a plan of action begins to reveal itself. The ideas under consideration are most commonly evaluated against whether they will address the customer's problem, save production time or eventually reduce the 'hassle' for MTI personnel. At this point, someone is typically assigned responsibility to do more investigation along with an assigned time frame as to when to

Table 4.2 Characteristics of self-selected MTI Innovations

|                                     | <b>Recently completed innovation</b>   | <b>Ongoing innovation</b>   | <b>Recently terminated innovation</b>  |
|-------------------------------------|--|---|--|
| <b>Project name</b>                 | New CNC  | Parts stencilling process   | Robotic welder   |
| <b>Time information</b>             | Four months start to finish  | One year since equipment purchase, but need realized over 15 year period, 80% complete.   | Two year project that died over subsequent two years. Finally terminated in 1998.  |
| <b>Innovation type</b>              | Process  | Product/process   | Process  |
| <b>Core innovation group size</b>   | 4-5  | 4   | 8  |
| <b>Reason cited for development</b> | Increasing volume of orders and backlogs<br>Introduced additional technical capability to shop.        | Existing manual punch method was a hassle for production workers, record keepers. New method can be integrated with computer tracking | High volumes of large welds needed in production area. Concerns about safety of welding personnel and need for repeatable quality prompted development.  |
| <b>Total investment</b>             | \$250,000  | \$20,000  | \$200,000  |
| <b>New technology or market</b>     | No   | New technology to CylDiv to serve new and existing markets  | New technology to CylDiv to serve existing market  |
| <b>Status</b>                       | Installed and running. Slowly coming up to capacity as programming for individual pieces is completed. | New equipment in house and trial completed. Once summer student left that was working on it, project has stalled somewhat.            | Dismantled and removed from shop floor. Developers of the welder have all left the company. Key welder involved in development found it difficult to return to production welding and has also left the company. |

report back to the group. The delegation of someone to investigate an idea does not often correspond with the establishment of any cost or revenue predictions.

A similar process takes place for problems identified as the result of shop complaints with the exception that quick trials are often undertaken in the shop before they are brought to management's attention. Once the shop personnel are satisfied with the quality of their idea, management will then be approached to consider the idea. One of the shop floor personnel described the practice as follows:

*“a lot of times in that, in certain set of circumstances I may not go to the foreman, I may just do it on my own and if it works well and I run the whole order or do the whole job like that and it works really well, then I will approach him and say, listen, this is how you did it before, this is how I did it, I did it in half the time and the results were excellent”*

A delay in responding to ideas is the chosen method to determine which ideas have ongoing merit. If the problem identifier does not champion the cause long and loudly enough, and/or if enough other personnel do not raise it as an issue, then the idea is not likely to be acted on as it is seen to not really be necessary. One of the respondents described this method by saying:

*“Probably by a consensus, so majority rules ...a good idea usually has lots of favourable responses to it and follow-up. I don’t have to follow up on everything myself because the people that are in favour of something say, whatever happened to, or when are we going to do that, so you know when something is favorable and you know when a good idea is out there and we are not doing anything with it, so, you kind of listen for that majority consensus”*

Those ideas that survive the evaluation process continue towards implementation with a project champion taking ownership and pushing it through the various steps. In the circumstance of the terminated innovation project, the departure of the project champions is seen as a major contributing factor to the demise of this particular project.

After the innovation is completed, no evidence exists of a proactive innovation review process. For example, shop employees only learn whether their incremental improvements to manufacturing methods have been successfully adopted when the routing sheets for the next order arrives in the shop with or without the suggested changes. In addition, no evidence was found of a process that compared the effectiveness of pre- and post-innovation methods.

#### **4.2.5 Discussion of innovation elements**

##### *Idea generation*

With respect to CylDiv, it appears that the primary methods used for idea generation include:

- close connection with customers’ needs
- team make-ups are heterogeneous (cross-functional problem solving teams are used extensively)
- medium to high levels of trust exist between innovation team members resulting in open communication patterns across levels, especially within the shop



Particular restrictions on idea generation are a consequence of the industry served, a lack of time to work on ideas (due to production pressures) and insignificant parent company commitment to innovation within CylDiv.

### *Idea evaluation*

In terms of idea evaluation within CylDiv, there appears to be:

- a moderate willingness to expand technical competencies
- the presence of a project champion(s) or lack thereof is used as a powerful indicator of the value of proposed ideas
- a continual evaluation of the ripple effects of any idea on existing manufacturing processes

There does not appear to be:

- substantive financial analysis in advance of any implementation decision, other than estimation of the order of magnitude of development costs. Most ideas appear to be evaluated against metrics of projected cost savings and reductions in “hassle” for CylDiv employees. This role of the perceived hassle was described as follows;

*“is the hassle worth it for me to fight all the way through, bringing a vendor with me who intends to sell his product, only to find out it’s a dead end, and then it’s harder for me for the next one, for me to say, ah, Do I really want to do this? I mean I already went to the well three times unsuccessfully thinking that this was better but I can’t seem to dissuade everybody involved, so we just, hey, just carry on you know”*

In terms of assessing whether ideas are evaluated for their disruptive or sustaining characteristics, this is a difficult variable to assess without being present while new ideas are being considered.

### *Idea implementation*

Within CylDiv it appears that the principal mechanisms driving the schedule of innovations include meeting customer delivery dates that are associated with the problem-solving innovation and being ready for the next meeting wherein progress of the innovation in question will be reviewed.

For ideas that have been previously endorsed by an evaluation meeting, and for those ideas that are generated within the shop that stay within the shop, the project champion seems to take ownership over the idea and is quite concerned about being seen as not living up to their assigned responsibility. This sense of responsibility leads the champions to try a variety of tactics to see that their innovation is seen to be moving ahead. One of the implementation tactics used within the shop is the proactive use of cheap and quick testing of concepts before too many personnel get involved.

### *Barriers to innovation*

A number of the barriers to innovation mentioned within the literature (mixed messages from management (Pearson, 2002), quantity and enforcement of multiple levels within organisation (Quinn, 1986) (Pearson, 2002), extensive analysis before a decision is made to devote some time towards an idea (Kanter, 1989)) do not seem to be evident within CylDiv.

On the other hand, innovation does not happen as often as it might otherwise as the “hassle” of innovation is seen to be significant. One of the respondents reflected on the energy required to innovate within CylDiv by saying,

*“how do you put it, ah, it’s like on the same negativity or you can’t teach an old dog new tricks, people are stuck in their ways and not willing to cooperate, like age factor or employee seniority or that they’ve been here too long, if it was a new person and you said we are going to do it this way then there is no question, he does it. So I don’t know how you put it in words, I guess you could say it’s tired blood as opposed to new blood.”*

In addition, the practice of waiting for support to gather to prove ideas are necessary requires that champions put more energy into pushing a cause than they feel they have available. A similar sentiment was expressed with respect to available time as personnel feel they are scrambling all the time just to keep up with day-to-day deadlines.

Suspicion of a lack of financial support from MTI Corporate is also a common excuse for not trying things. In addition, the industry’s well-known preference for the status quo often provides a credible reason not to pursue particular innovations.

### *Outside forces enabling innovation*

The recent introduction of internet and e-mail to the organisation made a significant difference in their ability to scan supplier offerings and competitive offerings. CylDiv's alignment with MTI corporate has exposed CylDiv to a more thorough understanding of their OEM competitors. The current robust health of the mining industry led CylDiv into larger volumes so that economy of scale decisions can play a larger role inside the shop.

#### **4.2.6 CylDiv summary discussion**

CylDiv experienced negligible revenue and employment growth between the mid-1980's and 2004. It appears that the most significant constraints on this growth are the innovation-adverse cyclical industry that they serve; a lack of available energy among the very stable employee group; and a lack of corporate demands or support for innovation. Solving problems as they arise, characterizes the bulk of their innovative work with customer complaints and manufacturing difficulties identified as the principal problem sources. Occasional proactive innovation attempts are made primarily based on ideas provided by suppliers and competitors.

In terms of innovation process, no formal method or objective innovation success metrics are used. An ad-hoc cross-functional practice has developed with assigned individuals driven by specified meeting dates to report progress to their peers and ship dates for product associated with the problem in question. Innovation filtering is based on how often and how loudly interested individuals state the need for the particular innovation. Assessment of innovation success centres on subjective customer acceptance and subjective peer acceptance. Moderate levels of 'ownership' of problems and associated respect levels among peers provide the principle source of any energy devoted to innovation.

### **4.3 Wepackit Inc (Wepackit)**

The following case study is the result of the analysis arising from interviews occurring over three days during the spring and summer of 2005 with a total of nine personnel from Wepackit, a packaging equipment manufacturer located in Orangeville, Ontario. An organisation chart (see Appendix D3) serves to identify the interviewed personnel and their roles.

Among the potential users of automated packaging equipment, Wepackit chose to service the least sophisticated niche of users with moderate packaging speed requirements in the applications of case erectors, packers and closers and tray formers. . In terms of product design strategy, Wepackit pursued a systematic approach to use robust mechanical designs to ease the machine maintenance and repair to enhance machine availability for the end users. This decision was taken to serve the perceived needs of this group of customers and to fit with Wepackit's design competencies. One of the consequences is that lead users are not pursued as potential customers. Wepackit finds itself redesigning their individual models about every 5 years, sometimes with a goal of incorporating a well-accepted new technology that previous models did not include and sometimes to design out manufacturing costs. In terms of competitive position, Wepackit strives for a middle of the pack pricing position and attempts to acquire sufficient premium over costs by selling the increased availability benefits of its type of design. In terms of manufacturing strategy, Wepackit assembles their equipment in stationary manufacturing cells on a build-to-order basis, but machines and fabricates common parts in large batches on a build-to-inventory basis. One of the key manufacturing management dilemmas surrounds make/buy decisions and order quantity decisions for parts.

### **4.3.1 Company history**

The President, CEO and controlling shareholder (President) of Wepackit Inc. (Wepackit), began his career building and designing value-added packaging equipment in 1980. He is widely acknowledged within Wepackit as a packaging equipment designer with particular talent in the solving of complex mechanical problems associated with corrugated case erecting, packing, sealing and other packaging line production problems. Wepackit was incorporated in 1987 and until 1999 survived primarily through word-of-mouth spread through the industries it served. The company evolved to designing, manufacturing and providing field support for a line of case erectors/closers, case sealers, case packers, tray formers and tape sealers for manufacturers in the food, beverage, snack, automotive, pharmaceutical and dairy industries. Marketing evolved into a North American sales organisation made up primarily of manufacturing representatives supported by a small in-house marketing group. Marketing is conducted primarily through sales calls, responding to

requests for quotation, an information-only website and a presence at the packaging industry's major tradeshow.

As of February 2005, Wepackit had sales of approximately \$10 million/year, (70% of which were export sales to the US) employed about 60 personnel and enjoyed profitability rates of about 9% of sales before taxes. Between 2002 and 2005 these sales and employment figures reflected a 15% annualized growth rate and a turnaround in profitability from a loss position. According to the industry association known as the Packaging Machinery Manufacturer's Institute (PMMI), over this same period annualized industry growth rates averaged less than 2% indicating that Wepackit has been growing faster than the market rate by a significant margin of 13% per year.

The history of Wepackit resulted in an operation which exhibits entrepreneurial behaviours held over from its start-up phase that at the time of the study were being challenged by the growth of the organisation. Whereas Wepackit started out solving package-handling problems and manufacturing associated machinery within commercially acceptable shipping periods, progress now is being made in the creation of structured innovation programmes. Particular to this study of innovation practices, the tension between the former and latter structure is informative as Wepackit continues to sort through the valuable parts of the respective entrepreneurial and corporate-like approaches.

#### **4.3.2 Industry context**

The North American packaging machinery manufacturing industry can be characterized as having a large number of SME-sized firms selling less than \$20 million annually (these firms make up about 74% of members of the PMMI) and very few significantly large firms. (Source: PMMI's 10th Annual Packaging Machinery Shipments and Outlook Study, 2004). The industry serves a number of producer industries with 67% of the packaging equipment dollar volume being absorbed by a combination of the food, beverage and pharmaceutical industries. Trends within the producer industries include purchases of automated packaging equipment to reduce labour costs and to handle the trend towards more single servings. The machinery manufacturing equipment industry has broken itself down by function (i.e. case packing is serviced by a different group of firms than blister

packers while another group of firms serves the needs of palletizing customers) with firms most often staying within their particular niche and designing the custom package holding requirements of different shape and size packages as a routine matter. Some attempts at consolidation across packaging function have taken place by some of the larger firms in the industry which, in the opinion of the President of Wepackit, have met mixed to poor results.

Purchases of this type of equipment often follow a process of specification-writing by the producer (commonly influenced by the machinery manufacturer's salespeople), followed by a request for quotation to the machinery manufacturer that they respond to with a bid. In the preferred approach, this leads to comprehensive follow-up of the bid by the manufacturer's salespeople and when successful, this leads to the issuance of a purchase order by the producer firm. From a macro perspective, a typical packaging evolution for a small to medium-sized producer starts with their use of a contract packer (co-packer) to package their product on a per-piece price basis. If the product being packed generates sufficient volume then the producer begins to look towards self-packing as an economic alternative to co-packing. The producer's personnel charged with acquiring this packaging equipment often have limited packaging expertise and as a consequence they look for simple productive units that have quick change flexibility built-in to handle different package shapes.

More established, higher volume producers follow much of the same process but their economies of scale bias their equipment decision criteria towards higher operating performance which can only be satisfied with recently developed complex electronic and electromechanical components such as servos. The added maintenance and infrastructure costs to support these more sophisticated technologies are offset by the volume gains these higher volume producers are seeking.

### **4.3.3 Innovation practice research methodology**

The President agreed to participate in this case study and was asked to identify a recently completed innovation, an ongoing innovation and a recently terminated innovation.

Characteristics of the innovations selected by the President for study are described in Table 4.3.

Members of these innovation teams as well as the senior managers most affected by innovation and the assembly lead hands and floor level production and R&D personnel were interviewed about the innovation projects they were involved with as well as overall innovation characteristics of the company. The organisation chart in Appendix D3 details the positions of the individual respondents within the organisation.

#### **4.3.4 Context of Wepackit innovation practices**

The President is a mechanical designer who enjoys participating in innovative activity.

*“...there’s nothing like making money off your hobby”* - excerpt from interview with the President.

He surrounded himself with like-minded personnel resulting in an organisational culture wherein employees are expected to propose new ideas on an ongoing basis and management is effective in dealing with these ideas in a supportive manner. The development of this culture has been supported by:

- 1) The producer industry requirement for custom designing of equipment to handle the large variety of package shapes and sizes, and,
- 2) Wepackit’s relatively recent history as a small company and a resulting ease and frequency of internal communication.

A core value of this innovation culture is the President’s belief in simplicity of design, whereby simple mechanical components are favoured over more recently developed electromechanical and electronic components. While this ‘simplicity mantra’ is consistent with the President’s skill set and those of many of Wepackit’s personnel, it also is seen by the management of Wepackit to assist their customers as it simplifies their maintenance and repair tasks resulting in more machine availability and reliability. Not everyone in the firm shares this belief to the same degree as the President and one of the findings of the

Table 4.3 Characteristics of self-selected Wepackit Innovations

|                                     | <b>Recently completed innovation</b>   | <b>Ongoing innovation</b>  | <b>Recently terminated innovation</b>  |
|-------------------------------------|--|--|--|
| <b>Project name</b>                 | 350E Case Erector – new product  | 310E Case Erector -modification of 300E  | 400 Case Packer -new product   |
| <b>Time information</b>             | Ten month project completed 4 months in advance of study                                   | Project just beginning at time of study. Expected display at trade show 6 months later   | Last unit shipped one year before study. Decision to terminate model made 2 ½ to 3 years earlier   |
| <b>Innovation type</b>              | Product  | Product  | Product  |
| <b>Core innovation group size</b>   | 4-5  | 3  | 5  |
| <b>Reason cited for development</b> | Filled performance gap in product line, helped customer who specified incorrect capacity   | Potential identified to build it for less with more flexibility of applications if redesigned. Potential identified during development of 350E | Helped customer who specified incorrect capacity   |
| <b>Total investment</b>             | \$100,000  | \$50,000 so far  | \$70-80000   |
| <b>New technology or market</b>     | Existing technology, new capacity for existing markets                                     | No, opens up possibilities for new markets   | New technology to Wepackit to serve existing market  |
| <b>Status</b>                       | Orders received and manufacturing drawings completed and first units delivered and running | R&D tradesmen assigned to task and some parts already built.   | Terminated as active product. A key part of the development team for the 400CP has left organisation, partly over disagreement over the preferred approach to product development (i.e. engineering-driven complex products, or prototype testing – driven simpler products) |

interview process was that some personnel are disappointed by a lack of exposure to new technology and they have not wholly accepted, as an interesting substitute, an innovation mission oriented around simplifying things for the customer. One of the consequences of the differences between the believers and non-believers in this simplicity mantra is that there appears to be the beginnings of a division into two camps with the simplicity camp referring to the high-tech devotees as being from the world of ‘virtual reality’ in a slightly derogatory sense.



### 4.3.5 Discussion of innovation elements

#### *Idea Generation*

Personnel within Wepackit do not perceive idea generation as a problem because they do not believe they are held back by a shortage of ideas. The idea generation practices at Wepackit are driven by a combination of ongoing problem-solving activities by various Wepackit personnel and serendipitous ideas that occur to the President. The principal identifiers of problems occur: 1) During assembly/testing of units, 2) As the result of regular reviews of product-specific manufacturing costs cast against well-established benchmarks for outside parts purchases and labour components and 3) Based on complaints from customers transmitted by Wepackit's field service personnel. Additional opportunities for innovative activity also arise on a fairly regular basis as the result of requests for quotations received from customers that require something different than their current product line offers.

Several cultural characteristics of the firm seem to influence the generation of ideas.

- An organisational culture that engenders a requirement to innovate even though formal written statements that describe innovation as a strategic imperative do not exist.
- Individual personnel that perceive their ability to see problems through to a resolution as a point of pride and status within the company. This was described by one of the shop floor personnel as follows:

*“Pride plays a big part. You are always trying to do the best you can to my way of thinking anyway”*

- High levels of mutual respect for competencies of personnel inside the firm
- Team make-ups are often heterogeneous (cross-functional problem solving teams are use extensively)
- For the most part open, honest communication patterns take place between management and shop personnel

### *Idea Evaluation*

The evaluation process for new product designs begins with a technical evaluation of its potential to meet functional requirements (e.g. 25 cases of 24 beverage containers /minute with case sizes up to 24”wide and 18” long) followed by an assessment of the potential profit margin for the new product. This margin estimate is based on a projection of costs to produce the new product based on costing experience with other similar products and an informal assessment of the market price of the proposed unit. When asked, none of the respondents could identify the number used to identify the target margin threshold, but the President did identify a criterion of potential sales of 10-12 units per year as being important to a go/no-go decision. This stems from their practice of evaluating target margin based on the life of a ‘machine programme’ that incorporates learning curve advantages that helps them reduce manufacturing costs as manufacturing experience with the unit grows.

Another important metric for evaluation of new ideas is how it compares to the simplicity mantra and the projected percentage of required purchased parts is used as an evaluation proxy. For example, if the proposed design is expected to exceed the established benchmarks of no more than 25% of selling price to be spent on purchased parts, then the design is seen to require revision before it goes to the next step.

New product designs also must keep engineering costs to a targeted level of 4-5% of sales. The President wishes to avoid another “adventure” similar to the development of the 400CP model case packer which eventually had to be withdrawn from the product line due to excessive costs for “complicated” purchased electromechanical parts.

*“Our engineering department is not there to turn every single piece of business that we do into an adventure. Our engineering department is there to make sure that what we do is as well documented as possible and that what we can resell that design again and again and again. So we want to do one piece of engineering and we want to get multiple sales for very little adjustment out of that one piece of engineering. When you look at some of our competitors, what they do is that whereas we spend maybe 4 or 5 percent on engineering, these guys will spend 15 to 20 percent on engineering”.* Excerpt from interview with President.

### *Idea Implementation*

The nature of Wepackit's business of designing machinery to handle different sizes and shapes requires that some design changes are required for each order. These changes are identified early in the production process with a cross-functional order coordination meeting between sales/marketing, engineering, manufacturing and the President. The requirements for additional design changes reveal themselves during the assembly/testing process.

For those product-design problems that involve the President, he will often take on the role of project champion, produce sketches and have several conversations with one or both of the tradesmen in the R&D shop whom he then co-opts into a co-champion. Together, they will work to produce several iterations of prototypes cheaply and quickly, with personnel from other areas in the plant and engineering participating in design review sessions three or four times before the first couple of commercial units are manufactured within the R&D shop. It appears that as designs evolve, a consensus of approval is actively sought among representatives from the different functional areas within the company (with the exception of the accounting/finance function as this role is taken on by the President). Once these first units are produced, engineering staff are then invited to document what was built and make suggestions to improve manufacturability. The President is involved in all the major new product developments, but sometimes other problems arise on the assembly/test floor that are addressed by consultation between assembly personnel and multiple trials to meet the functionality requirements. Engineering sometimes documents these changes.

In terms of process innovations, the VP Manufacturing assumed responsibility to manage these innovations. The genesis of these ideas primarily stem from difficulties encountered during manufacturing and as the result of reviews of labour costs for shipped product. Process innovations are managed with a great deal of variability depending upon the magnitude of the change envisioned. Some process innovations will be handled directly by the VP Manufacturing with shop personnel, while other larger changes will involve managers of the machining, fabrication and assembly areas and will involve ongoing regular reviews of progress.

### *Barriers to Innovation*

Many of the barriers described within the earlier literature do not appear to be significant issues for Wepackit. Many of the barriers related to socio-political issues (e.g. mixed messages (Pearson, 2002), inappropriate incentive systems (Quinn, 1986; Farson and Keyes, 2002) appear to have been negated by the enthusiasm for working with new ideas that is evident throughout the firm. On the other hand, barriers particular to small firm environments (e.g. access to capital (Freel, 2000) and lack of exposure to new technologies (Shapira, 1990)) do seem to be playing a blocking role towards innovations. Systematic barriers specifically mentioned by the respondents included lack of systems for learning from past mistakes (e.g. systems to enshrine solutions to field and assembly problems) and the requirement to occasionally share resources necessary for R&D activities with manufacturing.

The most significant barrier towards satisfying the simplicity agenda or towards satisfying the high tech agenda appears to be the lack of cohesion of direction. Technical advances are seen to be blocked by the simplicity-focused group for philosophical and cost reasons, and the high-tech group is not seen as devoting all of their energies towards advancing the simplicity mission, resulting in change resisting behaviours.

### *Outside Forces Enabling Innovation*

The packaging industry has an inherent need to accommodate new designs due to the large variety of package shapes and sizes. As a consequence, any manufacturer that wishes to be successful in this industry must willingly try new designs on an ongoing basis. As not every design will be successful, the pattern of trial and error that is required to survive in this industry becomes the organisational norm which sets the stage for other attempts at innovation. In addition, this industry-wide requirement to accommodate change created an expectation among the producer industries that packaging equipment suppliers will accommodate their needs, and if one will not, another one will. The resulting function-based competition leads to ongoing improved offerings from Wepackit's competition and matching their improvement becomes a significant motivator for Wepackit to continually innovate.

Suppliers to the packaging equipment original equipment manufacturers (OEM) such as Wepackit also find themselves competing through new offerings. One of the consequences has been the trend over the past seven to nine years beginning with the use of electrical relays and progressing to programmable logic controllers and from simple electromechanical valves to servos and from mechanical limit switches to optically-based limit switches. Some OEMs see these moves toward high tech componentry as a defence against an expected Chinese invasion of low cost machinery. Each of these electronics-based enabling technologies forces Wepackit to either adopt the new technologies along with the attendant changes inside the organisation (as was attempted with the 400CP) or respond defensively with mechanical innovations that offer other benefits to their customers (e.g. simpler design for reduced maintenance).

From a cost perspective, the increase in the Canadian dollar from the \$.67US range to the \$.80US range during 2004 and 2005 erased significant portions of the margin for exported units thereby putting pressures on costs. This has caused Wepackit to review their manufacturing methods and designs to find ways to drive costs out of their product.

Respondents also discussed how innovation within the industry can be driven by the need to attract attention of the producer industries at the PMMI trade show that occurs every two years and how the litigious climate in the US has driven new designs in machine guarding.

#### **4.3.6 Wepackit summary discussion**

Between 2002 and 2005, Wepackit enjoyed growth in sales, profits and employment that has significantly exceeded the average for its industry. Sales of new products introduced between 2000 and 2005 made up 40% of sales. In short, Wepackit enjoyed a measure of success and its innovative activities appeared to be contributing in a significant way.

A three year-old strategic shift towards simplicity of design appeared to be meeting with some success with customers and with high levels of acceptance among the Wepackit hands-on shop personnel. Wholesale enthusiastic support did not exist throughout the whole organisation as those personnel that are more often exposed to new technology developments were concerned that the advantages of simple design may be overridden by

the real advantages offered by new technologies or as they are perceived by Wepackit's customers.

Much of Wepackit's innovation culture stemmed from the company's founder and the environment in which the firm found itself. As the company grows and especially as the President considers retirement, expansion and entrenchment of these successful practices are likely to form an important challenge for management. On the other hand, if the President is considering completing the entrepreneurial cycle through a sale of the company to outside interests, company valuation is likely to be enhanced as the result of evidence of a more structured approach to the innovation processes. In either case, further structuring or entrenchment of the innovation practices appeared to be a necessary condition for the continued growth of Wepackit.

#### **4.4 Priority One Packaging Company (P1)**

The following case study is the result of the analysis arising from interviews occurring over two days during the spring and summer of 2005 with a total of nine personnel from P1, a packaging equipment manufacturer located in Waterloo, Ontario. An organisation chart (see Appendix D4) is included in the appendices to identify the interviewed personnel and their roles.

P1 is the final firm studied and it also serves the packaging equipment industry but uses a significantly different approach to that adopted by Wepackit. To begin with, P1 serves different applications as they have historically focused on palletizing applications while slowly adding other related applications as they arise. In addition, P1 chose to pursue lead customers that have very high volume performance requirements and P1 prefers to become the sole source supplier of equipment that can meet the sophisticated performance expectations of these customer organisations. The large organisations (primarily located in the US) that they serve are typically high volume manufactures with sophisticated in-house packaging engineering expertise. This resulted in an engineering-driven interface with their customers and a corresponding engineering-driven organisation and structure within P1. P1 strives to maintain first mover advantages for its equipment but inevitably competition arises and P1 finds itself competing on a price basis for about half of its offerings. Product

life cycles for P1's equipment are approximately 15 years. In terms of manufacturing strategy, similar to Wepackit, machines are assembled in cells on a build-to-order basis, but parts are manufactured primarily in-house on a build-to-inventory basis. One other key difference between P1 and Wepackit is the significantly higher levels of complexity involved with P1's equipment designs. Dollar volumes per machine are often an order of magnitude higher for P1's equipment.

#### **4.4.1 Brief overview of P1**

P1 is in its third decade of operation serving an ever-growing portion of the North American packaging equipment market. The company and its 110 employees operate out of a six-year old custom-built, 100,000 square foot building located within a modern industrial park. By virtue of annual company revenues ranging between \$20 and \$30 million (CDN), and the breadth of its product line, the company is positioned as one of the medium sized-players in the highly-fragmented industry which serves the packaging equipment needs for the consumer product industry and a wide variety of other industries primarily located in North America.

P1 was incorporated in 1982, by the current CEO with a focus on the provision of systems of palletizers and de-palletizers (placement and removal of individual boxes or items onto or off of pallets) through a combination of manufacturing and resale activities. An increasing demand for provision of systems integration services led to the formation of an Automation Division in 1995. Another significant decision was taken when Priority One negotiated exclusive sales and manufacturing agreements with Langguth, a German supplier of labelling equipment that serves similar packaging markets. This pattern of adding capabilities and products to the firm's offerings continues with day-to-day efforts now led by the President. The CEO removed himself from day-to-day management of the firm. The list of services and products offered by P1 now consists of line-integration engineering services, high and low-level palletizers, small footprint palletizers, multi-line (shuttle and rotary) palletizers, pail palletizers, bulk palletizers, high and low-level de-palletizers, full load stackers, labellers, table-top and mat-top conveyor systems, pressured and pressure-less single filers, pallet conveyor systems, bottle and case

elevators/lowerators, rinsers, magnetic elevators, and cable track. (Priority One website, 2006)

As of the fall of 2005, the plant was operating below peak capacity, as over the last three years revenues had suffered an 11% decline, accompanied by a 15% decline in employment. The declines have been primarily attributed to the effect on sales to U.S. customers of the rising Canadian dollar (15.4% average increase in the CDN/US exchange rate between 2003 and 2005) (x-rates.com, 2006). Within this more challenging environment for sales to their principal market, the company is enjoying annual double digit rates in profit growth over the last three years (to approximately 3% of sales) after having turned around from an earlier loss position.

#### **4.4.2 Industry setting**

P1 competes within the same industry as Wepackit (see Section 4.3.2. for a description of the industry), but in a slightly different niche as they produce equipment for a different portion of the packaging process. Wepackit serves the case erecting and case packing applications, whereas P1 takes the erected and packed cases and automatically places them on pallets to ease handling by lifting equipment such as forklifts. Given their expertise with placing product on pallets, a natural extension to provision of de-palletizers was added to their product line.

#### **4.4.3 Strategic positioning of Priority One**

P1 is on the verge of entering the ranks as one of the few large packaging equipment firms. They achieved their success to-date by starting with a particular application (i.e. palletizing) and focusing on the provision of high margin, high performance machinery sold to customers who are often quite sophisticated in their levels of packaging equipment knowledge and needs. While palletizing remains the core of their business, over the long term they have also consciously continued to add to their product line - extending designs into new applications, and adding new applications (e.g. labelling) through a combination of resale and manufacturing agreements that allows them to learn about particular applications.



Their choice of the high performance niche requires that P1 provides high levels of technical sales support and engineering design expertise and this is reflected in their human resource breakdown within the firm (see the organisation chart in Appendix D that follows for details). The emphasis on engineering talent is reflected in internal practices wherein a lot of effort has gone into creating knowledge management structures (i.e. hand-off criterion between sales engineering and design engineering have been thought through). Engineering is valued as the principal activity whereas the manufacturing, installation and service functions are expected to deliver conversions of the completed engineering design packages with minimum hassle.

#### **4.4.4 Innovation practice research methodology**

The President was approached and agreed to participate in this case study. He was asked to identify the innovations he would consider the most typical of the innovation processes that fit into the categories of a recently completed innovation, an ongoing innovation and a recently terminated innovation. Characteristics of the innovations selected by the President for study are described in Table 4.4,

Members of these innovation teams as well as the senior managers most affected by innovation and the production managers and R&D personnel were interviewed about the innovation projects they were involved with as well as the overall innovation characteristics of the company. The organisation chart in Appendix D details the positions of the respondents.

#### **4.4.5 Operating context for innovation practices**

P1's well-entrenched methods for acquiring and fulfilling customer orders provide an organisational structure and set of practices that form the backdrop for most new product development at P1. As much as possible, innovation projects are handled using the same practices used for build-to-order machinery for customers.

Table 4.4 Characteristics of self-selected P1 innovations

|                                     | <b>Recently completed innovation</b>  | <b>Ongoing innovation-OI(1)</b>  | <b>Ongoing Innovation – OI(2)</b>  | <b>Recently terminated innovation</b>   |
|-------------------------------------|---|--|--|---|
| <b>Project name</b>                 | Rotary Index Table  | Next generation palletizer   | Introduction of MRP to shop floor  | Bulk Water Mariner project  |
| <b>Time information</b>             | Five months   | Six months into the project  | Eighteen months into project. Expect to take 'years' to finish the project | Worked at it for 2 years, decision made to terminate the project about 5 years ago    |
| <b>Innovation type</b>              | Product   | Product  | Process  | Product   |
| <b>Core innovation group size</b>   | 4   | 5  | 8  | 6   |
| <b>Reason cited for development</b> | Produce an index table with better performance for less cost than table previously purchased from others for resale | To reach an application portion niche of an existing market and to increase the size of our product line | To increase volumes and reduce manufacturing costs                         | To expand the product line and to address the huge growth in the bottled water market |
| <b>Total investment</b>             | \$75,000  | \$10,000 so far, total expected to reach \$300,000   | \$50,000 to date with total expected to exceed \$400,000                   | \$500,000   |
| <b>New technology or market</b>     | No  | New niche in existing market   | No   | New market  |
| <b>Status</b>                       | First unit completed and available for sale   | Twenty-five percent complete   | Ten percent complete   | Product is no longer offered for sale   |

This process begins with the sales and application engineering groups following a conventional business-to-business marketing process which then results in the preparation of a quotation for consideration by the customer. Within the quotation process, preliminary application engineering is completed and a set of layout drawings are often prepared to be included with the quotations. P1 is comfortable with investing these sales and application engineering funds for projects that may or may not be successful, so no significant attitudinal changes are required to involve the sales and application engineering groups in innovation projects. For example, a member of the engineering staff described the process as follows:

*“Other times it’s not so complex, and we just quote it. We say, ‘yeah we can do that’, we can figure it out, we’re comfortable with that technology so we just go ahead and get our estimating tools out and away we go.”*

In the normal course of business, once an order is received, the design engineering group is engaged in the project and a coordination meeting between the sales, application and design engineering groups and the customer's technical personnel takes place. At this point, responsibility for completion of the order is handed over to the design engineering group. This group then completes its work and turns over responsibility to the plant to follow their directions to build and install the equipment. With respect to the process, P1 is comfortable with responsibility turnovers between groups and these knowledge management practices are also used for new product developments.

#### **4.4.6 Discussion of innovation elements**

##### *Idea generation*

The principal source of ideas identified by the respondents is the practice of P1 sales personnel and technical sales personnel meeting with customers to identify their current and upcoming needs. P1 takes pride in working with the leading-edge customers in their industries and believe that the ideas gleaned from these lead users are very important to maintaining their competitive advantage.

*“And we're working with almost all of the big players but we're leading with the company that's kind of two years ahead of everybody else”* Excerpt from interview with President

Depending upon the respondent's function within P1, the second most important source of ideas was seen as “the shop floor”, or “competitors” or “the sales group”. In terms of methods to generate ideas, shop and engineering-based respondents thought that listening to their ideas was the most important method, whereas executive and sales-based respondents believed that attending trade shows and monitoring developments by competitors was the most important method to generate ideas.

Some recent changes of personnel within the engineering group and the accompanying changes in culture have increased the level of knowledge sharing. Particular engineers that have left the firm held attitudes that were biased towards their personal ownership of ideas and the resulting hoarding of ideas has now been replaced by a culture more amenable to the sharing of ideas for the common good. This has been widely seen as a positive

development for P1. Other cultural characteristics of the firm that seem to influence the generation of ideas include:

- A long term interest throughout the management ranks to make ongoing additions to the product line even though formal written statements that describe innovation as a strategic imperative do not exist. The status quo in terms of the product line is seen as unacceptable.
- High levels of mutual respect for competencies of personnel inside the firm.
- Recognition that all new ideas need to be honoured with some form of response.
- For the most part, open, honest communication patterns take place between various members of the management team.

The bulk of respondents suggested that they spend between 10 and 20% of their time on innovation and overall, personnel do not perceive that there is a shortage of ideas to pursue.

#### *Idea Evaluation*

The process for evaluating ideas varies with the level of novelty the idea entails for individual P1 personnel. This variance in the evaluative practices was confirmed when respondents provided a wide range of answers to the question of: How many endorsement stages occurred at P1? Their responses included one stage, six stages, eight stages and continuous evaluation.

For evaluation of those ideas that are seen to be relatively incremental changes to known products, the quoting procedures that have been developed by P1 for the normal course of business are used. Any incremental idea evaluation that occurs is primarily technical in nature on the part of the P1 application personnel, with the commercial part of the evaluation being performed by the customer. If the customer finds it too expensive based on their decision criterion, then the idea is dropped. In summary, these relatively known incremental innovations are based on P1 technical feasibility criterion and the customer's economic feasibility criterion.

For ideas that engender higher levels of risk and novelty, a more detailed technical and financial analysis is undertaken to address the question of whether it will receive approval

to go to design engineering for creation of manufacturing drawings. One of the innovation team members described the practice as follows:

*“..and in a lot of cases, what we do is we take a look at what’s in our product line already and what we would have to modify or develop in addition to that to meet the application. And that way we can minimize the risk. Then we work out a lot of the specifications. There’s a lot of up-front calculations to be done. And then we’ll meet through that whole process, and then beyond that there is a conceptual design complete with cost estimates....”*

Carrying through to building of new product designs typically requires an order from a customer that has been sold on the product innovation. Preliminary technical analysis consists of a practice of ad hoc brainstorming among engineering personnel on potential methods to achieve the required levels of technical performance. Deliverables of this early portion process include concept drawings for the riskiest technical portions and significant amounts of engineering analysis around performance capacities. In addition, the riskiest technical portions will sometimes be isolated and a concept prototype built and tested before additional investment in the idea continues.

On the financial side of the analysis, a target cost for the new product is set based on the sales and executive group’s estimate of what the market will bear based on the executive’s generic market knowledge and the desired margins. Other than some ad hoc questioning of P1 sales people, there does not appear to be any evidence of formal market research being undertaken to support these estimates. The target for these margins is based on a goal of achieving a profit on the second machine built. The level of these target margins do not appear to be widely known within P1 and do not seem to be a hard and fast rule. For example, for the current innovation project, there appears to be consensus within P1 that the next generation palletizer will not add to P1’s profits until the fifth machine is built and delivered. In addition, the harder-to-estimate impact on system sales resulting from complementary new product introductions enters into the thinking behind the establishment of target margins.

In terms of assessment of what the machine is likely to cost to build, projected cost estimates form part of the package required before a decision is made to proceed to the design engineering stage. For technically risky projects, these cost estimates will not be

assembled until the proposed solution for the technically challenging portion of the project has passed conceptual testing.

Throughout this process of assembling a technical and financial analysis, any project that lacks a supportive consensus among the involved personnel is at least delayed, if not completely stopped. Once an acceptable amount of technical and financial analysis has been completed, the President acts as a gatekeeper to control movement to the design engineering stage. There seemed to be consensus among the respondents that about 80% of the projects that make it this far, receive the President's approval. Outright rejection of projects that make it to this level are seen to be within the purview of the President's responsibilities and for those projects which get rejected, "gut feel" is cited as the common reason for rejection. No evidence was found of significant ongoing efforts to support projects by other personnel once they are cancelled by the President.

In terms of innovation metrics, it appears that a product that attracts repeat sales resulting in four or five orders per year with an acceptable margin is seen as a success by the sales and executive group. For the engineering and manufacturing groups, innovations which deliver technical performance and reduce shop floor problems respectively are seen as the hallmarks of successful innovations. Cost-to-market tracking begins when a project number is assigned and the idea has survived the first brainstorming/evaluation meeting.

#### *Idea implementation*

For those innovations that are seen as incremental additions to known equipment, and have been sold to a customer, the implementation process follows the design/build cycle which is the normal order fulfilment process for P1.

For those bigger, riskier projects that receive the go-ahead to produce manufacturing drawings, they begin this phase with a meeting wherein personnel from other areas within P1 are introduced to the idea and responses are solicited with respect to problems and opportunities. Also, near the beginning phases of the design cycle, some limited market research consisting of web-based competitive analysis and discussions with customers via selected sales personnel is undertaken. The purpose of this 'market research' appears to be

settling on a selling price and the acquisition of a paying customer for the innovation in question.

As part of the continuing series of weekly project meetings, the early meetings also work towards creating a budget with assigned resources and a schedule (often using Microsoft Project software). The design then either gets included in the design cycle of a current project if the innovation is being added to existing machinery designs, or if it is a standalone project it will be slotted into the design engineering group's work schedules.

As the project progresses, these weekly meetings continue with completed manufacturing drawings and continually updated costing spreadsheets used as the principal tools to report to the group on the project's progress. Cost variances are analyzed with bigger investments attracting higher levels of scrutiny.

Driving forces for completion of projects normally includes externally-imposed deadlines such as meeting commitments made to customers or the need to have new products ready for an important trade show. For internally generated projects, meeting negotiated project schedule deadlines negotiated during the early stages of the project is the norm. Externally-based deadlines are seen as being moderately more effective at driving on-time project delivery than internally-agreed schedules with day-to-day work being the most common obstacle cited for delays in internally-driven projects.

As stated earlier, incremental component innovations commonly occur simultaneously with a customer order, so that no market launch effort is required for the first sale. For the bigger, riskier projects a coordinated market launch primarily focused on selling the first production unit to an existing customer is undertaken. This first sale often requires incentives to accomplish the sale (e.g. discount from list price, and extra field service support). A complementary press release and e-mail campaign is coordinated through selected trade magazines and the production of brochures and videos is completed to support the introduction to other existing customers through the P1 sales force. When the timing works, the bi-annual PMMI Packaging Equipment Tradeshow also provides a venue for introducing the new product.

*Barriers to innovation*

The next two sections break down the innovation factors into barriers and outside enablers of innovation. Each of these factors has been viewed exclusively through the lens of whether it helps or hinders the innovation process.

The most commonly identified barrier to innovation at P1 is seen as the day-to-day order delivery pressures which restricts the time availability of the skilled personnel required to lead and complete the innovation process. This restriction was described thus:

*“Yeah, well there’s only so many people here, resources...internal resources is a big one. We’re in a business where it’s feast or famine sometimes so we kind of have to place according to our averages, so when we’re really busy everybody’s really busy, when we’re slow there’s a little bit of time but you don’t want to carry a lot of people because you simply can’t afford to. So you can only afford to carry so many people in this business. So there’s definitely an issue with just having people available to do the development work.”*

This is slightly different than the consensus in the innovation literature that suggests that the most common barriers for SME-sized manufacturers include a lack of access to capital and a lack of exposure to new technologies (Freel, 2000). While these are both seen to be important barriers at P1, they are not seen as important as the lack of availability of the key personnel.

#### *Strategic level barriers*

At the strategic innovation management level, barriers to innovation include the following:

- The relatively long (15 year) product life cycle for major products within the industry does not require continuous introduction of major new product introductions to be competitive.
- The absence of statements of innovation intent (e.g. volumes and margins required, targets for new products/markets per year, and sales dollars per year from products introduced within last 3 years) means that personnel are guessing at what criterion to use when deciding whether to pursue an idea further. This uncertainty is ameliorated somewhat by management’s perceived openness to ideas and honouring ideas with a timely response.
- A practice that manages the risk portfolio of innovation ideas according to available cash positions as opposed to what the market requires.



- No process is in place to learn what innovation methods proved most effective so that innovation processes become more effective in the future.

#### *Knowledge management barriers*

Given the engineering-driven nature of P1, the transfer of both tacit and formal knowledge is critical to ensure that both sales and design engineers receive the required knowledge to create effective designs. The transfer process between these two groups appears to be routinized. On the other hand, most of the communication between engineering and the manufacturing group appears to be one-way from engineering. Even less transfer of knowledge appears to be transpiring from in-the-field installers to engineering. The resulting gaps in tacit knowledge transfer have the potential to result in missed ideas or problems not being discussed and as a consequence, innovations not being developed. Similarly, the lack of a formal training plan for all key personnel may have similar consequences as personnel are foregoing opportunities to be exposed to new ideas from outside the organisation.

#### *Project execution barriers*

In terms of barriers to the execution of individual innovations, the clear delineation of responsibilities and feelings of ownership for their area of responsibility within P1 (identified as high levels of “formalization” by Olson et al (Olson et al. 2005), results in personnel taking on the role of gatekeeper for their areas as one of their first reactions to new ideas. As a consequence, even if an idea is good for the overall firm, if the idea in question does not address the functional area that the reviewing personnel represent, then ideas that should survive often are not pursued. Multiple respondents were aware of this barrier and consciously tried not to follow their common first reaction and become ‘idea-killers’.

With respect to the preliminary meetings involved in project execution that take place around an idea, these take place mostly between engineers. These personnel bring a somewhat homogeneous viewpoint to the ‘brainstorming’ portion of the innovation process and as a consequence are likely to miss ideas that might have root in another viewpoint. By waiting until the idea has become more formalized before presenting it to members of other functions within the firm, this additional work required to get to the formality of presenting

it to a wider audience within the company, makes acceptance of any new ideas coming from other functions more difficult and as a result some worthwhile ideas are likely being missed. In addition, these brainstorming sessions could become more efficient if classic brainstorming techniques (e.g. no criticism allowed for first stage) rather than ad hoc techniques were used.

#### *Other*

Other situation-specific barriers to innovation at P1 include the exchange rate-driven uncertainties associated with serving the US industry as their major market. This additional uncertainty increases the stakes for gambles on longer-term innovations. Also P1's location in the high growth region of Waterloo has resulted in high levels of competition for skilled employees which could impact P1's long term innovation capabilities if they are not able to recruit and retain the required talent.

#### *Outside forces enabling innovation*

The packaging industry has an inherent need to accommodate new designs due to the large variety of package shapes and sizes. As a consequence, any manufacturer that wishes to be successful in this industry must adapt designs to accommodate these differences on an ongoing basis. As not every design will be successful, the pattern of trial and error that is required to survive in this industry becomes the organisational norm which sets the stage for other attempts at innovation. In addition, this industry-wide requirement to accommodate change has created an expectation among the producer industries that packaging equipment suppliers will accommodate their needs and if one will not, another one will. The resulting function-based competition leads to ongoing improved offerings from P1's competition and matching their improvement becomes a significant motivator for P1 to continually innovate.

The second tier of this industry, the suppliers to the packaging equipment original equipment manufacturers (OEM) also find themselves competing through new offerings. One of the consequences has been the trend over the past seven to nine years from the use of electrical relays to programmable logic controllers and from simple electromechanical valves to servos and from mechanical limit switches to optically-based limit switches.

Some OEMs see these moves toward high tech componentry as a defence against an expected Chinese invasion of low cost machinery.

Other outside forces enabling innovation for P1 include:

- From a cost perspective, the 15.4% exchange rate decrease in the Canadian dollar between 2003 and 2005 erased significant portions of the margin for exported units thereby putting pressures on cost innovations.
- The need to attract attention of customers at the PMMI trade show that occurs every two years sometimes drives innovation schedules
- Litigious climate in the US drove new designs in machine guarding.
- The Scientific Research and Experimental Development tax credit programme offered by the federal government provides funds to offset riskier developments. This programme has been accessed several times by P1.

#### **4.4.7 P1 Summary discussion**

P1 pursues the high performance niche of the palletizing market and the resulting organisation that has been built is a relatively sophisticated engineering-driven company that has grown into one of the medium-size players in this industry. As part of their ongoing corporate development they are continually scouting for ways that they can add to their product line to cover increasing portions of the packaging process. They prefer to pursue potentially high-margin developments, targeted at putting them in the position of being their customers' only source for particular equipment. Inevitably, competition in particular segments has arisen, so that P1 finds they are competing on price more often than they would like.

Their drive to create industry-leading proprietary designs means that they regularly pursue technically challenging, high value projects and they are comfortable doing so. What was evident during the on-site interviews was that they were less comfortable with dealing with the ongoing process innovation of installing MRP in their plant, which raises questions around their change management skills and their resulting abilities to pursue process innovations to be successful in lowering their costs.

## Chapter 5 Cross-case analysis of findings

Within this Chapter, the information gleaned during the individual firm case studies is reviewed using comparative and summarizing methods. The intent of this analysis is to begin answering the research questions around what innovation practices are used within MechSMEs, how MechSMEs evaluate innovation performance and which innovation practices seem to contribute to firm innovativeness based on the innovation success metrics used by the personnel of the MechSME. The discussion of these findings and how they relate to the extant body of literature and business performance follows in the final Chapter of the thesis.

In order to begin answering the research questions, three different approaches are employed to ensure no important concepts are missed. The first approach involves the provision of summary statistics for all of the individual innovations studied. Clearly, the small sample size of thirteen innovations and paucity of innovation metrics used by MechSMEs prevents this information from being very generalizable. The second approach documents the *presence* and *relative influence* of innovation practices, barriers and enablers within each firm. Two sources were used to create the overall listing of innovation practices that were to be assessed for their presence and relative influence. The first source used was the innovation practices identified within the summarizing typological framework derived from the extant literature as part of the discussion of the research methodology. The addition of commonly-occurring innovation practices identified as the result of these case studies and relevant SME literature completes the tabular structure for this second analytical approach. The final approach mimics the structure used in the individual case studies wherein the data gathered from all of the case study transcriptions and the results of the second analytical approach is reduced to descriptions of the innovation practices associated with idea generation, evaluation and implementation and barriers and enablers. This section highlights the commonalities and also describes the unique innovation practices that seem to be important to particular firms. The combination of all of these methods serves to rigorously document what innovation practices are used by the respondent firms.

As described in the following sections, one of the key findings of this research project is that MechSMEs do very little evaluation of innovation success, even in terms of the limited innovation metrics that were identified by the respondents. This is perhaps not surprising given the multi-functional nature of the management task inside the respondent firms and the difficult administrative issues attached to monitoring innovation metrics (e.g. dilemmas about correct attribution of sales/profit volumes to incremental innovations that are part of larger systems and making accurate cost-allocation decisions between day-to-day problem solving, conventional engineering work and innovative work). These difficulties and management's perception that these metrics are not important enough to monitor means that very little tracking happens except when highly visible, expensive or extraordinarily successful innovations occur.

*"...when we put something new in the field we're all very interested in it and watch it closely and communicate with the customer, but I don't know if we've sat down and actually surveyed or calculated return on our investment".* Excerpt from interview with senior manager who was also an innovation team member.

These case studies found that the respondent firms focus almost exclusively on objective metrics that are associated with business performance (i.e. sales growth and profitability) and do very little tracking of innovation success. The one exception is ACEP that is expected to complete an innovation score carding process mandated by their parent organisation. While the existence of the corporate directive was mentioned during the interviews, no other evidence existed of score carding playing a role in the innovation process or being part of the mindset of ACEP respondents.

This lack of measurement of innovation success by the respondent firms and the resulting absence of a dependent variable makes it difficult to answer the final portion of the research question, which seeks to identify any common elements that seem to be important to contributing to their firm innovativeness. This requires an innovative approach to analysis of the findings to attempt to address this problem.

A *firm innovativeness* index that accumulates the *relative influence* on activities within the firm of the assembled constructs of idea generation, idea evaluation, idea implementation, enabling forces and barriers, is offered as a proxy to the missing innovation performance measures. Each of these constructs is assembled by evaluation of the relative influence on

in-firm activities of associated individual innovation practices. In effect, this input measurement model proposes that a greater collection of relatively influential innovation practices as well as fewer relatively influential barriers to innovation is an indication of a higher relative degree of innovativeness within the firm. This index to identify the most innovative firms is constructed by summing the mean relative influence ranking for each assembled construct. This ranking work also lays the groundwork for part of the concluding Chapter wherein the connection between firm innovativeness and business performance is discussed further.

Identification of the innovation practices that are ranked as most influential *and* that are shared by the two most ‘innovative’ firms begins to address which innovation practices seem to be commonly used by the most innovative firms. This does not preclude use of the other innovation practices suggested by the literature (as they are also likely shaped by use of the recommended innovation practices (Van de Ven et al. 2000; Edwards et al. 2005), but simply suggests that the most innovative firms studied seem to be influenced by these particular innovation practices.

Completion of this proxy development work leads to the concluding portion of this penultimate Chapter which summarizes the findings around the innovation processes and metrics used within MechSMEs and sets the stage for the following Chapter’s discussions relating to firm innovativeness and business performance.

## **5.1 Summary statistics for studied innovations**

As part of the process of learning about innovation practices inside the respondent firms, the senior manager of each firm was asked to identify a recently completed innovation, an ongoing innovation and a recently terminated innovation. These senior managers were asked to select innovations for study that they viewed as being the most typical examples of how innovation occurred within their firm. The summarizing data for all the innovations studied have been compiled in Table 5.1.

- Analysis of this compilation highlights several results that might have been predicted based on the extant literature and several surprising results. The notable

Table 5.1 Summary statistics for all individual innovations studied

| <b>Firm/Innovation metric</b>            | <b>Recently completed innovation</b> | <b>Ongoing innovation</b>     | <b>Recently terminated innovation</b> | <b>Averages for all innovations surveyed</b> |
|--|--------------------------------------|-------------------------------|---------------------------------------|--|
| <b><i>ACEP</i></b>                       |                                      |                               |                                       |  |
| Type of innovation                       | Product                              | Process                       | Product                               |  |
| Actual/anticipated time for completion   | 3 months                             | 7 months                      | 14 months of work before termination  | 8 months                                     |
| Actual/anticipated investment/% of sales | .025%                                | .067%                         | .25 %                                 | .11%   |
| Core innovation group size               | 3                                    | 3                             | 2                                     | 2.66   |
| New technology or new market             | No                                   | No                            | New technology                        |  |
| <b><i>CylDiv</i></b>                     |                                      |                               |                                       |  |
| Type of innovation                       | Process                              | Product/<br>Process           | Process                               |  |
| Actual/anticipated time for completion   | 4 months                             | 15 months                     | 48 months                             | 22 months                                    |
| Actual/anticipated investment/% of sales | 2.94%                                | .23%                          | 2.36%                                 | 1.84%  |
| Core innovation group size               | 4-5                                  | 4                             | 8                                     | 5.5  |
| New technology or new market             | No                                   | New technology                | New technology                        |  |
| <b><i>Wepackit</i></b>                   |                                      |                               |                                       |  |
| Type of innovation                       | Product                              | Product                       | Product                               |  |
| Actual/anticipated time for completion   | 10 months                            | 7 months                      | 4 months                              | 7 months                                     |
| Actual/anticipated investment/% of sales | 1%                                   | .5%                           | .75%                                  | .75%   |
| Core innovation group size               | 4-5                                  | 3                             | 5                                     | 4.2  |
| New technology or new market             | No                                   | No                            | New technology                        |  |
| <b><i>PI</i></b>                         |                                      |                               |                                       |  |
| Type of innovation                       | Product                              | OI1 -Product<br>OI2 - Process | Product                               |  |
| Actual/anticipated time for completion   | 5 months                             | 6 months<br>36 months         | 24 months                             | 17.7 months                                  |
| Actual/anticipated investment/% of sales | .3%                                  | 1.2%<br>1.6%                  | 2%                                    | 1.27%  |
| Core innovation group size               | 4                                    | 5<br>8                        | 6                                     | 5.75   |
| New technology or new market             | No                                   | New market<br>niche<br>No     | No                                    | New market                                   |

Table 5.1 (cont'd)

| <i>Cross-case analysis</i>  | <b>Recently completed innovation</b> | <b>Ongoing innovation</b>   | <b>Recently terminated innovation</b>  | <b>Averages for all innovations surveyed</b> | <b>Totals</b>  |
|---|--------------------------------------|---|--|--|--|
| Type of innovation – totals   | 3 product, 1 process                 | 2 product<br>2 process<br>1 that was both product and process   | 3 product<br>1 process   |  | 8 product<br>4 process<br>1 that was both product and process  |
| Average actual/anticipated time for completion  | 5.5 months                           | 17.7 months   | 22.5 months  | 15.4 months                                  |  |
| Average actual/anticipated investment/% of sales                                      | 1.06%                                | .72%  | 1.34%  | 1.02%  |  |
| Average core innovation group size  | 4                                    | 4.6   | 5.25   | 4.66   |  |
| Totals of innovations employing new-to-the-firm technology(s) or aimed at new markets | None                                 | 3 innovations not using new technologies and aimed at existing markets and 1 innovation utilizing new-to-the-firm technology and 1 innovation aimed at a new market niche | 1 innovations not using new technologies or aimed at existing markets and 3 innovations utilizing new-to-the-firm technology |  | 8 innovations not using new technologies and aimed at existing markets and 4 innovations utilizing new-to-the-firm technology and 1 innovation aimed at a new market niche |

results included:

- The bulk of the innovations described were product innovations (as opposed to process or administrative innovations) which supports the work that specifically suggests that manufacturers of assembled products that do not benefit from effective intellectual property protection must compete based on the ongoing development of products that offer differentiation advantages to their customer (von Hippel, 1998). Nevertheless, the emphasis on product innovation was not as pronounced as expected with nearly a third of the ‘typical’ innovations selected for study being of the process variety. This possibly supports the earlier finding that SMEs that were



comprehensive innovators (both product and process) as opposed to single focus innovators (product or process only) reported higher levels of profitability (Baldwin and Gellatly, 2003).

- The bulk of the innovations pursued did not involve new-to-the-firm technologies, but the bulk of the recently terminated innovations did require the use of new-to-the-firm technologies. This begins to indicate discomfort and questionable competence with new technologies among the respondent firms. This supports the findings that SMEs are faced with a barrier to use of new technologies because their personnel often do not get formal exposure to new technologies similar to what they might receive through training programmes (Freel, 2000) While no previous literature has identified typical innovation investment rates for MechSMEs, the levels documented here were lower than expected by the author. This supports the general consensus among respondents that financial resources were not the problem, but that the problem was in finding the time for key personnel to perform the necessary planning to access available financial resources. This supports the findings that access to key human resources is a significant barrier (Freel, 2000) but discounts that financial resources are a significant barrier to innovation (Shapira, 1990)

## **5.2 Presence and ranking of influence of particular innovation practices**

Open-ended interviewing of multiple respondents within the same firm offers the advantage of acquiring a more comprehensive description of how innovation happens within the firm. On the other hand, the differing roles and knowledge bases of the respondents and the differing understandings of innovation held by managers within the same firm (Storey, 2000) leads to differing opinions about the presence and influence of particular innovation practices. With a few exceptions, these differences make binary statements about the presence of innovation practices within each firm problematic. Alternatively, the relative ranking of influence of particular innovation practices can accommodate these differences and begins to provide some insights into the overall importance of particular innovation practices.

The assessment issues identified with the social, technological, motivational and cognitive aspects of routines (Becker et al. 2005) are similar. Relative influence assessment also begins to address these concerns as it reflects the net effect on the firm, as moderated by the firm's idiosyncrasies. In effect, the relative influence metric includes the effect of the collection of strong and weak social, technological, motivational and cognitive aspects of routines for each firm.

The ranking of influence of a particular innovation practice for each firm ('4' is most influential, '1' is least influential) combines a frequency count of the portion of the respondents who perceived the presence of the particular practice in question *and* the author's perception of the amount of influence of this particular practice on the activities of the overall firm. For example, a greater portion of the personnel that use the innovation practice in question is perceived by the author to contribute to its overall influence and strong statements about the importance of that practice by respondents would also be perceived by the author to contribute to its overall influence. The combination of these two factors has then been compared to assessments for each of the other firms and relative rankings have been assigned for each firm resulting in an ordinal scale wherein:

- a ranking of '4' (indicates that this particular innovation practice influences activities within this firm *more* than it does at the other three firms),
- a ranking of '1' (indicating that this particular innovation practice influences activities within this firm *less* than it does at the other three firms),

A ranking of 4, 3, 2 or 1 indicates a decreasing relative influence of a particular innovation practice. In addition, for some innovation practices, there is not a significant difference between firms in the amount of influence the practice has on its innovation activities. In this circumstance, equal rankings have been given rather than employing a forced ranking that would indicate a distinction that does not exist. For example, if a particular innovation practice was perceived to have equal levels of influence within two firms, and this influence was seen to be greater than either of the other firms, the ranking recorded would be 3.5. Similarly, if influence levels of the particular innovation practice are perceived to be equal within the two firms, but less than at the other two firms, then a ranking of 1.5 would be used. For the purposes of identifying the most innovative firms, a key assumption has

*Table 5.2 Ranking of influence of particular innovation practices among respondent firms*  
 (Shading indicates those innovation practices found to be in use in all four firms that seem to be most influential in the two ‘most innovative’ firms). Note: ‘\*’ indicates innovation practice identified in SME-based literature or as the result of these case studies.

| <b>Innovation Practice</b>  | <b>ACEP</b> | <b>CylDiv</b> | <b>Wepackit</b> | <b>P1</b> |
|---|-------------|---------------|-----------------|-----------|
| <b><i>Idea generation</i></b>   |             |               |                 |           |
| <i>Active monitoring of competitive moves</i>   | 4           | 1             | 2               | 3         |
| <i>Active management of employee training and development to acquire exposure to new concepts</i>         | 4           | 1             | 2               | 3         |
| <i>Efforts to stay current with government policies that affect their industry and innovation funding</i> | 2           | 2             | 2               | 4         |
| <i>Active knowledge sharing internally</i>  | 4           | 1             | 2               | 3         |
| <i>Pressure for growth imposed from senior on-site management</i>   | 4           | 1             | 2               | 3         |
| <i>Permission to fail seen as being given by management</i>   | 1.5         | 1.5           | 4               | 3         |
| <i>Time set aside specifically to work on ideas</i>   | 2           | 1             | 4               | 3         |
| <i>Working with lead users</i>  | 2           | 3             | 1               | 4         |
| <i>Team make-ups are heterogeneous</i>  | 2           | 4             | 3               | 1         |
| <i>Use of brainstorming and creative problem solving techniques</i>                                       | 2           | 1             | 4               | 3         |
| <i>Openness to potentially disruptive ideas</i>   | 3           | 1             | 2               | 4         |
| <i>Openness to exploration of new technologies</i>  | 2.5         | 1             | 2.5             | 4         |
| <i>Openness to exploring new types of markets</i>   | 1           | 2             | 3               | 4         |
| <i>Proactive listening to customer problems</i>   | 4           | 1             | 2.5             | 2.5       |
| <i>*Management support for innovation regularly communicated</i>  | 2           | 1             | 4               | 3         |
| <i>*Employee’s perception of openness to new ideas by senior manager</i>                                  | 2           | 1             | 4               | 3         |
| <i>*Commitment by senior manager to respond to ideas offered within a short time frame (24-48 hours)</i>  | 2           | 1             | 4               | 3         |
| <i>*Willingness to pursue incremental innovations</i>   | 2           | 1             | 4               | 3         |

Table 5.2 (cont'd)

|  |     |     |     |     |
|--|-----|-----|-----|-----|
| <i>*Technical problem solving performance as a method of determining peer acceptance/respect in manufacturing shop is supported.</i> | 1   | 3.5 | 3.5 | 2   |
| <i>*Technical problem solving performance as a method of determining peer acceptance/respect in management levels is supported.</i>  | 4   | 2   | 1   | 3   |
| <i>*Requirement that some custom design required for each order</i>  | 2   | 1   | 3   | 4   |
| <b>Idea evaluation</b>   |     |     |     |     |
| <i>Market potential assessment forms part of evaluation of product or service ideas</i>  | 2   | 1   | 3   | 4   |
| <i>Business case evaluation makes up part of idea evaluation</i>   | 4   | 1   | 3   | 2   |
| <i>*Technical feasibility forms important part of idea evaluation</i>  | 2   | 1   | 4   | 3   |
| <i>*Evaluation involves questioning whether the proposed product will deliver the required margin.</i>                               | 2   | 1   | 3   | 4   |
| <i>*Questioning of specific customers about likelihood of market acceptance</i>  | 4   | 1.5 | 1.5 | 3   |
| <i>*Ideas are assessed as to whether it will reduce in-shop problems</i>   | 1   | 4   | 3   | 2   |
| <b>Idea implementation</b>   |     |     |     |     |
| <i>Investment in market launch activities/expenditures for completed innovations</i>   | 4   | 1   | 2   | 3   |
| <i>Internal marketing of innovations to remainder of organisation</i>  | 4   | 1   | 2.5 | 2.5 |
| <i>*Experience with and comprehensiveness of routines to implement ideas that survive evaluation</i>                                 | 2   | 1   | 3   | 4   |
| <i>*Active support for project champions (provision of tools, time, access to management)</i>  | 2   | 1   | 3.5 | 3.5 |
| <i>*Minor and major ideas follow different implementation paths</i>  | 4   | 1   | 2   | 3   |
| <i>*Use of project management tools</i>  | 3.5 | 1   | 2   | 3.5 |

Table 5.2 (cont'd)

|  |     |     |     |     |
|--|-----|-----|-----|-----|
| <i>*Regular progress reporting meetings used as source of peer pressure to meet deadlines</i>  | 2.5 | 4   | 1   | 2.5 |
| <b>Outside forces enabling innovation</b>  |     |     |     |     |
| <i>Industry served accepts/demands innovation</i>  | 1.5 | 1.5 | 3   | 4   |
| <i>Supplier-provided innovation ideas</i>  | 1   | 4   | 3   | 2   |
| <i>Access to corporate parent's information sources</i>  | 4   | 3   | 1.5 | 1.5 |
| <i>Reduction in exchange rate advantages has forced costing reviews of designs to remain competitive</i>   | 2   | 1   | 3   | 4   |
| <i>*Externally-sourced deadlines (e.g. preparation of a new product for a trade show, meet shipping deadline) are consciously used to pressure completion of idea implementation</i> | 3   | 1.5 | 4   | 1.5 |
| <i>*Need to attract attention of customers at biennial trade show</i>  | 2   | 1   | 3   | 4   |
| <i>*Safety legislation requiring more protection for workers</i>   | 1.5 | 1.5 | 3.5 | 3.5 |
| <b>Barriers to innovation</b>  |     |     |     |     |
| <i>Lack of capital</i>   | 1   | 4   | 3   | 2   |
| <i>Mainstream, day-to-day delivery pressures preclude access to key personnel for work on ideas</i>  | 2   | 4   | 1   | 3   |
| <i>*Required time investment by proponents outweigh gains available from incremental investments</i>   | 3   | 4   | 1.5 | 1.5 |
| <i>*Industry's preference for the status quo</i>   | 3   | 4   | 1.5 | 1.5 |
| <i>*Reluctance to fully engage manufacturing personnel in innovation practices</i>   | 3   | 1.5 | 1.5 | 4   |

been made that each of the assembled innovation constructs (e.g. idea generation and evaluation) can affect activities within the firm equally and so should contribute equally (weighting of 1.0 for each construct) to the overall assessment of the firm's innovativeness. This assumption is made in the absence of any other previous work using this original grouping of innovation constructs and in the absence of sufficient data to perform factor analysis to confirm the makeup of the constructs and in the absence of a dependent variable

to statistically determine appropriate weightings between constructs. Confirmation of the appropriateness of the selection of equal weighting would be a useful objective for a future research project.

In Table 5.3 the results of the calculated mean relative influence ranking for each innovation construct is reported and summed together to create the firm innovativeness ranking.

Analysis of Table 5.3 suggests that P1 and Wepackit are the most innovative firms studied.

Using this assessment of firm innovativeness as the defining criterion and selecting those innovation practices that are seen to be the most influential within P1 and Wepackit

*Table 5.3 Means of relative influence ranking for innovation constructs and index for firm innovativeness*

| <b>Innovation Construct</b>                                 | <b>ACEP</b> | <b>CylDiv</b> | <b>Wepackit</b> | <b>P1</b>   |
|---|-------------|---------------|-----------------|-------------|
| <i>Idea generation</i>                                      | 2.52        | 1.52          | 2.83            | 3.12        |
| <i>Idea evaluation</i>                                      | 2.50        | 1.58          | 2.92            | 3.00        |
| <i>Idea implementation</i>                                  | 3.14        | 1.43          | 2.29            | 3.14        |
| <i>Enabling forces</i>                                      | 2.14        | 1.93          | 3.00            | 2.93        |
| <i>Barriers to innovation</i>                               | -2.4        | -3.5          | -1.7            | -2.4        |
| <b>Summative index of firm innovativeness (15 possible)</b> | <b>7.91</b> | <b>2.96</b>   | <b>9.34</b>     | <b>9.79</b> |

(ranked as either 4 or 3 (2.5 if shared) in *both* firms), from Table 5.2, the common-occurring innovation practices which *may* seem to contribute to firm innovativeness are:

- *Permission to fail seen as being given by management*
- *Time set aside specifically to work on ideas*
- *Use of brainstorming and creative problem solving techniques*
- *Openness to explore new types of markets*
- *Employees' perception of openness to new ideas by senior manager*

- *Willingness to pursue incremental innovations*
- *Proactive listening to customer problems*
- *Technical feasibility forms important part of idea evaluation*
- *Evaluation involves questioning whether the proposed product will deliver the required margin.*
- *Experience with and comprehensiveness of routines to implement ideas that survive evaluation*
- *Need to attract attention of customers at biennial trade shows*
- *Intrapreneurship is celebrated*

It would be desirable if this listing could be generalized to other MechSMEs, but the reader needs to remember the potential pitfalls attached to using this list for more than a potential starting point for a future research project. The key methodological concerns of tiny sample size, the fact that the rankings are based on a collection of perceptions without any objective measures to verify them against and the overall question whether the proposed proxy is an accurate or complete estimation of firm innovativeness should all caution against making any categorical statements as to the applicability of this list in other MechSMEs.

In addition to this ranking of the influence for particular practices, there were a number of practices for which no evidence of their application was found within at least one of the respondent firms. This information is carried in Table 5.4 which lists the missing practices by firm.

### **5.3 Cross-case innovation process descriptions**

As with the individual firm case studies, the comparative and summarizing innovation process descriptions are broken down into elements of the overall innovation process surrounding idea generation, idea evaluation, idea implementation and material factors such as outside enablers and barriers to innovation. Before these individual elements are described, some comments describing the industries in which the firms operate and the

*Table 5.4 Particular innovation practices for which no evidence was found within at least one of the respondent firms*

(‘x’ indicates no evidence found and shading indicates those innovation practices that seem to be most influential in P1 and Wepackit, the two ‘most innovative’ firms). Note: ‘\*’ indicates innovation practice identified in SME literature or as the result of these case studies.

| <b>Innovation Practice</b>   | <b>ACEP</b> | <b>CylDiv</b> | <b>Wepackit</b> | <b>P1</b> |
|--|-------------|---------------|-----------------|-----------|
| <b>Idea generation</b>   |             |               |                 |           |
| <i>Active monitoring of competitive moves</i>  |             | x             |                 |           |
| <i>Active management of employee training and development to acquire exposure to new concepts</i>        |             | x             |                 |           |
| <i>Pressure for growth imposed from senior management</i>  |             | x             |                 |           |
| <i>Working with lead users</i>   |             |               | x               |           |
| <i>*Management support for innovation regularly communicated</i>   |             | x             |                 |           |
| <i>*Commitment by senior manager to respond to ideas offered within a short time frame (24-48 hours)</i> |             | x             |                 |           |
| <i>*Requirement that some custom design required for each order</i>                                      |             | x             |                 |           |
| <b>Idea evaluation</b>   |             |               |                 |           |
| <i>Market potential assessment forms part of evaluation of product or service ideas</i>                  |             | x             |                 |           |
| <i>Business case evaluation makes up part of idea evaluation</i>   |             | x             |                 |           |
| <i>*Questioning of specific customers about likelihood of market acceptance</i>                          |             | x             | x               |           |
| <i>*Ideas are assessed as to whether it will reduce in-shop problems</i>                                 | x           |               |                 |           |
| <b>Idea implementation</b>   |             |               |                 |           |
| <i>Investment in market launch activities/expenditures for completed innovations</i>                     |             | x             |                 |           |
| <i>Internal marketing of innovations to remainder of organisation</i>                                    |             | x             |                 |           |
| <i>*Active support for project champions (provision of tools, time, access to management)</i>            |             | x             |                 |           |
| <i>*Minor and major ideas follow different implementation paths</i>                                      |             | x             |                 |           |
| <i>*Use of project management tools</i>  |             | x             |                 |           |
| <b>Outside forces enabling innovation</b>  |             |               |                 |           |
| <i>Industry served accepts/demands innovation</i>  | x           | x             |                 |           |
| <i>Access to corporate parent’s information sources</i>  |             |               | x               | x         |
| <i>Reduction in exchange rate advantages has forced costing reviews of designs to remain competitive</i> |             | x             |                 |           |
| <i>*Safety legislation requiring more protection for workers</i>   | x           | x             |                 |           |



Table 5.4 (cont'd)

|  |   |   |   |   |
|--|---|---|---|---|
| <b>Barriers to innovation</b>  |   |   |   |   |
| <i>Lack of capital</i>   | x |   |   |   |
| <i>*Required time investment by proponents outweigh gains available from incremental investments</i> |   |   | x | x |
| <i>*Industry's preference for the status quo</i>   |   |   | x | x |
| <i>*Reluctance to fully engage manufacturing personnel in innovation processes</i>                   |   | x | x |   |

operating strategies they have adopted is useful to establish the context in which these innovation processes take place.

### 5.3.1 Context for innovation practices: Industry and strategy selection

Two of the respondent firms manufacture production equipment for the hard-rock mining industry and two operate in the packaging equipment industry serving the manufacturers of packaged goods for consumer markets. As described in the ACEP and CylDiv case studies, the portions of the hard-rock mining industry in which they compete have a slow learning process and innovations are often viewed with scepticism. On the other hand, the packaging equipment industry has a characteristic requirement for innovation to be built-in to every machine (to handle the variety of package shape and sizes) and the package goods manufacturers have many alternative suppliers from which to select. The net result is that the packaged goods manufacturers can and do tell packaging equipment manufacturers that if they cannot provide what they want, they certainly can find a competitor who will try. This leads to an expectation in this industry that innovation is an ongoing requirement to be competitive.

In brief summary, the differences in context introduced by the industry, strategy and manufacturing process selections of the four firms studied suggest that appropriate corresponding organisations have been constructed to service their selected niches. The principal resulting characteristics that provide context for the innovation practices of each firm are:

- ACEP focuses on a very specific, highly volatile, slow-to-learn sector with a small number of fairly sophisticated products and they jealously guard their market share of this sector while accepting the volatility that accompanies servicing of this sector.
- CylDiv focuses on a geographically-based stable portion of the hard-rock mining industry with both service and manufacturing offerings. The simple products and generic technologies they use result in low barriers to entry for competitors and they attempt to maintain their competitive position by offering specialised service and an ever expanding documented list of products to help their customers ease their purchasing processes.
- Wepackit pursues a wide variety of unsophisticated packaging customers that are likely to derive value from Wepackit's robust simple designs. They compete in a crowded marketplace and are strategically bracketed by lower cost designs and higher performance designs.
- P1 strives to gain first mover advantages by serving lead users within their industry. This requires a willingness to pursue new technologies and new applications and greater risk tolerance than the approaches adopted by the other three firms. At the same time, competitive offerings have arisen and costing pressures have begun to assert themselves within P1 for a significant portion of their offerings that are based on older designs.

### **5.3.2 Idea generation**

From analysis of Table 5.2., the most influential innovation practices in P1 and Wepackit oriented towards creating or acquiring new ideas that were utilized by all four firms were:

- *Permission to fail seen as being given by management*
- *Time set aside specifically to work on ideas*
- *Use of brainstorming and creative problem solving techniques*
- *Openness to exploring new types of markets*
- *Employee's perception of openness to new ideas by senior manager*
- *Willingness to pursue incremental innovations*
- *Proactive listening to customer problems*

In addition, three of the firms made extensive use of cross-functional teams during brainstorming sessions at the idea generation phase, whereas P1 added to their engineering groups' thought processes by using a cross-functional team after a project had acquired formal approval and add-on ideas and manufacturability questions were being addressed.

In addition to simply listing the shared practices that were the most influential within the most innovative firms, there were several particular practices that warrant additional comment as they stood out as being very influential within the respondent firms.

Proactive listening to customers played a very influential role within all four firms. In the case of ACEP, this listening practice (this practice is known as 'brickwalling' by ACEP personnel and it was introduced last year) is managed as an annual exercise wherein arrangements are made for multiple ACEP personnel to travel to the customer's location to meet with multiple customer personnel for a formalized evaluation of their past year's service. A middle manager within ACEP described the influence of this innovation practice in this way:

*".. I would say it (brickwalling) is a basic. It's a part of the strategy of the company. I would say it's a core strategy of the company and a really good strategy."*

In the case of Wepackit, the President works to maintain a long-established routine of averaging about eight site visits per year to end users wherein his specific focus is oriented toward looking for developing needs and addressing any problems that have arisen. In all of the respondent firms, these interactions with their customers provide the bulk of the starting points for the innovations that they pursue with problems experienced by customers acting as the most common starting point.

A nearly equal influence on the generation of ideas seems to stem from the senior manager's attitude toward new ideas. Senior managers who were seen to be open to considering ideas, desirous of receiving ideas to consider and that honoured ideas with a timely response were mentioned by a broad cross-section of the respondents. The following response was typical in the firms that felt that there was not any shortage of ideas for innovations within their firm:

*“... I mean I can tell you that people are very open to come up with new ideas here. It really seems like the environment is a big part of that. I think that the overall positive work environment is something that’s fostered from the top down... both from the general manager and the general manager previous to him who are very personable, approachable people.”*

The effect of the senior manager’s attitude was to leverage the other employees’ efforts toward or away from work on development of ideas until they were ready for presentation to their peers.

Within all four firms, personnel striving for peer acceptance and respect also play a very important role with respect to the generation of ideas. Within Wepackit and CylDiv, the most respected personnel in the shop are those who prove that they can solve the toughest problems and some personnel will go to extraordinary lengths (e.g. experimenting in their shop at home and working unpaid overtime) to find solutions to problems to support their status within the shop. One shop floor-level respondent described the role of pride this way:

*“if you combine happiness with a little bit of pride you can come out (with results that) usually make somebody very happy and make yourself happy. I’m happy that he gave it to me. He trusts that I can do something like (that).”*

Within ACEP and P1, a similar dynamic seems to be in place within the technically-oriented members of the management ranks. For all the firms, the results of these extraordinary efforts have a significant impact on the innovation process as a substantial portion of the potential problem solutions that are considered are derived in this manner. The background of the firm’s personnel seems to support this dynamic as the bulk of the manufacturing personnel and technical management personnel are machinists, welders, millwrights and engineers, most of which have chosen their trade or profession partly because of their successful experiences as ‘backyard mechanics’ and the solving of mechanical problems is a well-entrenched practice for many of these personnel.

Several other practices seem to stand out in terms of their influence on the generation and acquisition of new ideas. For example, within ACEP and P1, senior management (imposed from corporate in the case of ACEP) have a vision for the growth of their firms that is based upon the addition of new products and this underlying long term goal makes up part of the day-to-day decision making in these firms.

*“It’s my job to make sure we’re here tomorrow, and I don’t want to work anywhere else, I don’t want to go anywhere else, and so I think that moving our product lines ahead and looking for new market lines and industries and products is essential to that.”* Excerpt from interview with President of P1.

In these same firms, moves by competitors also are a significant source of ideas. This likely stems from their strategic stance wherein they both actively defend their shares of existing markets. Within Wepackit, a routine of performing periodic reviews of manufacturing costs have led to several redesigns of their product leading to brainstorming sessions oriented towards creation of ideas for cost reductions.

The idea generation practices mentioned in this section are by no means the only ones in use within the respondent firms but do represent the practices with the greatest influence on activities within the respondent firms.

### **5.3.3 Idea evaluation practices**

As was stated earlier, there is not a lot of effort spent on measuring innovation success and this lack of importance attached to innovation measurement is seen within each of the respondent firms. The bulk of the evaluation practices that take place are ad hoc and quite idea-specific and are not used to evaluate the success of the innovation programmes by revisiting whether developments have met their initial projections. The most influential innovation practices in P1 and Wepackit oriented towards evaluating ideas that were utilized by all four firms were the following:

- *Technical feasibility forms important part of idea evaluation*
- *Evaluation involves questioning whether the proposed product will deliver the required margin.*

In addition, three of the firms (all but CylDiv) tried to ensure that ‘major’ ideas were evaluated on a business case basis as much as possible. Within Wepackit and P1 this evaluation was done primarily by the senior manager and they used a ‘machine programme’ as their unit of analysis. If they felt the proposed product was technically feasible and the market would bear the prices they need to meet their normal margin

requirements (once the learning curve effects of a machine programme had lowered their costs), and there was sufficient demand to complete a ‘machine programme’ then they would support the development. The senior managers relied on their extensive experience within their markets and some cursory checking with their internal sales people to evaluate the accuracy of their market price estimate. No demand surveys or extensive promotion to multiple customers were done, but most development programmes did not continue to fruition without a customer’s order firmly in place. Within ACEP, if the cost for the proposed idea was likely to exceed \$20,000, then a business case presentation to a Product Board from corporate became the normal procedure. The go/no go metrics used here were one year payback, the existence of a “testing partner customer” and the proposed idea must affect ACEP sales by 10% as a minimum.

The foregoing evaluation practices were the practices that the managers described as their preferred approach. A greater number of respondents (primarily based in the shops of the respondent firms) described their evaluation of any idea as being measured against two metrics, Will it work technically? And will it make our jobs easier? In the case of CylDiv, this second metric was the overriding metric for any ideas considered. This was possibly the case due to the extensive involvement of members from the shop in cross-functional teams at all stages of the innovation process.

In addition, two of the firms seemed to have an idiosyncratic approach to evaluating ideas that seemed to be quite influential in their consideration of ideas. Within CylDiv, their desire to avoid disrupting normal shop processes plays a key role in stopping many ideas. A further ‘gate’ that any idea must pass to survive within CylDiv is that it must be sponsored by a tenacious project champion as ideas that are not repeatedly raised are deemed to be not important enough to pursue. This evaluation criterion is an effective idea killer. Within Wepackit, proposed machine ideas are routinely evaluated against a benchmark that costs for the purchased components (e.g. motors, switches, and valves ) required by the design, should not exceed 25% of selling price and engineering costs should not exceed 4-5% of selling price. When a proposed product innovation exceeds these benchmarks, machine redesign often begins.

### 5.3.4 Idea implementation practices

From analysis of Table 5.2 there is only one highly influential innovation practice in P1 and Wepackit oriented towards implementing ideas that were utilized by all four firms, that being:

- *Experience with and comprehensiveness of routines to implement ideas that survive evaluation*

Unfortunately, the respondent firms do not track meaningful implementation process metrics (e.g. time-to-market, cost-to-market, and time-to-market as % of forecast) so that an objective comparison of the effectiveness of their implementation practices is not possible. At a subjective level at least, within all the firms, the amount of history and the level of sophistication of the implementation routines subjectively seem to greatly influence the activities within the firm. For example, within P1 the practices utilized for implementing an innovation are nearly identical to their day-to-day delivery routines for equipment orders. The additional challenges associated with a particular innovation (technical and market) were not handled in a particularly repetitive manner, but the rest of the innovation development utilized project management methods, project accounting methods and meeting protocols that have been long established for their day-to-day business. Each of the involved individuals saw the practice as routine and are comfortable with the pressure points of budget and schedule. On the other end of the ‘firm innovativeness’ continuum, CylDiv has a long history of suppressing changes to their basic formula and they have not built up a history of a standardized approach to innovation implementation. As a consequence, personnel do not know what to expect next and tread carefully (and slowly) before making their next move on any particular idea.

Another innovation practice used to significant effect in all four firms was the use of regular progress reporting meetings during the course of development of the new idea. Responses by senior managers indicated that part of the reason for setting up these meetings was to utilise peer pressure felt by those responsible to move the project forward. These meetings highlighted individual personnel’s efforts toward completing their assigned

tasks and the perceived need to report progress typically resulted in these meetings becoming deadlines for action. A typical response from a member of the innovation team follows:

*“With any projects involving more than one person which is almost all of them, then you basically have other peoples time being involved in the process and if your not accomplishing your tasks on time, then essentially your wasting their time and you know projects going past due for no particular good reason are just not a particularly good habit to get into”*

Another side benefit for the senior managers is it shifts the responsibility for staying on schedule from themselves to the group. This was found to be especially helpful for those situations wherein the senior manager was seen as an equal participant in the idea implementation process. The shift in schedule responsibility to the group supported the senior manager’s efforts as a team member as he did not find himself having to switch hats from ‘team mate’ to ‘boss’ as often. This resulted in the senior manager being able to bring more focus to his role as a contributing member of the implementation team.

Within P1, ACEP and Wepackit, there is an established distinction in the routines used for major and minor ideas. For example, within ACEP a \$20,000 cost threshold is the break point between ideas handled within the plant site organisation, on a mostly ad hoc basis, and the significantly more formal routine required when ideas need to involve the corporate Product Board. Within Wepackit the distinction is between new product development and product redesign and process innovations or incremental product design changes. Within P1, the distinction is between new product development and incremental product design changes. In each case, the result is that the minor ideas are handled on an ad hoc basis, they do not face some of the barriers that accrue to the idea evaluation process, nor do they attract additional resources to assist in their completion. Many of the respondents indicated that these types of projects were expected to be handled within their normal workload and when day-to-day activities were busy, either these ideas got postponed, or the respondents worked longer hours in order to add them to their task list. The inherent acceptance in use of these different routines creates a net advantage for the firms as incremental innovations still can be accommodated and a practice exists to introduce more discipline for those ideas that transition from minor to major. In the case of CylDiv, the lack of established



distinctions in innovation routines creates uncertainty for the proponents resulting in delays and more ideas being stopped.

Other implementation practices that were particularly influential within several of the firms included:

Within P1 and Wepackit:

- *Active support for project champions (provision of tools, time, access to management)*

Within P1, and ACEP

- *Investment in market launch activities/expenditures for completed innovations*
- *Use of project management tools (Microsoft Project was used by both firms)*

Within ACEP:

- *Internal marketing of innovations to remainder of organisation*

### **5.3.5 External forces enabling innovation**

All four firms were highly influenced by the innovation stance of the industries they serve and the comprehensive firm-specific effects have been described within the individual case studies. In addition, for P1 and Wepackit the American concentration of their customer base and the impact of the recent loss of advantageous CDN/US dollar exchange rates have forced costing reviews of their equipment designs to remain competitive with US-based competitors. These reviews have stimulated several product redesigns.

Within both the packaging equipment industry and the mining industry, trade shows are widely-used for marketing and particularly for the introduction of new products to attendees of the trade show. Within the packaging industry, the biennial PMI trade show has become the venue of choice for many packaging equipment manufacturers to introduce new equipment, and as a consequence, some new product development activities have been stimulated at both P1 and Wepackit to compete with expected moves by their competitors. For all four firms, external deadlines such as trade shows and meeting shipping commitments given to their customers were commonly used as driving forces to stimulate progress on implementation of ideas. These external deadlines were more commonly cited

by the respondents as the source of motivation to make development progress than pressure brought to bear by the senior managers. Similar to the advantages offered by peer pressure created by regular progress report meetings, using these external deadlines help senior managers to avoid strain in relationships within the implementation teams of which they are a participant.

Less influential but present in all four firms is the innovation-enabling practice of using ideas provided by suppliers to stimulate product redesigns and process innovations. In practice, these innovations were primarily incremental in nature with conventional supplier/buyer relationships remaining the norm as there was little evidence of the creation of structures embodying joint ventures or similar arrangements with the supplier.

### **5.3.6 Barriers to innovation**

The only influential barrier to innovation that played a role in all four firms was the mainstream, day-to-day delivery pressures that precluded access to key personnel to spend time working on ideas and the construction of the necessary arguments to acquire a commitment of resources. Without exception, respondents repeatedly referred to a lack of time to work on ideas, as for managers at least, their workload to just meet delivery schedules for booked orders often resulted in them working overtime.

*“...we could be probably out looking for ideas more. I don't think we're proactive enough in looking for new technologies and new ideas on how to do things because we seem so wrapped up right now just trying to fill orders. Were not looking at how can we do things better down the road. Not enough time and not enough resources which is dangerous. You should be looking out how you think you should be doing things down the road...”. Excerpt from interview with a middle manager.*

Work on ideas was seen as a second priority unless budgets and schedules were struck that indicated a commitment by management to the importance of working on the idea.

Within ACEP this hesitancy to invest time in an idea before a management commitment is made is exacerbated by the requirement to meet the significant bureaucratic minimums to acquire resources from the Product Board structure. Within CylDiv, the ambiguity

surrounding what innovation practices should be followed added a layer of uncertainty for idea proponents that in effect makes these key personnel less likely to work on developing ideas.

A wide variety of other barriers to innovation were described by the respondents with the bulk of them appearing to be firm-specific. For example, other than workload pressures, within ACEP and CylDiv, the next most influential barrier to innovation was the hard-rock mining sector's well-known preference for the status quo. Knowing that new ideas presented to this sector are likely to face a hostile, sceptical reception acts as a significant deterrent to proposals for new approaches.

One of the barriers to innovation mentioned in the literature is the lack of exposure to new technologies due to the lack of training opportunities for personnel (Shapira, 1990). This barrier was described as a problem by respondents within CylDiv and Wepackit and is not surprising given the relatively lower levels of technical sophistication employed within these two firms.

An interesting contrast in approaches revealed itself in terms of the amount of involvement manufacturing and field service personnel has with the innovation activities of the firm. The two smaller firms and less technically sophisticated firms of Wepackit and CylDiv make extensive use of manufacturing personnel in their innovation activities. On the other hand, ACEP and P1 do not often engage in significant two-way discussions around new ideas with their manufacturing personnel. A similar communication gap exists at Wepackit wherein lessons learned in the field are not documented or pursued as a valuable source of ideas. In each case where the production or field service personnel are not involved, there is a corresponding barrier to the creation of ideas that might stem from the experience sets of these personnel.

### **5.3.7 Organisational Culture**

In addition to the aforementioned innovation elements which fit within the innovation process model, two other organisational culture factors seem to influence activities considerably within the respondent firms. The 'celebration of intrapreneurship' within

Wepackit and P1 seemed to provide a supportive environment for personnel to try new things. In the case of Wepackit, respect and admiration for the inventive entrepreneurial talents of the President were mentioned by the bulk of the respondents. These responses were accompanied by positive references to inventive and successful work of other employees (mostly from within the shop) which gave the impression that a bit of competition exists within the company to follow the President's lead and find inventive solutions. Within P1, the respondents also displayed respect for other employee's inventive and project championing efforts. The leadership of innovations perceived to be successful was seen as a natural and appropriate reason to justify promotions within the company. Mostly within the engineering department of this engineering-driven company, levels of technical expertise and the willingness to use it to develop and pursue inventive solutions were highly respected.

Communication and respect between management and the shop floor was the second item that affected the innovation activities of the firm that could be labelled as a cultural factor. For this factor the information received from the respondent firms is a study in contrasts. The two larger firms, P1 and ACEP normally followed a routine wherein management completed their processes and made their decisions and then told the shop what they wanted done. On the other hand, Wepackit and CylDiv extensively involved shop personnel throughout the decision cycle. Within the two larger firms, minimal shop input restricts the flow of ideas around manufacturability issues. The effect is to act as a barrier to these types of innovation. To the same effect, within CylDiv, the involvement of shop personnel adds to management's preoccupation with not upsetting day-to-day operations. Wepackit on the other hand, seems to make effective use of the innovative capabilities of their shop resources but one of the results of this has been a less effective engineering department that finds itself starved of resources and less able to influence design decisions. Within the respondent firms these wholly different cultures are quite evident and do seem to have a fairly significant impact on day-to-day and innovative activities.

## 5.4 Summary

Within this Chapter three methods of summarizing and comparative cross-case analysis have been used to answer the research questions of: 1) What innovation practices are in use within MechSMEs? 2) How do MechSMEs measure their innovation success? and 3) Which innovation practices seem to be important to their firm innovativeness?

The first method was a collective description of the characteristics about the thirteen innovations that were studied. The results of interest were:

- Only innovations oriented towards existing technologies and existing markets were listed as recently completed,
- The bulk of the recently terminated innovations focused on technologies that were new to the firm,
- Typical investment levels were quite small as a percentage of sales (i.e. approximately 1% of sales for each innovation studied),
- The average actual/anticipated time to market for a single innovation was about 15 months and they typically had the heavy involvement of 4 or 5 people.

The second method sought to document which innovation practices were in use and how MechSMEs measure their innovation success. One important finding was that MechSMEs do not track innovation success in any meaningful way. This absence of a dependent variable has led to an attempt to construct a firm innovativeness index based on the relative measure of perceived influence of innovation constructs to begin to approach answering the third question. A total of 43 individual innovation practices have been identified in this analytical approach. On a summary basis, of interest was that 23 of the 43 innovation practices were found to be in use in all four firms. In effect, about half of the innovation practices assessed were shared by all four firms and this finding supports both sides of the argument in the body of innovation literature about whether innovation is firm-specific as there seems to be both a significant portion of their innovation practices that are shared across all four firms and a nearly equal portion of the practices which are not shared.

Of additional interest was that of a total of 18 innovation practice that were identified as most influential within the ‘most innovative’ firms, a full third (6) of these innovation practices were not in use in at least one of the other firms, conversely, 12 were shared. These 12 practices appear to have some potential for further study of their impact within other MechSMEs. These 12 practices were:

- *Permission to fail seen as being given by management*
- *Time set aside specifically to work on ideas*
- *Use of brainstorming and creative problem solving techniques*
- *Openness to exploring new types of markets*
- *Employee’s perception of openness to new ideas by senior manager*
- *Willingness to pursue incremental innovations*
- *Proactive listening to customer problems*
- *Technical feasibility forms important part of idea evaluation*
- *Evaluation involves questioning whether the proposed product will deliver the required margin.*
- *Experience with and comprehensiveness of routines to implement ideas that survive evaluation*
- *Need to attract attention of customers at biennial trade shows*
- *Intrapreneurship is celebrated*

In the event additional opportunities arise to further study the impact of innovation practices within MechSMEs, study of the other six identified practices would also likely be worthwhile. It is likely useful at this juncture to remind the reader that these findings have not been tested for causalities and as such, prevent these findings from being broadly generalizable to other MechSMEs. What they do offer is a potential starting point for a future research project to evaluate their relative contributions to firm innovativeness within this sector.

The final method used to perform cross-case analysis mimicked the case method reporting structure used for the individual case studies. Description of which innovation practices were used for each of the categories of idea generation, evaluation and implementation,

barriers and enablers and an additional category of organisational culture was described for the collection of cases studied.

The next Chapter utilizes some of the findings of this Chapter to discuss the relative merits of the schools of thought described in the literature review portions of this thesis, the relationship between innovativeness and business performance and suggestions for how these preliminary results might be used in a future research project to support the generalization of these results to other MechSMEs.

## **Chapter 6 Conclusions, recommendations and future research directions**

### **6.1 Introduction**

In the earlier Chapters of this thesis, a wide variety of literature was reviewed, firstly from a broader innovation basis and secondly by reviews of the innovation literature based in the context of SMEs. These reviews concluded that the innovation literature is widely varied and fragmented and often contradictory in its findings and that for the context of MechSMEs that very little was known about what innovation practices were used or seemed to contribute to firm innovativeness. In order to try to bring some order to the previous findings and to provide a template for ensuring that important concepts were not missed, a process approach has been used both for the source of the questions and for the structure of the individual case studies. In addition to this process approach, an attempt was made to categorize the literature into schools of thought, each of which are supported by groups of innovation researchers. This chapter begins by reflecting on the innovation process-based research methodology followed in turn by comparisons of the findings of this dissertation with other research in similar contexts and by comparison with the larger body of innovation literature.

This Chapter concludes by undertaking two significant tasks; 1) the making of recommendations for managers of MechSMEs that wish to improve their sustainable innovation efforts and government agencies that wish to support MechSMEs in these efforts; and 2) the identification of potential targets for future research in this context. Also the relationship between the derived firm innovativeness rankings and business performance is discussed. This discussion is an important consideration for future research projects within this context.

### **6.2 Reflections on innovation process research**

The completion of the case studies provides an opportunity for reflection on the effectiveness of process-based research within this context. Process research uses a



longitudinal temporal foundation that remains focused on a particular set of activities. One disadvantage of focusing on the steps within a process is that it removes emphasis from the study of the overall environment for innovation within the firm. Assessment of the organisational culture is one example of the type of overarching variables that does not lend itself to effective study using a process focus. At the same time, the focus provides an opportunity for more detailed questioning about topics that have been identified in earlier innovation literature as possibly being important. Given that little is known how innovation happens in detail in this context, the need for the depth of analysis offered by process research outweighs the possible disadvantage that significant issues will be missed by focusing the questioning. In terms of the practicality of the process model for this PhD, the checklist of questions provided by the innovation process model (see Appendix A) seemed to be easily understood by the majority of interviewees from all levels within the respondent firms and the questions were seen as logically following one from the other.

Within this dissertation, the research design attempted to access the advantages and reduce the disadvantages of process research. This was done by combining questioning around individual innovations with questions about overall innovation policies and by the fairly extensive use of open-ended questions to provide respondents with opportunities to describe overarching variables.

In summary, the process research approach is an effective method to assess the presence and relative influence of previously identified variables and additional variables that reveal themselves as a consequence of the open-ended nature of the questions and the case study methodology.

### **6.3 Comparison of findings with other SME-based innovation literature**

There are five particular studies within the body of innovation literature which approximate to some degree the context of the firms studied here and it is relevant to compare the findings of this thesis with the results of these five studies. The descriptions of the five studies and the differences in their methodology and the contexts researched are summarized in Table 6.1.

*Table 6.1 Descriptions of previous SME studies and caveats for transferability to MechSMEs*

|  | <i>Baldwin &amp; Gellatly, 2003</i>  | <i>Motwani et al, 1999</i>  | <i>Chandler et al, 2000</i>   | <i>Barnett &amp; Storey, 2000</i>  | <i>Covin &amp; Slevin, 1989</i>   | <i>This research</i>   |
|--|--|---|---|--|---|--|
| <i>Context studied</i>                           | Canadian SMEs across all sectors   | French SMEs in mfg., communication, construction and transport sectors  | Manufact'g SMEs in American southwest   | SME manufacturers that were UK innovation award winners  | Manufacturing SMEs in 25 industries in eastern US   | Canadian MechSMEs in two industries  |
| <i>Sample description</i>                        | Data for '000s of firms taken from 5 gov't surveys ranging from new entrants to established firms with up to 500 employees | Senior managers of 87 firms in four sectors (approx. average of 140 employees per firm)   | Sampling of 429 employees within 23 firms with a median size of 31 employees  | Case studies, 5 individual innovations, 50 managers inside 5 mfg. SMEs (ranging between 4 and 280 employees) | Senior managers of 161 firms (average size, 73 employees)   | Case studies of 13 indiv. innovations within 4 firms, total of 32 employees (average size, 82 employees)                             |
| <i>Basis of research</i>                         | Business performance vs. managers' attitudes towards importance of particular innovation activities                        | Senior managers' perception of the importance of certain factors in influencing their satisfaction with innovative actions within their firms | Employee's perception of presence of innovation-supportive culture vs. innovation factors, and, vs. business performance in environm'ts of differing hostility  | Case study narrative   | Business performance vs. strategy selection that is appropriate for level of environmental hostility  | Individual and overall innovation practices, what they are, how they are measured and which ones seem to lead to firm innovativeness |
| <i>Caveat for applicability to this research</i> | Cross-contextual sample blurs findings into marginally useful generalizations  | Hi-tech bias as questions derived from findings of previous research within high technology SMEs  | Measure of perception of an innovation-supportive culture ignores other innovation elements. For some env'ts. this culture is demonstrated to not be an effective contributor to business performance | Innovation award criterion is unknown, so sample selection criterion is unknown                              | Only 20% of profitability variance explained by strategy selection (including orientation towards innovation) and hostility of environment. Majority of key variables remain unidentified |  |

Findings around the impact of the business environment on innovation are examined within these studies from a variety of perspectives. For example, technological innovativeness of the operating sector is seen to increase technological innovation by the respondent firms in the study of French SMEs (Motwani et al. 1999). One of the key conclusions of earlier research on Canadian SMEs (Baldwin and Gellatly, 2003) concluded that innovation is at least industry-specific, if not firm specific. This was taken further within the UK study that concluded that innovation was firm-specific (Barnett and Storey, 2000).

Within the respondent firms in this thesis, there is ample evidence of the influence of the business sector in which they operate. This influence has likely been exaggerated by the sectors chosen for comparison because of the significant differences in innovation stances between hard rock mining and packaging, with the former striving to maintain the status quo to accommodate their slow learning rate and the latter responding to significant levels of innovation in consumer markets with an expectation that their suppliers will follow suit.

Each of the sector-effect findings of the other SME studies are supported to some degree. For example, the two mining firms use less electronics-based technologies in their products than do the packaging firms. The innovation types (product vs. service, new product design vs. incremental design changes) also seem to be influenced by sector specifics. For example, there appeared to be newer, riskier product designs developed in the packaging equipment firms than there is within the mining equipment firms. This supports the earlier finding that innovation is at least industry-specific (Baldwin and Gellatly, 2003). The findings of this thesis suggests that innovation is affected by a combination of industry-specific and firm-specific factors as the results suggested that significant portions of innovation practices are both shared and unique among the firms.

Additional studies conducted within US-based SMEs researching the impact of operating environment on innovation found that comparisons of business performance to environmental hostility revealed that an internal innovation-supportive culture positively influences business performance only in hostile, dynamic environments (Chandler et al. 2000), and that, firm performance can be explained by a combination of strategic posture (including an orientation towards new product development or incremental product

development) and environmental hostility (Covin and Slevin, 1989), although a maximum of only 20% variance in profitability is explained by these factors.

With respect to idea generation, the other studies of SMEs found a variety of sources of idea generation. The earlier American study found that competitors are seen as a significant source of ideas (Covin and Slevin, 1989), whereas the UK study (Barnett and Storey, 2000) and this thesis found customers to be the single most important source of ideas. This finding's robustness is boosted when one considers that the UK study looked at firms with high levels of interconnectedness with their customers (e.g. joint ventures, and interlocking ownership) and this dissertation specifically selected firms for study wherein no single customer made up more than thirty percent of their business. This was intended to limit the study to the internal innovation practices generated by the management of the firms, and to preclude the study of firms whose innovation practices were those of some single customer imposing their own criteria. Even given this sampling criterion, customers were still found to be the single most important source of ideas.

In terms of other methods for generating ideas, process innovations were found to be often started as a consequence of a bias towards continuous improvement (Motwani et al. 1999) while the broad cross-contextual Canadian study (Baldwin and Gellatly, 2003) found that pro-activity in management actions creates ideas while repeated statements of support for innovation were found to be important generators of ideas in the American southwest (Chandler et al. 2000). This thesis did not find evidence of continuous improvement programmes or mindset within the respondent firms, but did document the perceptions of many respondents that felt that management statements of support for innovation and openness to new ideas and other similar factors were important contributors to idea generation.

The later US study (Chandler et al. 2000) found that SMEs do not place any emphasis on evaluating innovation success, but do focus their periodic evaluative efforts on indicators of overall business performance. Chandler's finding is contradicted to some degree by their other finding that the perception of the presence of an innovation-supportive culture is supported by the organisational systems that reward innovation indicating that at least some respondents perceive that innovations were being measured somehow. This second finding

also supported the earlier French study (Motwani et al. 1999). This thesis did not find any indication of efforts by the respondent firms to evaluate firm innovativeness. Any innovation-related evaluation efforts took place as ideas were being considered with the bulk of evaluation focused around technical feasibility, feasibility of building the product at a cost that would support normal margins and whether it made the respondents' work easier. Once the group-based decision was made to proceed, formal tracking of costs till launch occurred, but after launch the innovation was considered part of normal business and no evidence was found of it being tracked separately to assess success of the innovation programme that created it.

In terms of implementation, the study of French SMEs (Motwani et al. 1999) found that established routines for innovation increased senior manager's satisfaction with innovation actions. This finding is supported by this thesis that found that the firm's experience with and comprehensiveness of routines to implement ideas that survive evaluation was quite influential on the firm's innovation activities. Measurement of the impact of this 'maturity' of process could be an interesting research topic to help value the learning that happens each time an innovation is attempted.

In terms of barriers, the US study found that day-to-day workload pressures are negatively associated with the perception of an innovation-supportive culture (Chandler et al. 2000). In combination with the five broad studies of SMEs, two narrower studies focused on the barriers to innovation within SMEs have suggested these barriers include the finding that SME-sized manufacturer's face difficulties in applying new technologies (due to both a lack of capital and a lack of exposure to new technologies for their employees) (Shapira, 1990). Further, SMEs have difficulty attracting capital to spread risk for innovative projects, lack technically qualified labour, do not use external information and expertise effectively and are often managed by a technical entrepreneur who has not been prepared for a management role (Freel, 2000). In this thesis, significant support has been found for the most important barrier to innovation being the day-to-day workload pressures. In addition, it is interesting that the bulk of recently terminated innovations described by senior managers were attempts to introduce new technologies. This supports the finding that manufacturing SMEs have difficulty taking up new technologies (Shapira, 1990). The other barriers to innovation noted within the respondent firms seemed to be firm-specific.

Of interest was that difficulty in finding capital was not seen as a significant barrier, but more specifically, the most significant barrier was seen as the unavailability of the time required for personnel to prepare the case to access the capital.

#### **6.4 Comparison of findings with the larger body of innovation literature**

In order to provide insights to the complex and comprehensive process of innovation, simplification of the wide variety of sources and often contradictory findings within the body of literature was attempted by deconstructing the body of literature into six schools of thought and the use of an orientation looking towards the practices involved with innovation. As part of the description of these new literature groupings, comments were made on the likelihood of application of the particular schools of thought to the context of MechSMEs and for the most part these comments have been borne out as the result of the case studies. Some discussion of the exceptions follows;

*‘Innovate in order to learn how to innovate’*

The first school of thought reviewed (see section 3.2 for detailed comments) described a process wherein learning is used as a means to build core competences and the creation of intellectual property is seen as a key strategy to innovate successfully. Within this school of thought, the active and routinized management of the transfer of both formal and tacit knowledge along with the corresponding investments and structures required to make it happen are seen as prerequisites for innovation. The aforementioned comments included the expectation that the respondent firms would be quite effective at the transfer of tacit knowledge and these studies found that each of these firms makes extensive use of cross-functional teams and opportunities for tacit knowledge transfer were extensive and endemic to each of the firm’s normal operating routines. This was most evident in Wepackit and CylDiv, possibly because of their smaller size. On the other hand, the expectations were that MechSMEs would not invest in mechanisms or structures for formal knowledge transfer due to the difficulties in profiting from assemblage of a strong intellectual property position. Some formal knowledge transfer was found within all four firms as manufacturing drawings are the common media for transmission of design ideas. Otherwise, there was

very little evidence of measurement and formalization of knowledge gained during innovation.

Innovation programme effectiveness assessments and proactive programme management were not in evidence in any of the firms, so that the respondent firms do not purposefully innovate in order to learn to innovate. Even though the respondent firms did not purposefully pursue learning through doing, in P1, Wepackit, and ACEP there was a residue of established routines from previous innovation efforts that provided an established route for handling of new ideas. This supports the earlier studies on evolutionary economics and the importance of routines (Nelson and Winter, 1982; Nelson and Winter, 2002). This reduced a layer of uncertainty for the involved personnel. The absence of these established routines within CylDiv was notable as a barrier to innovation as proponents often hesitated before moving on to the next step as they were not sure what step to take next.

In summary, the respondent firms were very adept at the tacit portion of knowledge transfer, only marginally so for the formal portion, and did not actively seek to learn from previous innovation efforts. Despite their apathy towards the value of learning from previous innovation efforts, the establishment of routines from handling innovations seems to be a form of learning that firms benefit from in spite of themselves.

#### *'New economy model'*

A substantial portion of innovation activities (11 of 13) undertaken by the respondent groups fall into the category of sustaining innovations as they are pursued using existing organisation resources to service existing markets with slightly different new products or pursue new marginally different markets with existing products. The two exceptions out of the thirteen innovations studied, were the attempted introduction of a robotic welder into the manufacturing processes within CylDiv and the introduction and finally withdrawal of a complex electromechanical case packer as a new product by Wepackit. In both cases, the novel technology was not embraced by important players within the organisation, possibly because the technologies fell outside of their areas of expertise.

An additional innovation that ACEP had experience with involved the introduction of computer-controlled drilling rigs to their customer base and while some of the rigs have been embraced by some larger, more established customers, in other cases, ACEP has had to recall the drills and carry out a significant remanufacture to retrofit them with a simpler mechanical control system. The principal reason given for the redesign for some customers is the mismatch between the technologies offered by ACEP and the maintenance capabilities of the particular customer. In most of these cases, the remote operating sites and the small population of rigs result in challenging economics for customers and ACEP to provide computer capable support. For these late adopter customers, the computerized drills represent a disruptive innovation.

As predicted in the earlier discussion about the potential application of this innovation school of thought, these examples of the new economy model at work within the respondent MechSMEs are relatively isolated. Low levels of scalability within the MechSMEs sector suggest that the likelihood of a widespread disruptive innovation becoming important to this sector is quite remote.

*'Intrapreneurship can solve everything'*

The third school of thought considered suggests that individual supra-normal personnel within the organisation can make innovation happen by finding ways to knock down or drill through the barriers to innovation within the firm. Supporting these 'rule-breakers' and providing them with resources are seen as the key levers to producing innovation successes. With respect to MechSMEs, there was little expectation that high-profile, ambitious, individual intrapreneurs would remain with their organisations due to the low barriers to entry in the field.

The findings from these case studies suggest that for all of the individual innovations studied, they were seen by the bulk of the respondents as being championed by a collection of personnel and no one individual was seen as the sole champion for the projects. Efforts are made to acquire consensus on moving ahead within the cross-functional teams for any project and if consensus does not happen, then the innovations are stalled. No evidence was found of projects being continued to be pushed by individuals with the exception of those longer term ideas promoted by the original entrepreneurs, the owners of Wepackit and P1.



When asked about why they promote ideas within the firm, the respondents most commonly used words such as, “for the challenge” and “to help the company survive” and “to enhance my skill set” as their primary motivations for pouring their energy into pursuit of ideas. Making money for themselves was not described as a motivator although there were some occasional mentions of the possibility of business-performance-oriented bonuses that could be paid at the discretion of the senior manager.

If the practice of intrapreneurship is defined as an organisational maverick that acquires financial rewards by pushing ideas to a successful conclusion through sheer perseverance, then intrapreneurship does not exist within the respondent firms. On the other hand, if the intrapreneur is defined as the original entrepreneur who then goes on to display entrepreneurial behaviour by continually leading the firm they created into new areas, then in both the case of Wepackit and P1, the practice of intrapreneurship is ongoing. Interestingly enough, this type of behaviour was not evident from the senior manager of either of the corporately-owned firms as targets for new business were set corporately and these managers were expected to find ways to meet them within their current business framework.

*‘Organic, or disciplined, or organic then disciplined’*

Each of these three related schools of thought suggest their preferred approach to innovation is the constant application of either organic or disciplined methods, or a switch between methods part way through innovation projects. The findings of these case studies suggest that pieces of each approach are used, but none of the single-minded approaches are used in their entirety.

Organic methods oriented around egalitarian management methods aimed toward generation of significant, often disruptive ideas are only partly in use. Even though formal mechanistic structures existed in each firm, the informal day-to-day routines were based on their extensive use of cross-functional teams throughout the innovation process. Without exception, high levels of mutual respect for each other’s particular talents were stated by the respondents and this respect within the team results in a need for nearly total consensus before projects are pursued. On the surface, the structures appear mechanistic however the bulk of behaviour observed was closer to egalitarian.

Disciplined methods utilizing mechanistic structures and extensive control to keep personnel focused on their particular niche were partly used. The cross-functional teams stayed focused on their existing markets and expertise but did it using the egalitarian methods described earlier. Reasons for sticking with the status quo include the desire for certainty that is inherent in this industry that strives for quality product and no surprises, and the limited envelopes of capabilities represented by the equipment the respondent firms use to produce their goods. Significant capital expenditures (and lengthy time delays) are often required before a firm can move out of the production niche it knows and as a consequence, journeys into unknown territory are generally looked upon with disdain by the members of the cross-functional teams.

The organic then disciplined approach suggests a switching of methods is required that was not found within the respondent firms. A more accurate characterization is described in Figure 3.4 which describes idea implementation. This shows that over the course of the innovation implementation process, there is a gradual move from openness to new designs and acceptance of higher levels of uncertainty toward restrictions on design options and the desire for more certainty as a project approaches completion. In the two larger firms, ACEP and P1, the use of project management methods began early in the project, but there was minimal investment by personnel in updating the project plan on a regular basis. No switching point to move from wholly organic to wholly disciplined methods was observed, but there was a contiguous approach used to cope with technical uncertainties observed at both P1 and Wepackit. In this approach, the most challenging technical concerns were addressed early in the project with some inexpensive testing of design concepts. If the tests were positive then the project would move onto the next stage and a significant result could lead to a step increase in the formalization of the project.

Broadly speaking, in terms of organic or disciplined approaches, the respondent firms use an egalitarian management approach to serve established product/market niches and an incremental approach to managing projects with a goal of reducing risk and uncertainty as the project approaches launch.

### *Applicability of schools of thought*

In terms of applicability of the proposed schools of thought, examples of the application of a portion of each school of thought could be found in all firms, but the dominant school of thought appeared to be disciplined approaches moderated by the organic characteristics of the extensive use of cross-functional teams. Significant entrepreneurial behaviour seemed to be limited to owner/managers and organisational learning and knowledge transfer was primarily restricted to tacit knowledge. This varied applicability of the schools of thought is similar to the varied levels of applicability of the various theoretical paradigms (e.g. resource-based view, learning organization theory, actor-network theory, etc.) described in the wider body of innovation literature. While the schools of thought are representative of sub-collections within the extant literature, given these findings it is questionable whether these schools of thought do in fact simplify the task or confuse it further.

The advantage that the schools of thought offer for practitioners is the accessibility of the language and the direct advice offered by each. Ideally this advantage could be maintained, but the method of application likely requires a new approach to make these assemblies of earlier findings more useful for practitioners.

In addition to the findings already mentioned in this Chapter and the identification of the individual innovation practices which seem to support firm innovativeness that were identified in Chapter 5, there are some other findings of interest that are also important. These are as follows:

- The introduction of the elements of innovation (e.g. idea generation, evaluation, etc.) during the study appeared to be the first time many respondents had given thought to the different components of the innovation process.
- Within the firms, there was broad disagreement about the meaning of innovation among the respondents. This supports earlier work which surveyed manager's opinions as to the meaning and importance of innovation (Storey, 2000).
- Within all the firms, very few efforts were devoted to evaluating the financial or market success of individual innovations. This contradicts earlier findings from

larger firms (Griffin and Page, 1993) that suggest firms do measure individual innovation success using a variety of financial and customer acceptance metrics.

- No evidence was found of attempts to manage a programme of innovation (i.e. set up a programme, measure its progress and take steps to improve its performance). This supports the large-firm findings of Griffin and Page (1993; 1996).
- Presence of ideas and early, seemingly minor commitments to pursuit of ideas (e.g. the decision to attend a trade show leads to a decision to introduce a new product to appear competitive, or the decision to say ‘yes’ to a minor customer request, etc.) lead to meetings and deadlines that drive much of their efforts. This innovation process can be broadly characterized as a series of seemingly operational small decisions as opposed to a single large and risky decision that is informed by extensive, financial, marketing and technical analysis.
- There was broad agreement among the four firms that their key barrier to innovation was the pressure to fulfil mainstream responsibilities with ‘newstream’ activities being pursued as time became available.
- Within all firms, financial performance on a short term basis was paramount, and this bias was revealed through their repeated choices to focus their resources (primarily personnel) on short term, revenue-producing activities before efforts aimed at pursuing innovation are undertaken.
- Financial investments in innovation were found to be relatively small when they were undertaken and availability of funds was not seen as a significant barrier to the respondents as the time investment by key personnel required to access the funds.
- Innovativeness appears to be an accepted requirement for long term survival by the bulk of the respondents, however this is only acted upon when time allows.

These findings are an accurate assessment of how innovation happens within the respondent firms, but unfortunately they do not provide a list of causally-linked ‘silver bullet’ variables for managers of MechSMEs that see innovation as a likely option to improve growth and profitability. Empirically-supported causal links are difficult to acquire and this challenge is described in the next section.

## **6.5 Firm innovativeness and business performance, a challenge for future research**

Using a similar approach to the ranking of firm innovativeness, business performance for each of the respondent firms has been described on a relative basis. The elements of this business performance index is made up of the addition of each firm's *relative* ranking of their % sales increase/decrease over the last three years, increase/decrease in % profit/sales over the last three years and % increase/decrease in employment over the last three years. Increases in sales and profits are included as past indicators of performance while employment has been included as it reflects the firm's performance in adding, or losing, valuable assets that can influence the firm's future capabilities. Any firm with an overall index score of 3 would be considered to have displayed the best business performance among the respondent firms. Three years has been chosen as a compromise evaluation period to attempt to capture the effects of both shorter term events that have material effects on the companies (e.g.. significant exchange rate fluctuations and commodity price changes) and the likely longer term impacts of firm innovativeness developments (e.g. construction of a culture that values ideas). The firm's relative business performance and innovativeness rankings are contained in Table 6.2

Analysis of the results described in Table 6.2 shows that, of the four firms, the best two business performers were ranked second and third in terms of innovativeness, while the business performance of the most innovative firm was ranked as worst among the four firms. Even within this small sampling, there is evidence of a disconnect between firm innovativeness and business performance. This disconnect could stem from faulty analysis of firm innovativeness, or, it could stem from other factors swamping the impact of firm innovativeness on business performance.

In terms of the validity of the analysis, given the rigor with which the documentation of innovation practices have been pursued for this project, it is quite reasonable to state that the findings stated here are an accurate recording of how innovation happens within these firms. The other part of the analysis which influences the validity of the firm innovativeness rankings is the core assumption that more relatively influential innovation

*Table 6.2 Individual metric business performance rankings, firm innovativeness rankings and rankings of overall business performance and overall firm innovativeness.*

|  | <b>ACEP</b> | <b>CylDiv</b> | <b>Wepackit</b> | <b>P1</b> |
|--|-------------|---------------|-----------------|-----------|
| <b><i>Business Performance Ranking</i></b>                 |             |               |                 |           |
| Sales increase rank  | 2           | 3             | 1               | 4         |
| Profit change rank   | 1           | 4             | 2               | 3         |
| Employment increase rank                                   | 2           | 3             | 1               | 4         |
| Additions of ranks (3 possible)                            | 5           | 10            | 4               | 11        |
| <b><i>Firm Innovativeness Ranking (from Table 5.2)</i></b> |             |               |                 |           |
| Idea generation construct (+4 possible)                    | 2.52        | 1.52          | 2.83            | 3.12      |
| Idea implementation construct (+4 possible)                | 2.50        | 1.58          | 2.92            | 3.00      |
| Idea evaluation construct (+4 possible)                    | 3.14        | 1.43          | 2.29            | 3.14      |
| Enabling forces construct (+4 possible)                    | 2.14        | 1.93          | 3.00            | 2.93      |
| Barriers to innovation construct (-1 possible)             | -2.4        | -3.5          | -1.7            | -2.4      |
| Overall firm innovativeness score (15 possible)            | 7.91        | 2.96          | 9.34            | 9.79      |
| <b>Rank of overall business performance</b>                | <b>2</b>    | <b>3</b>      | <b>1</b>        | <b>4</b>  |
| <b>Rank of firm innovativeness score</b>                   | <b>3</b>    | <b>4</b>      | <b>2</b>        | <b>1</b>  |

practices leads to more firm innovativeness. This assumption has been made in the absence of any other widely accepted objective measures of innovativeness. Whether this is a useful and accurate assumption is only likely to be borne out over time and as the result of future studies testing its accuracy.

If this core assumption of the firm innovativeness ranking is accepted as accurate, then the more likely source of the disconnect between firm innovativeness and business performance is the swamping of the impact of firm innovativeness by other business performance related factors. For example, the senior manager of the firm ranked as the most innovative, P1, described how fluctuating exchange rates over a three year period have seen the sales volumes in Canadian dollars decrease by 12%, but the amount of product shipped remain about the same. The reductions in revenue required offsetting reductions in costs (reflected in a 16% decrease in employment over the same three year period). In order to achieve these employee reductions while shipping about the same amount of product required some process re-engineering and product redesigns, both of which would be considered by most innovation researchers to be forms of more innovation. Yet this firm was ranked as the worst business performer. This example is illustrative of how innovative efforts can be swamped by the impact of other business factors which creates a challenge for future innovation research efforts.

Given that rational business decisions are oriented towards improved business performance, the ideal deliverable for innovation researchers would be credible evidence of the positive impact of innovation efforts on overall business performance and the most important management actions to take to support the most effective types of innovation. Unfortunately the lack of a universally accepted objective metric for innovation for use as the independent variable (notwithstanding the relative innovativeness ranking proposed within this dissertation) makes comparing the effect of innovation on business performance impossible. The results of this study which show that the effect of relative innovativeness can be swamped by short run business conditions complicates the research as it means that any valid study would have to be longitudinal and carried out over a very lengthy period. In addition, the research would have to account for the dynamics of the business conditions and variance in firm innovativeness over time that results from internal changes (e.g. changes in personnel, periods of fiscal restraint, etc.). Given the difficulties that researchers face when trying to show causal links between innovativeness and business performance, consideration of alternative tracks for analysis is appropriate. Suggestions for future research projects to address this concern are described in the final section of the dissertation.

## **6.6 Recommendations for managers of MechSMEs**

Notwithstanding the challenges of providing empirical causal evidence of particular innovation practices on firm performance, and the challenges of defining firm innovativeness, the findings of this dissertation and the large body of extant innovation literature leads to the following set of generic recommendations for managers of MechSMEs that wish to improve the innovation practices within their firms. A lengthy and exhaustive list would only serve to continue the confusion among practitioners that has resulted from the extant literature. To satisfy the principal objective of this dissertation, a restricted number of suggestions that seem to be the most important as a result of this PhD have been made in the hopes that they will be helpful to practitioners.

Managers of MechSMEs who wish to practice effective innovation management should;

- 1) Identify their principal business strategy to ensure their innovation objectives fit their business strategy. If for example, the business is competing on differentiated

products, then much of their innovation practices should be focused on delivering successful new product development. Within most multi-product firms, their innovation objectives may vary by product line. Choose which innovation objectives should have priority, recognize any need to accommodate industry-specific innovation practices and manage your portfolio of innovation activities accordingly.

- 2) Tell personnel what type of innovations that management are interested in and repeatedly tell personnel that it is an expectation that new ideas will be generated and pursued.
- 3) For process innovation, generate new ideas by searching out and treating problems raised by internal personnel as opportunities for innovation. For product innovation, search out and treat customer problems in a similar way.
- 4) Use cross-functional teams throughout the innovation process that are appropriate to the innovation objectives. Do not, for example, count on help from sales personnel to cut manufacturing costs. Do count on manufacturing personnel to help cut manufacturing costs.
- 5) When possible, acquire an externally-sourced deadline (e.g. trade show for new product introductions, etc.) to help drive an innovation project schedule towards completion.
- 6) Acquire a project management software package (MS Project appears most popular) for use on innovation projects and train a few personnel how to use at least its basic functions (Gantt charts, critical path, etc.). The most effective personnel are likely those that have duties that will involve them often in innovation projects (e.g. engineering personnel for product innovation, manufacturing supervisors for process innovation).
- 7) When new ideas emerge, isolate the toughest technical challenge(s) associated with the idea and find a way to test the proposed technical solution(s) as early, quickly and inexpensively as possible.
- 8) Evaluate the likely margins that the new idea might deliver with increasing rigour as additional investments in the project are required. Stage the level of detail of this analysis, so that the financial analysis is not seen as a barrier to pursuing ideas in the early stages.



- 9) To support the development of mature innovation routines within the firm, publish/disseminate/talk about and celebrate how innovations come to happen. Keep a rolling list of ideas in front of personnel and at least rudimentary minutes of project meetings to detail assigned responsibilities and agreed-to schedules.
- 10) If costs are going to be tracked for innovative activities then attempt to track incremental profits as well so that a balanced picture of the innovation activity is acquired, and finally,
- 11) Work towards providing slack resources for key personnel so that they can spend more time on innovations. Without exception, lack of slack resources for these personnel has been identified as the key barrier to innovation for MechSMEs.

As a starting point, implementation of this list of basic recommendations should result in an improvement in the firm's chances of innovation success. As firms become comfortable with these suggestions, additional beneficial innovation practices should be pursued. The ideal result will be that more ideas aimed at achieving business goals will be generated and pursued successfully, using known routines. Innovation management proficiency should improve over time which will better prepare the firm to handle changes in their operating environment as they arise.

## **6.7 Recommendations for government agencies looking to support innovation within MechSMEs**

The combination of the completion of this dissertation, the economic importance of MechSMEs in North America and the recent pressure on manufacturing jobs in North America from Chinese manufacturers (Malmgren, 2004; Rothstein, 2005; Olszynski, 2005) presents an opportunity to make recommendations to government agencies on how they can best support increased innovativeness among MechSMEs. These preliminary recommendations for a pilot program should be tested in-situ prior to widespread adoption due to the lack of proven causality that is endemic within the supporting innovation research.

Rather than providing an exhaustive list that may just add to the confusing advice that has resulted from the extant literature, just the principal and hopefully clearer recommendations follow;

Notwithstanding the political challenges attached to supporting MechSMEs with the following actions, agencies that wish to positively influence rates of innovation, in order of priority, should seek to:

- 1) Using firm-specific consultations raise the profile of innovation inside the firms so that the firm's management begin to develop consensus on the definition of innovation for them and an awareness of their existing innovation practices. The resulting awareness of the existing barriers to innovation will provide them with a list of issues to address that should help them become more innovative.
- 2) As slack resources among 'key personnel' are the most common barrier, provide incentives or assistance for MechSMEs to increase their capacity for innovation among their experienced and trusted key personnel. This is likely to be in the form of off-loading of some mainstream activities to newly-hired personnel as opposed to the hiring of full-time R&D personnel, as new R&D personnel are not likely able to develop the necessary levels of trust in the organization to be effective at championing innovations in a timely manner.
- 3) Provide accounting tools and training to firms to track innovation costs and the success metrics used within large firms (Griffin and Page, 1993; 1996) that being, measures of customer acceptance, measures of product level financial performance and measures of firm benefits (e.g. savings accrued from process innovations, etc.). Assisting MechSMEs in learning how to measure these results of their innovation efforts will help at least some of the firms improve their innovation routines over time.

## **6.8 Contributions to the literature**

This PhD offers a number of original contributions to the literature. The principal contribution consists of the rigorous and thorough documentation of how innovation happens and how personnel within MechSMEs assess the success of innovative activities within their firms. The practices involved in individual innovations and descriptions of the overall innovation process within each of the respondent firms has been assessed through extensive questioning of a broad cross-section of the firm's personnel, so that a documentation has been completed of how innovation happens that is not biased by the

experience sets of any one particular group. Replication of these thorough case studies among multiple firms led to the important finding that the respondent firms share some innovation practices with all of the other firms, while at the same time each of the firms also utilise their own unique innovation practices. This finding in and of itself, helps to clarify the confusion in the extant literature wherein some authors claim innovation is firm-specific, while other authors are more optimistic about discovery of a one-size-fits-all solution for managing innovation within each industry. This key finding of this PhD suggests both camps can find evidence to support their position, but when an overall view is taken about how innovation happens within at least this context, a mix of industry specific and firm-specific practices seems to be the norm. Armed with this knowledge that a mix of practices are likely to exist, future researchers are likely to alter their research objectives and research instruments.

Another important contribution is related to the absence of use of ‘conventional’ innovation metrics by the respondent firms. This absence either provides an opportunity for outside agencies interested in helping MechSMEs become more innovative (i.e. governments) by introducing MechSMEs to these conventional metrics and the connected improvements that would likely follow, or sounds a warning to those agencies designing assistance programmes based on performance metrics that do not exist.

In addition to these useful overall themes of findings, there are a number of other individual findings (e.g. innovation practices that were shared by all the firms) that offer a starting point for empirical testing based on larger sample sizes. Once the presence of these practices is shown to be widespread, then there may be opportunities to develop support programmes to enhance these abilities for other MechSMEs. For example if project championing was found to be a common practice, then programmes to enhance the effectiveness of champions (e.g. training in use of scheduling software, how to run effective meetings, etc.) could become effective at enhancing innovativeness among MechSMEs. Other instances of findings similarly important to government policymakers are also likely to be found, given the size of this sector and the relative paucity of sector-specific innovation research before this dissertation.

The lack of a well-accepted definition of innovation and innovativeness precluded the task of discovering causal links for innovation or innovativeness. Nevertheless, an attempt has been made to assess innovativeness for the purposes of sorting between which innovation practices *seem* to lead to firm innovativeness. This assessment of innovativeness has been based on the assumption that firms that appear to be more influenced by innovation practices are more likely to be innovative. In short, more affective innovation practices are more likely to result in innovation than fewer affective innovation practices. On the face of it at least, this assumption appears to be robust and may offer an improved method for defining innovativeness among firms. If further research confirms its robustness, then work could begin on ferreting out which innovation practices are the most effective to improve a firm's innovativeness. This would then constitute a significant contribution to the literature.

With respect to the respondent firms, the contributions that they found valuable included; a) that the identification of barriers to innovation that they should address provided the beginning of a 'to do' list if they felt it was wise to increase their firm's innovativeness, b) the participation of their employees in this project served to raise the profile of innovation throughout the firm, and c) the indirect result of the focused study on their innovation practices was that they were confronted with the need to examine innovation in light of their strategy, and they found that in some circumstances it is best not to pursue innovation for innovation's sake.

The other contributions of this thesis are likely to be useful to other members of the innovation research community as they plan future research projects. To the best of the author's knowledge, two new theoretical concepts have been proposed consisting of (1) the deconstruction of the extant literature into simplified schools of thought, and (2) the construction of a summarizing typological model based on the process of innovation. Several proposed research tracks for the context of MechSMEs follow, all of which are oriented towards satisfying the objective of performing research that assists practitioners with advice on how to improve their management of innovation:

- (1) Future innovation research efforts could bypass the development/testing of a firm innovativeness metric and use business performance as the dependent variable to sift between which programme-level innovation processes are the most effective at

improving a firm's business performance. The long periods of time required to realize the effects of programme-level efforts would require an extensive longitudinal study and industry-specific effects would have to be carefully controlled. Unfortunately, the situation-specific disconnect between firm innovativeness and business performance described earlier in this dissertation echoes the findings of other work that found that the predictive power of any innovation to profitability model is likely to be weak. (Covin and Slevin, 1989; Chandler et al. 2000; Olson et al. 2005)

- (2) Future innovation research efforts could focus on using individual innovations as the unit of analysis so that readily-measured business performance metrics for each innovation (e.g. unit sales, time-to-market, etc.) can be used as the dependent variable. This would assist in sifting between which innovations practices are the most effective at improving the chances for each innovation's business success performance. The compilation of these findings about how to make individual innovations more successful can then be used as a prescription for managing an overall innovation programme. For example, if project champions were found to be important, then a programme-level prescription would include identification, support and training for potential project champions. It is important to note that this research track has the potential to miss programme-level factors that may be quite important (e.g. organisational cultural factors such as management's openness to new ideas) if only factors that are pertinent to individual innovations are assessed.
- (3) Future innovation research efforts could focus on the differing dynamics of business conditions and firm innovativeness. Macroeconomic study has attributed the bulk of economic growth to technological change (Lipsey, 1996; Solow, 1988) and extensive anecdotal information has catalogued the material effects of innovation on individual firm's efforts. While some of the reported economic growth includes the effects of entrants and exits of firms from the economy (only 20% of entrants survive their first decade (Baldwin and Gellatly, 2003) and MechSMEs make up part of this statistic) it appears very likely that these macroeconomic findings extend to individual firms that remain part of the economy, and over time, innovation is likely responsible for the majority of the growth within these firms. Sorting out the short term effects stemming from changing business conditions and the long term effects of building firm

innovativeness would at least address practitioner's needs to justify investments they are contemplating that are aimed toward building innovation capacity.

These alternative research tracks all attempt to deal with the lack of a widely accepted objective metric for innovation and the dynamics of the very powerful effect of changing business conditions that overlap the longer term effects of building firm innovativeness. Option (3) attempts to prove the need for innovation, although anecdotally at least the respondents within this study appear to have accepted this as a given. The first option involves difficult-to-access, subjective, organisational cultural variables and requires study over long periods and the depth of analysis required likely makes large sample sizes unworkable. The second option suggested offers a ground-up approach to building "to do lists" for practitioners once they are dealing with a particular idea and while it does not address the entire picture, it offers a feasible research project that will likely produce findings that will help practitioners become more effective at implementing ideas.

The foregoing proposed research tracks are all likely to be useful within the context of MechSMEs. In order to test for wider generalizability of these results, similar case studies-based research projects in different operating contexts would be useful. Operating contexts that share the environmental characteristics of ineffective intellectual property protection, primarily craft-based workers and SME-sized organized production are likely to replicate many of these results. Of additional interest would be the sampling of contexts that do not share these independent variables.

Considering that one of the principal assertions in the dissertation was that MechSMEs are a particularly useful 'Petri dish' for the study of sustainable innovation practices because of their relative lack of external influence, testing within similar contexts to add confidence in the findings through an 'increased' sample size, and comparing these results with those found in dissimilar contexts would serve to comment effectively on this assertion. If the findings of this dissertation are supported, then the recommendations offered here could be extended in their application to many more operating contexts.

## Appendix A – Question list

A total of 172 different questions were asked of respondents. Semi-structured interviews began with several easy-to-answer, closed-end questions related to the overall innovation process (to put the respondent at ease) followed by open-ended questions about the overall innovation process. The next group of interview questions pertained to the innovation projects in which the respondent was directly involved. The last few questions of each interview focused on the personal feelings and concerns of the respondent as they relate to innovation. The following list of questions has been broken down by open and closed questions and innovation specific questions related to current ongoing innovations, recently completed innovations and recently terminated innovations respectively. Subsequent lists detail the questions asked of the senior manager on-site, functional manager(s) most affected by innovation and first-line supervisors.

### *Open-ended questions*

1. Can you describe the roles you've played with the innovations you've been involved in?
2. For incremental innovations, please describe the role played by the customer.
3. From a personal perspective, what are the pitfalls that you watch out for when deciding whether or not to get involved in a particular innovation?
4. From the perspective of your career, what do you see as the impact of innovation?
5. How are employees that are seen as champions treated when ideas fail?
6. How do ideas get evaluated here?
7. How do ideas get implemented here?
8. How do you know whether your innovation efforts are successful?
9. How does innovation happen here?
10. How is new knowledge disseminated to other interested personnel with the firm?
11. How will you know whether your innovation efforts have been successful?
12. If financial control intensity differs, what are the shift points that trigger changes in control mechanisms?
13. In order for an innovation to proceed, is there a generally accepted maximum allowable range of uncertainty in costs or ongoing revenues?
14. Is there a group or team within the organisation that is responsible for innovation? If so, who are they?
15. Is there anything else you can tell me about the innovation process here that we haven't already discussed?
16. Once an idea has received support in principle to pursue it further, what methods does your firm employ to gather more information about the new product/process or service or new market?
17. Please describe the knowledge transfer mechanisms between engineering and Manufacturing.
18. Please describe the knowledge transfer mechanisms between manufacturing and field service.
19. Please describe the knowledge transfer mechanisms between sales and engineering.
20. Please describe the recent (last 10 years) innovation history of your industry.

21. Please describe your current level of profits at this site, compared to where it was last year at this time, and three years ago.
22. Please describe your current level of sales at this site, compared to where it was last year at this time, and three years ago.
23. Please describe your current levels of employment at this site, where it was last year at this time, and three years ago.
24. Thinking about innovation from a personal perspective, what is it that you get when you involve yourself in the process?
25. What are the different forms of financial commitments that your firm has made to innovations in the past?
26. What are the most important barriers to innovation here?
27. What are the most important efforts made to encourage employees to come up with new ideas?
28. What are the most important forces external to the firm that enable innovation here?
29. What are the most important methods for generating ideas here?
30. What financial criteria are used to approve work on innovations?
31. What is the duration of the typical product life cycle in your industry?
32. What proactive efforts are made to solicit ideas from customers?
33. What processes have been used to limit or expand design options in ongoing innovation projects?
34. What reporting mechanisms are used to pass on the increased knowledge up to management?

*Closed-end questions*

1. Are specific time resources assigned separate from day-to-day work to work on ideas?
2. Are there set milestones in the innovation process when increased certainty of revenue projections is required?
3. Broadly speaking, what percentage of your time would you say you spend coming up with or developing innovations?
4. Describe the integrity of your superiors, in other words, do they do what they say they will do?
5. Describe the level of competence of the other personnel involved in the innovation process.
6. Do large group information sessions occur? If so, how often and for what purpose?
7. Do you believe that you are treated fairly by your superiors?
8. Do you believe that you are treated fairly by your superiors? Subordinates?
9. Do you make a conscious effort to work with lead users of your type of products?
10. Is innovation an explicitly stated element in your business strategy?
11. Is there a generally accepted hurdle rate required for innovations to receive continuing support?
12. Is there a generally accepted required impact on revenues or profits before an innovation is pursued?
13. Is there a plan in place to stage the introduction of more design options?
14. Is there a practice of encouraging employees to come up with ideas?



15. Is there a separate budget line item for innovation?
16. Is there a specific company strategy to service new or existing markets?
17. Is there a systematically and periodically reconsidered R&D programme?
18. Is there a training plan in place for employees?
19. Is there an explicit strategy to exercise differing intensity of financial control depending upon the stage of the innovative work?
20. Please describe if brainstorming techniques are used and if so, how often and for what purpose(s)?
21. Please describe if creative problem solving techniques (e.g. case method, Delphi method, etc.) are used and if so, how often and for what purpose(s)?
22. Please describe if cross functional teams are used and if so, for what purpose?
23. Which of the following is your principle source of ideas, management, marketing, engineering, manufacturing, competitors, customers, other?
24. Which of the following is your second most important source of ideas, management, marketing, engineering, manufacturing, competitors, customers, other?
25. Would you consider your company's technology strategy to be characterized as "leading edge", "first to be second", "middle of the pack" or "the status quo is fine"?

*Questions about currently ongoing innovation*

1. For the currently ongoing innovation did management set market, technical or completion date objectives early?
2. For the currently ongoing innovation did the core group volunteer or "sign on" to meet the project objectives?
3. For the currently ongoing innovation does it physically require other parts of the product or production process in order to function?
4. For the currently ongoing innovation how many endorsement stages by management have been given?
5. For the currently ongoing innovation how many formal meetings have occurred?
6. For the currently ongoing innovation is there at least one individual that is widely identified as the project champion?
7. For the currently ongoing innovation please describe its potential impact on revenues and profits.
8. For the currently ongoing innovation please describe the degree of uncertainty in development costs and ongoing costs and ongoing revenues.
9. For the currently ongoing innovation please describe the level of senior management support. Would you say it was hi, medium or low?
10. For the currently ongoing innovation please describe whether any existing personnel are likely to lose their current positions. If so, please describe what organisational level the threatened personnel currently occupy.
11. For the currently ongoing innovation please describe whether implementation will require existing personnel to relocate substantially out of the area.
12. For the currently ongoing innovation please describe whether implementation will result in significant shifts in power within the organisation.

13. For the currently ongoing innovation please describe whether it is addressed towards new or existing markets.
14. For the currently ongoing innovation please describe whether it requires the use of technologies that are new to the firm.
15. For the currently ongoing innovation please describe whether significant new external relationships will be required.
16. For the currently ongoing innovation please describe whether the innovation is a part of an offensive or defensive competitive strategy.
17. For the currently ongoing innovation please describe whether your existing supplier/customer relationships are likely to be enhanced or negatively affected.
18. For the currently ongoing innovation please describe whether your position within the firm is enhanced or diminished.
19. For the currently ongoing innovation please estimate its projected ROI.
20. For the currently ongoing innovation to what degree is the innovation being pursued in order to enhance your other offerings in current markets?
21. For the currently ongoing innovation was a numerical business case made to acquire the go-ahead?
22. For the currently ongoing innovation what are the forces driving the schedule for the innovation?
23. For the currently ongoing innovation what came first, market need or technical idea?
24. For the currently ongoing innovation what evaluation criteria have been used to justify continued work on the innovation?
25. For the currently ongoing innovation what forms of endorsement by management have been given?
26. For the currently ongoing innovation what methods were used to acquire endorsements by management?
27. For the currently ongoing innovation what methods were used to acquire endorsements?
28. For the currently ongoing innovation what percentage of the projects resources were spent on engineering/manufacturing documents?
29. For the currently ongoing innovation what percentage of the projects resources were spent on launch activity?
30. For the currently ongoing innovation what percentage of the projects resources were spent on market research?
31. For the currently ongoing innovation what percentage of the projects resources were spent on prototype development?
32. Have specific time resources been assigned separate from day-to-day work to work on the currently ongoing innovation system?
33. How big was the core group for the currently ongoing innovation?
34. Is the currently ongoing innovation intended for a new application?
35. Is the currently ongoing innovation intended for a new geographic market?
36. Please describe whether your position within the firm is enhanced or diminished as a result of the currently ongoing innovation.
37. Who was the source of the idea for the currently ongoing innovation?
38. Why has the currently ongoing innovation received continuing support?

### *Recently completed innovation*

1. For the recently completed innovation how many formal meetings have occurred?
2. For the recently completed innovation did management set market, technical or completion date objectives early?
3. For the recently completed innovation did the core group volunteer or “sign on” to meet the project objectives?
4. For the recently completed innovation does it physically require other parts of the product or production process in order to function?
5. For the recently completed innovation how many endorsement stages were given?
6. For the recently completed innovation please describe its potential impact on revenues and profits.
7. For the recently completed innovation please describe the degree of uncertainty in ongoing revenues.
8. For the recently completed innovation please describe the level of senior management support. Would you say it was high, medium or low?
9. For the recently completed innovation please describe whether any personnel were moved from their prior positions. If so, please describe what organisational level the personnel previously occupied
10. For the recently completed innovation please describe whether implementation required existing personnel to relocate substantially out of the area.
11. For the recently completed innovation please describe whether implementation resulted in significant shifts in power within the organisation.
12. For the recently completed innovation please describe whether it is addressed towards new or existing markets.
13. For the recently completed innovation please describe whether it requires the use of technologies that are new to the firm.
14. For the recently completed innovation please describe whether significant new external relationships were required.
15. For the recently completed innovation please describe whether the innovation is a part of an offensive or defensive competitive strategy.
16. For the recently completed innovation please describe whether your position within the firm has been enhanced or diminished as a result.
17. For the recently completed innovation please describe whether your prior supplier/customer relationships were enhanced or negatively affected.
18. For the recently completed innovation please estimate its projected ROI
19. For the recently completed innovation to what degree was the innovation implemented to enhance your other offerings in current markets?
20. For the recently completed innovation was a numerical business case made to acquire the go-ahead?
21. For the recently completed innovation was it intended for a new application?
22. For the recently completed innovation was it intended for a new geographic market?
23. For the recently completed innovation was there at least one individual that was widely identified as the project champion?
24. For the recently completed innovation were the basics of the design ever reviewed once they had been set for the first time?
25. For the recently completed innovation what came first, market need or technical idea?

26. For the recently completed innovation what evaluation criteria were used to justify continued work on the innovation?
27. For the recently completed innovation what forms of endorsement were given?
28. For the recently completed innovation what methods were used to acquire endorsements?
29. For the recently completed innovation what percentage of the projects resources were spent on engineering/manufacturing documents?
30. For the recently completed innovation what percentage of the projects resources were spent on launch activity?
31. For the recently completed innovation what percentage of the projects resources were spent on market research?
32. For the recently completed innovation what percentage of the projects resources were spent on prototype development?
33. For the recently completed innovation what were the forces driving the schedule for the innovation?
34. For the recently completed innovation when was the basics of the design set?
35. How big was the core group for the recently completed innovations?
36. Please describe whether your position within the firm is enhanced or diminished as a result of the recently completed innovation.
37. Who was the source of the idea for the recently completed innovation?
38. Why did the recently completed innovation receive the necessary support to complete the process?

*Recently terminated innovation*

1. For the terminated innovation did management set market, technical or completion date objectives early?
2. For the terminated innovation did the core group volunteer or “sign on” to meet the project objectives?
3. For the terminated innovation how many endorsement stages by management were given? Withheld?
4. For the terminated innovation how many formal meetings have occurred?
5. For the terminated innovation please describe its potential impact on revenues and profits.
6. For the terminated innovation please describe the degree of uncertainty in development costs and ongoing costs and ongoing revenues.
7. For the terminated innovation please describe the level of senior management support. Would you say it was high, medium or low?
8. For the terminated innovation please describe whether implementation of the innovation would have required any personnel to be moved from their prior positions. If so, please describe what organisational level the personnel previously occupied.
9. For the terminated innovation please describe whether implementation would have required existing personnel to relocate substantially out of the area.
10. For the terminated innovation please describe whether implementation would have resulted in significant shifts in power within the organisation.
11. For the terminated innovation please describe whether it would have been addressed towards new or existing markets.

12. For the terminated innovation please describe whether it would have required the use of technologies that are new to the firm.
13. For the terminated innovation please describe whether significant new external relationships would have been required if the innovation had been implemented.
14. For the terminated innovation please describe whether your prior supplier/customer relationships would have been enhanced or negatively affected if the innovation had been implemented.
15. For the terminated innovation please estimate its projected ROI.
16. For the terminated innovation project, please describe whether implementation would have resulted in significant shifts in power within the organisation.
17. For the terminated innovation project, please describe whether significant new external relationships would have been required if the innovation had been implemented.
18. For the terminated innovation project, please describe whether the innovation would have been part of an offensive or defensive competitive strategy.
19. For the terminated innovation project, what evaluation criterions were used to justify continued work on the innovation? Were financial criterions key in terminating the work?
20. For the terminated innovation to what degree would have the innovation enhanced your other offerings in current markets?
21. For the terminated innovation was a numerical business case made to acquire the go-ahead?
22. For the terminated innovation was it intended for a new geographic market?
23. For the terminated innovation was there at least one individual that was widely identified as the project champion?
24. For the terminated innovation what came first, market need or technical idea?
25. For the terminated innovation what evaluation criterions were used to justify continued work on the innovation? Were financial criterions key in terminating the work?
26. For the terminated innovation what forms of endorsement by management were given? Withheld?
27. For the terminated innovation what methods were attempted to try to acquire endorsement by management?
28. For the terminated innovation what percentage of the projects resources were spent on engineering/manufacturing documents?
29. For the terminated innovation what percentage of the projects resources were spent on launch activity?
30. For the terminated innovation what percentage of the projects resources were spent on market research?
31. For the terminated innovation what percentage of the projects resources were spent on prototype development?
32. For the terminated innovation would it have physically required other parts of the product or production process in order to function?
33. How big was the core group for the terminated innovation?
34. Please describe the role your organisational self-interest played in the decision to terminate the terminated innovation
35. Who was the source of the idea for the terminated innovation?
36. Why was the terminated innovation terminated?

## Questions asked of senior managers

1. Are specific time resources assigned separate from day-to-day work to work on ideas?
2. Are there set milestones in the innovation process when increased certainty of revenue projections is required?
3. Broadly speaking, what percentage of your time would you say you spend coming up with or developing innovations?
4. Can you describe the roles you've played with the innovations you've been involved in?
5. Describe the level of competence of the other personnel involved in the innovation process
6. Do large group information sessions occur? If so, how often and for what purpose
7. Do you believe that you are treated fairly by your superiors? Subordinates?
8. Do you make a conscious effort to work with lead users of your type of products?
9. For incremental innovations, please describe the role played by the customer
10. From a personal perspective, what are the pitfalls that you watch out for when deciding whether or not to get involved in a particular innovation?
11. From the perspective of your career, what do you see as the impact of innovation?
12. How are employees that are seen as champions treated when ideas fail?
13. How do ideas get evaluated here?
14. How do ideas get implemented here?
15. How do you know whether your innovation efforts are successful?
16. How does innovation happen here?
17. How is new knowledge disseminated to other interested personnel with the firm?
18. If financial control intensity differs, what are the shift points that trigger changes in control mechanisms?
19. In order for an innovation to proceed, is there a generally accepted maximum allowable range of uncertainty in costs or ongoing revenues?
20. Is innovation an explicitly stated element in your business strategy?
21. Is there a generally accepted hurdle rate required for innovations to receive continuing support?
22. Is there a generally accepted required impact on revenues or profits before an innovation is pursued?
23. Is there a group or team within the organisation that is responsible for innovation? If so, who are they?
24. Is there a plan in place to stage the introduction of more design options?
25. Is there a practice of encouraging employees to come up with ideas?
26. Is there a separate budget line item for innovation?
27. Is there a specific company strategy to service new or existing markets?
28. Is there a systematically and periodically reconsidered R&D programme?
29. Is there a training plan in place for employees?
30. Is there an explicit strategy to exercise differing intensity of financial control depending upon the stage of the innovative work?
31. Is there anything else you can tell me about the innovation process here that we haven't already discussed?

32. Once an idea has received support in principle to pursue it further, what methods does your firm employ to gather more information about the new product/process or service or new market?
33. Please describe if brainstorming techniques are used and if so, how often and for what purpose(s)?
34. Please describe if creative problem solving techniques (e.g. case method, Delphi method, etc.) are used and if so, how often and for what purpose(s)?
35. Please describe if cross functional teams are used and if so, for what purpose?
36. Please describe the knowledge transfer mechanisms between engineering and manufacturing.
37. Please describe the knowledge transfer mechanisms between manufacturing and field service.
38. Please describe the knowledge transfer mechanisms between sales and engineering
39. Please describe the recent (last 10 years) innovation history of your industry
40. Please describe your current level of profits at this site, compared to where it was last year at this time, and three years ago.
41. Please describe your current level of sales at this site, compared to where it was last year at this time, and three years ago.
42. Please describe your current levels of employment at this site, where it was last year at this time, and three years ago.
43. Thinking about innovation from a personal perspective, what is it that you get when you involve yourself in the process?
44. What are the different forms of financial commitments that your firm has made to innovations in the past?
45. What are the most important barriers to innovation here?
46. What are the most important efforts made to encourage employees to come up with new ideas?
47. What are the most important forces external to the firm that enable innovation here?
48. What are the most important methods for generating ideas here?
49. What financial criteria are used to approve work on innovations?
50. What is the duration of the typical product life cycle in your industry?
51. What proactive efforts are made to solicit ideas from customers?
52. What processes have been used to limit or expand design options in ongoing innovation projects?
53. What reporting mechanisms are used to pass on the increased knowledge up to management?
54. Which of the following is your principle source of ideas, management, marketing, engineering, manufacturing, competitors, customers, other?
55. Which of the following is your second most important source of ideas, management, marketing, engineering, manufacturing, competitors, customers, other?
56. Would you consider your company's technology strategy to be characterized as "leading edge", "first to be second", "middle of the pack" or "the status quo is fine"?

*Plus questions about any of the innovations of interest with which they were involved.*

### **Questions asked of functional manager(s) – manager(s) most affected by innovation**

1. Are specific time resources assigned separate from day-to-day work to work on ideas?
2. Are there set milestones in the innovation process when increased certainty of revenue projections is required?
3. Broadly speaking, what percentage of your time would you say you spend coming up with or developing innovations?
4. Can you describe the roles you've played with the innovations you've been involved in?
5. Describe the integrity of your superiors, in other words, do they do what they say they will do?
6. Describe the level of competence of the other personnel involved in the innovation process.
7. Do large group information sessions occur? If so, how often and for what purpose?
8. Do you believe that you are treated fairly by your superiors?
9. Do you believe that you are treated fairly by your superiors? Subordinates?
10. For incremental innovations, please describe the role played by the customer
11. From a personal perspective, what are the pitfalls that you watch out for when deciding whether or not to get involved in a particular innovation?
12. From the perspective of your career, what do you see as the impact of innovation?
13. Have specific time resources been assigned separate from day-to-day work to work on the currently ongoing innovation system?
14. How are employees that are seen as champions treated when ideas fail?
15. How do ideas get evaluated here?
16. How do ideas get implemented here?
17. How do you know whether your innovation efforts are successful?
18. How does innovation happen here?
19. How is new knowledge disseminated to other interested personnel with the firm?
20. How will you know whether your innovation efforts have been successful?
21. If financial control intensity differs, what are the shift points that trigger changes in control mechanisms?
22. Is innovation an explicitly stated element in your business strategy?
23. Is there a generally accepted hurdle rate required for innovations to receive continuing support?
24. Is there a generally accepted required impact on revenues or profits before an innovation is pursued?
25. Is there a practice of encouraging employees to come up with ideas?
26. Is there a specific company strategy to service new or existing markets?
27. Is there a systematically and periodically reconsidered R&D programme?
28. Is there a training plan in place for employees?
29. Is there an explicit strategy to exercise differing intensity of financial control depending upon the stage of the innovative work?
30. Is there anything else you can tell me about the innovation process here that we haven't already discussed?
31. Once an idea has received support in principle to pursue it further, what methods does your firm employ to gather more information about the new product/process or service or new market?



32. Please describe if brainstorming techniques are used and if so, how often and for what purpose(s)?
33. Please describe if creative problem solving techniques (e.g. case method, Delphi method, etc.) are used and if so, how often and for what purpose(s)?
34. Please describe if cross functional teams are used and if so, for what purpose?
35. Please describe the knowledge transfer mechanisms between engineering and manufacturing
36. Please describe the knowledge transfer mechanisms between manufacturing and field service
37. Please describe the knowledge transfer mechanisms between sales and engineering
38. Thinking about innovation from a personal perspective, what is it that you get when you involve yourself in the process?
39. What are the different forms of financial commitments that your firm has made to innovations in the past?
40. What are the most important barriers to innovation here?
41. What are the most important efforts made to encourage employees to come up with new ideas?
42. What are the most important forces external to the firm that enable innovation here?
43. What are the most important methods for generating ideas here?
44. What financial criteria are used to approve work on innovations?
45. What processes have been used to limit or expand design options in ongoing innovation projects?
46. What reporting mechanisms are used to pass on the increased knowledge up to management?
47. Which of the following is your principle source of ideas, management, marketing, engineering, manufacturing, competitors, customers, other?
48. Which of the following is your second most important source of ideas, management, marketing, engineering, manufacturing, competitors, customers, other?
49. Would you consider your company's technology strategy to be characterized as "leading edge", "first to be second", "middle of the pack" or "the status quo is fine"?

Plus questions about any of the innovations of interest with which they were involved.

#### **Questions asked of first line production supervisors**

1. Are specific time resources assigned separate from day-to-day work to work on ideas?
2. Are there set milestones in the innovation process when increased certainty of revenue projections is required?
3. Broadly speaking, what percentage of your time would you say you spend coming up with or developing innovations?
4. Can you describe the roles you've played with the innovations you've been involved in?
5. Describe the integrity of your superiors, in other words, do they do what they say they will do?
6. Describe the level of competence of the other personnel involved in the innovation process.
7. Do you believe that you are treated fairly by your superiors? Subordinates?

8. For the currently ongoing innovation does it physically require other parts of the product or production process in order to function?
9. From a personal perspective, what are the pitfalls that you watch out for when deciding whether or not to get involved in a particular innovation?
10. From the perspective of your career, what do you see as the impact of innovation?
11. How are employees that are seen as champions treated when ideas fail?
12. How do ideas get evaluated here?
13. How do ideas get implemented here?
14. How do you know whether your innovation efforts are successful?
15. How does innovation happen here?
16. How is new knowledge disseminated to other interested personnel with the firm?
17. How will you know whether your innovation efforts have been successful?
18. Is innovation an explicitly stated element in your business strategy?
19. Is there a generally accepted hurdle rate required for innovations to receive continuing support?
20. Is there a generally accepted required impact on revenues or profits before an innovation is pursued?
21. Is there a practice of encouraging employees to come up with ideas?
22. Is there a specific company strategy to service new or existing markets?
23. Is there an explicit strategy to exercise differing intensity of financial control depending upon the stage of the innovative work?
24. Is there anything else you can tell me about the innovation process here that we haven't already discussed?
25. Once an idea has received support in principle to pursue it further, what methods does your firm employ to gather more information about the new product/process or service or new market?
26. Please describe if brainstorming techniques are used and if so, how often and for what purpose(s)?  
Please describe if creative problem solving techniques (e.g. case method, Delphi method, etc.) are used and if so, how often and for what purpose(s)?
27. Please describe if cross functional teams are used and if so, for what purpose?
28. Thinking about innovation from a personal perspective, what is it that you get when you involve yourself in the process?
29. What are the different forms of financial commitments that your firm has made to innovations in the past?
30. What are the most important barriers to innovation here?
31. What are the most important efforts made to encourage employees to come up with new ideas?
32. What are the most important forces external to the firm that enable innovation here?
33. What are the most important methods for generating ideas here?
34. What financial criteria are used to approve work on innovations?
35. What reporting mechanisms are used to pass on the increased knowledge up to management?
36. Which of the following is your principle source of ideas, management, marketing, engineering, manufacturing, competitors, customers, other?

37. Which of the following is your second most important source of ideas, management, marketing, engineering, manufacturing, competitors, customers, other?
38. Would you consider your company's technology strategy to be characterized as "leading edge", "first to be second", "middle of the pack" or "the status quo is fine"?

## Appendix B – Recruiting and consent letters for respondents

Reference: Innovation Process Study, Mechanically-based SMEs

Dear Mr/Ms.,

This letter is intended to inform you about the research project we are undertaking and to ask you for permission to meet with you and ask you a number of questions about the innovation processes inside your firm. In preparation to send this invitation letter, we have been in contact with \_\_\_\_\_ (senior manager's name) and he has agreed to support the goals of our research project and encourages your cooperation with providing the necessary time and information.

The project is a multi-firm in-depth case study project with an objective of documenting innovation practices. This will be followed by the development of innovation process theory as it applies in your business context. It is our hope that useful management prescriptions that we will share with the study participants will be one of the benefits of the research.

Another important contribution of the research should be to help differentiate between the current schools of thought as to the most effective management strategies to deal with innovation. Currently, the principal competing concepts include:

- a. Management needs to support entrepreneurial behaviour as it leads to innovation, or,
- b. In order to innovate, set up your firm as a learning organisation by instituting active knowledge management practices, or,
- c. The only way to deal with disruptive innovations is through organisational redesign, or,
- d. More control inside firms leads to more focus on projects of merit, or,
- e. More organic structures and more chaos leads to more creative ideas leading to more innovations that make it to market, and or,
- f. Organisations need to support chaos for idea formation processes and control for market introduction activities. The tough part is knowing when to switch modes.

As you can see these ideas prescribe radically different approaches to the same objective of producing innovations. This research project is intended to shed some light on this debate by studying a particular business context in depth. Hopefully over time, other business contexts will also be studied in depth and more generic results will be able to be assembled.

In order for your firm to participate in the study we need to acquire limited access to key innovation personnel who are ideally placed to answer our questions about overall innovation processes, an ongoing innovation process, a recently completed innovation

process and a recently halted innovation process. Working in conjunction with \_\_\_\_\_ (senior manager), you have been identified as one of the key innovation personnel that will likely be able to help describe innovation processes within your firm. Our hope is that you will agree to participate and make yourself available for confidential focused interviews at your location on Tuesday, October 18<sup>th</sup> or Wednesday October 19<sup>th</sup>. These interviews are typically between 30 minutes and two hours in duration.

There are a number of other details (confidentiality, anonymity, informed consent, etc) that would need to be discussed before we could proceed with the research and I would be happy to discuss these with you as a preamble to our interview. In order to make the most efficient use of our time together I have enclosed a copy of the consent form for your signature and pickup when we meet. In the event you have any immediate queries, please feel free to contact me at my office either by e-mail: [glennb@nipissingu.ca](mailto:glennb@nipissingu.ca) or by telephone at 705-474-3461 ext 4479.

I'm looking forward to our conversation.

Yours truly,

Glenn Brophey, P.Eng., MBA  
Assistant Professor,  
School of Business and Economics

## **CONSENT TO PARTICIPATE IN RESEARCH – INNOVATION PARTICIPANTS**

**TITLE OF RESEARCH PROJECT:** The role of innovation processes within small and medium sized mechanically-based firms.

You and other members of your firm are being asked to participate in a multi-firm research study conducted by Assistant Professor Glenn Brophey, from the School of Business and Economics at Nipissing University for the purposes of completion of a doctoral dissertation at the direction of the School of Business and Economics of the University of Exeter in Exeter, UK. This research is supported by University of Exeter, Nipissing University, and Materials and Manufacturing Ontario (part of the Ontario Centres of excellence network).

If you have any questions or concerns about the research, please feel free to contact Glenn Brophey at 705-474-3461 ext 4479 or via e-mail at [glennb@nipissingu.ca](mailto:glennb@nipissingu.ca)

### **PURPOSE OF THE STUDY**

This exploratory research is designed to explore within small to medium-sized mechanically-based firms, what are the common types of innovation processes at work?

#### **• PROCEDURES**

If you volunteer to participate in this study, we would ask you to do the following things:

1. Agree to be interviewed about innovation processes at your location. This should require between 30 minutes and two focused hours of your time.
2. Agreement to provision of copies and/or viewing of internal company documentation that may be germane to the innovation process questions (e.g. meeting minutes, project budget documents, etc.).
3. If further follow-up questioning is required then agreeing to converse either in person or by telephone with the researcher. Time expectations for the follow-up are minimal.

#### **• PAYMENT FOR PARTICIPATION**

Respondent's participation is entirely voluntary.

#### **• CONFIDENTIALITY**

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission.

During the data gathering phase, interviews are expected to take place at the respondent's place of business in a confidential location such as a boardroom. These interviews will produce video recordings and written notes. The respondent has a right to review/edit the recordings if they so desire.

These recordings will need to be transcribed to a text format by a transcription service provider that has agreed to be bound by the necessary confidentiality provisions. The recordings, written notes and the results of the transcriptions will be stored in the researcher's locked office. Electronic files created from these efforts will be password protected and stored on the researchers computer. Once no further use of the data is planned, then the original recordings, transcriptions and electronic files will be destroyed.

- **PARTICIPATION AND WITHDRAWAL**

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may exercise the option of removing your data from the study. You may also refuse to answer any questions you do not want to answer and still remain in the study. The investigator may withdraw you from this research if circumstances arise which warrant doing so.

- **POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY**

It is anticipated that this study will document innovation processes inside successful small to medium sized mechanically-based firms. The resulting theory of effective innovation processes for this context will be described in a thesis document, a copy of which will be provided to the case study firms. The information gathered and developed here should serve to inform managers of these firms when they compare their innovation processes to the documented results.

To at least a limited degree, it is expected that the findings of this research will be able to be generalized to similar firms in other Western world jurisdictions and other types of firms that face similar operating environments. In addition, the findings should serve to inform the theoretical debate about the foundations of innovation.

- **POTENTIAL RISKS AND DISCOMFORTS**

There is the potential that you may perceive that answering of the questions in the interview to pose a threat to your status, privacy, and/or reputation within your organisation. The research questions revolve around processes inside organisations and exploration of issues that may have the potential to raise career-sensitive and reputation-related issues. Please be assured that your responses will be treated in a confidential manner and that any reporting of results will only be done in the aggregate. In the event effective dissemination requires more detailed reporting that has the potential of identifying individual respondents, then the researcher undertakes to either effectively disguise the respondents or acquire written permission from the respondent to report the more detailed information.

- **RIGHTS OF RESEARCH SUBJECTS**

You may withdraw your consent at any time and discontinue participation without penalty. This study has been reviewed and received ethics clearance through Nipissing University's Research Ethics Committee. If you have questions regarding your rights as a research subject, contact:

Research Ethics Co-ordinator  
Nipissing University  
North Bay, Ontario  
P1B 8L7

Telephone: 705-474-3461, # 4558  
E-mail: ethics@nipissingu.ca

- **SIGNATURE OF RESEARCH SUBJECT/LEGAL REPRESENTATIVE**

I understand the information provided for the study of THE ROLE OF INNOVATION PROCESSES WITHIN SMALL AND MEDIUM SIZED MECHANICALLY BASED FIRMS as described herein. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

\_\_\_\_\_  
Name of Research Subject (please print)

\_\_\_\_\_  
Signature of Research Subject

\_\_\_\_\_  
Date

- **SIGNATURE OF INVESTIGATOR**

In my judgement, the subject is voluntarily and knowingly giving informed consent to participate in this research study.

\_\_\_\_\_  
Signature of Investigator

\_\_\_\_\_  
Date



## Appendix C – Letter re coding bias

Anthony DiGiacomo  
Research Assistant  
522 Nipissing Street  
North Bay, ON P1B 4L7

August 22, 2005

Glenn Brophey  
Assistant Professor of Business Administration  
Nipissing University  
100 College Drive, Box 5002  
North Bay, ON P1B 8L7

Dear Mr. Brophey,

I am pleased to inform you that an *Internal Validity Assessment* has been completed for your research process and report findings on MTI Equipment Ltd. – which you requested on the date of July 1<sup>st</sup>, 2005.

The process used to determine the validity of your research was as follows:

**Step 1:**

The interview transcript was reviewed to form an understanding of general content and context.

**Step 2:**

The interview transcript was sorted – grouped by question, question code, and by respondent to assist research analysis.

**Step 3:**

Each individual response was examined and paraphrased to depict the essence of the respondent's thought or assertion. These summations were added to the transcript under respondent ID "xxname".

**Step 4:**

The interview transcript was sorted a second time – grouping respondent IDs "xxname".

**Step 5:**

The "xxname" summations were examined. Each question was answered by several different employees – therefore each question had several "xxname" IDs. For each question, every responding "xxname" was examined. The "xxname" IDs were then summarized again and added to the transcript under the respondent ID "AD". The "AD" IDs depicted the overall company response to each question.

**Step 6:**

"GB" IDs were examined – "GB" IDs represented your interpretation of the overall company response to each question given in the interview.

**Step 7:**

Each “AD” response was compared with your “GB” response for the purpose of checking overall congruency in response interpretation.

**Step 8:**

The final MTI Equipment Ltd. (CylDiv) report was examined to check for agreement and consistency in overall research findings.

The comparison between “AD” and “GB” IDs (Step 7) showed considerable congruency. Wherever an “AD” differed slightly from a “GB” I referred back to the original interview and found the mistake or overlook and corrected it – let it be known that in each case it was my interpretation that was faulted or incomplete. So in short, the comparison was very solid.

I could find nothing in the final MTI Equipment Ltd. report that seemed out of place or incorrect in terms of findings. I referred back to the original interview transcript to check some areas that I questioned, and in all cases everything was reported accurately.

However, one area of consideration that I would like to bring to your attention is regarding the interview questions themselves. Several questions in the interview refer to *methods of endorsement, forms of endorsement, and number of endorsements* etc. During the interview there were several occasions where it was obvious the respondent did not fully understand the intent of the question. In most cases where this was evident, your explanation of *endorsements* seemed to lead respondents into agreeing with what you perceived the answer to be. Though not a critical issue, it is possible that respondent’s thoughts are not being fully realized – being influenced by your leading. Therefore you may consider revising the questions regarding *endorsement* to facilitate respondents to answer the questions without assistance.

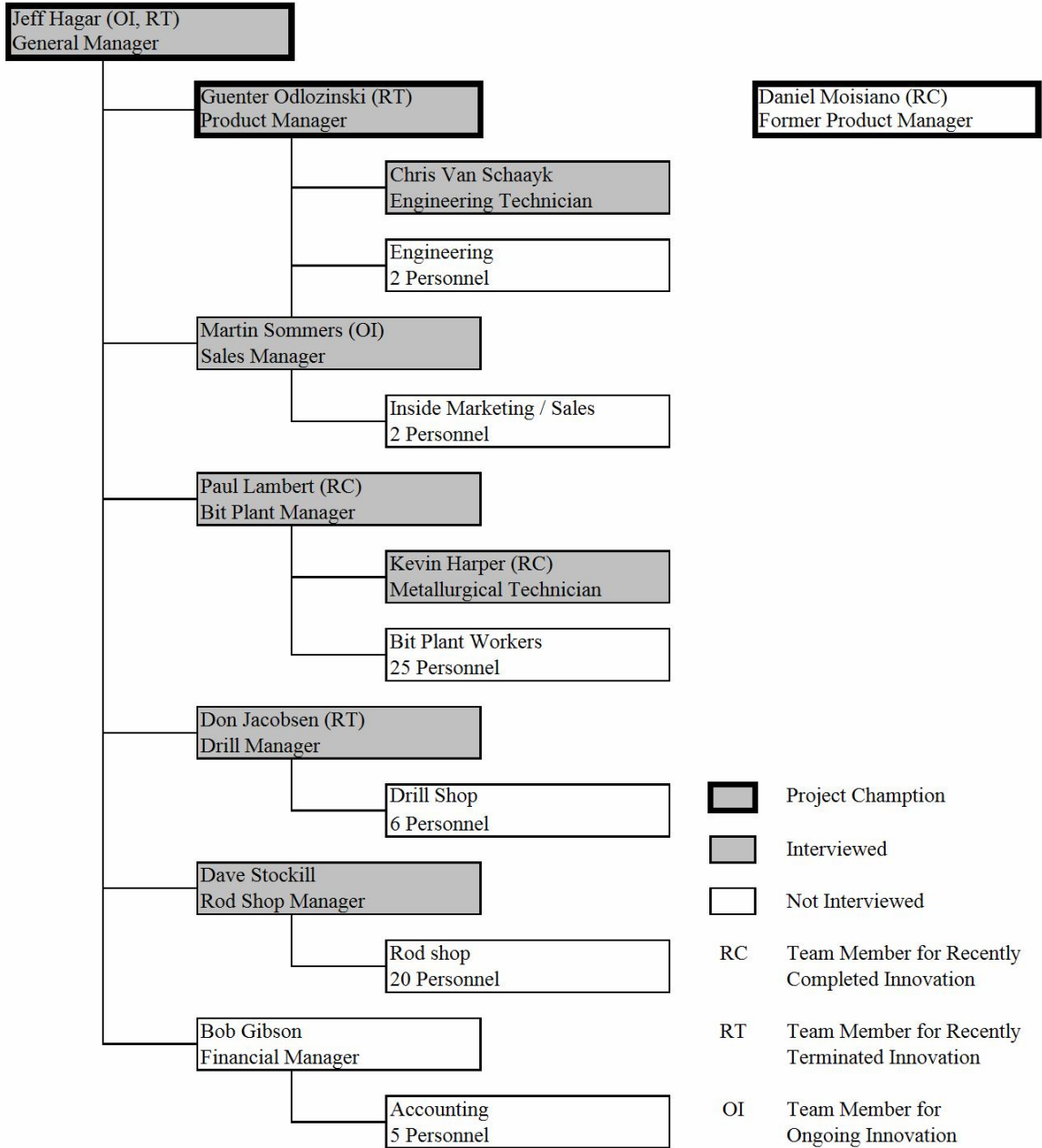
Overall, after scrutinizing your raw data and reviewing your final report, I am confident that the methods of collecting, sorting and interpreting data for MTI Equipment Ltd., (CylDiv) display great validity and have proved to be effective; and therefore can be used to analyze other companies using this same methodology.

Sincerely;

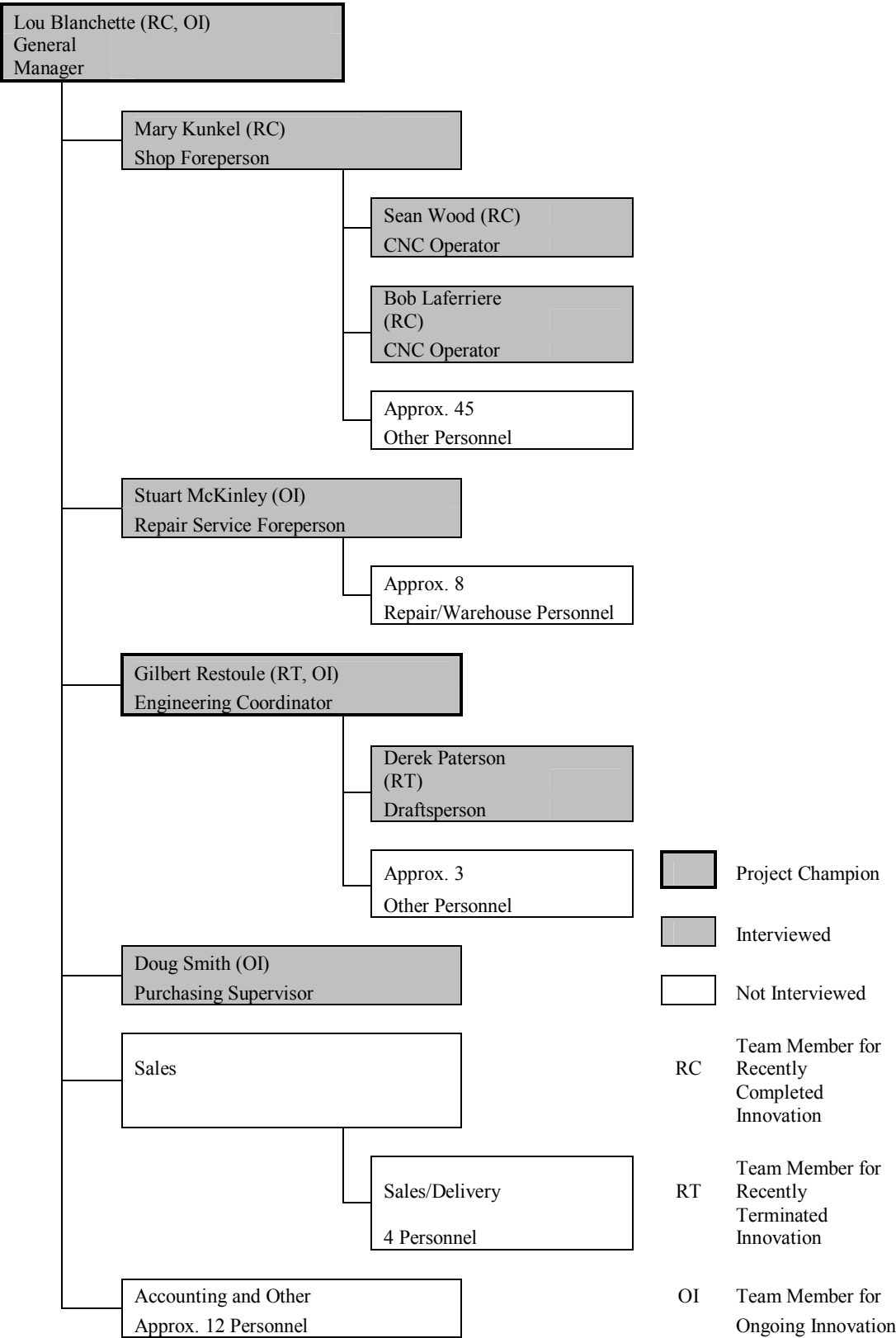
Anthony DiGiacomo  
Research Assistant  
School of Business and Economics  
Nipissing University  
Appendix D1

## Appendix D – In-plant organisation charts

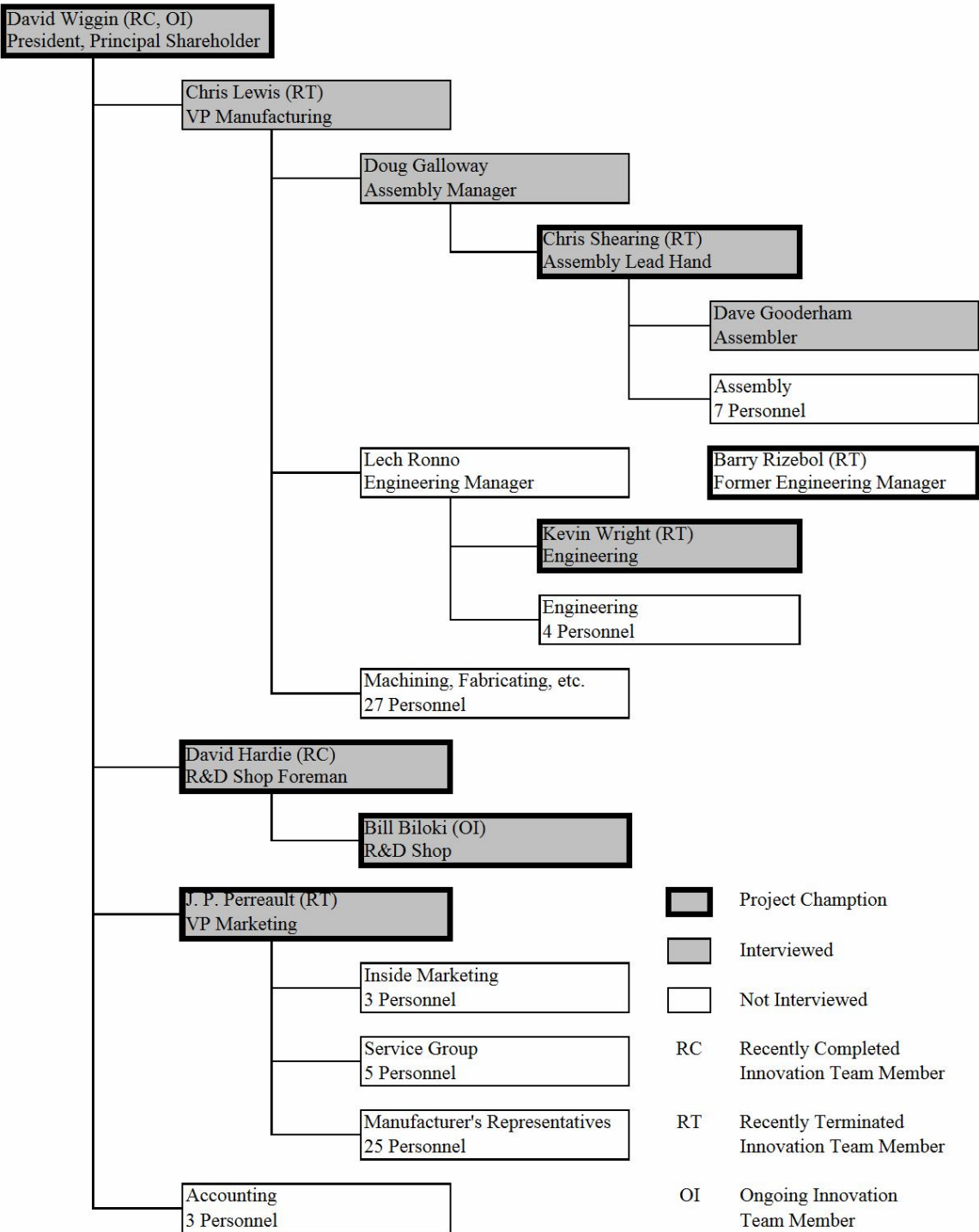
### *Appendix D1 In-plant organisation chart illustrating positions of respondents and project champions within ACEP North Bay*



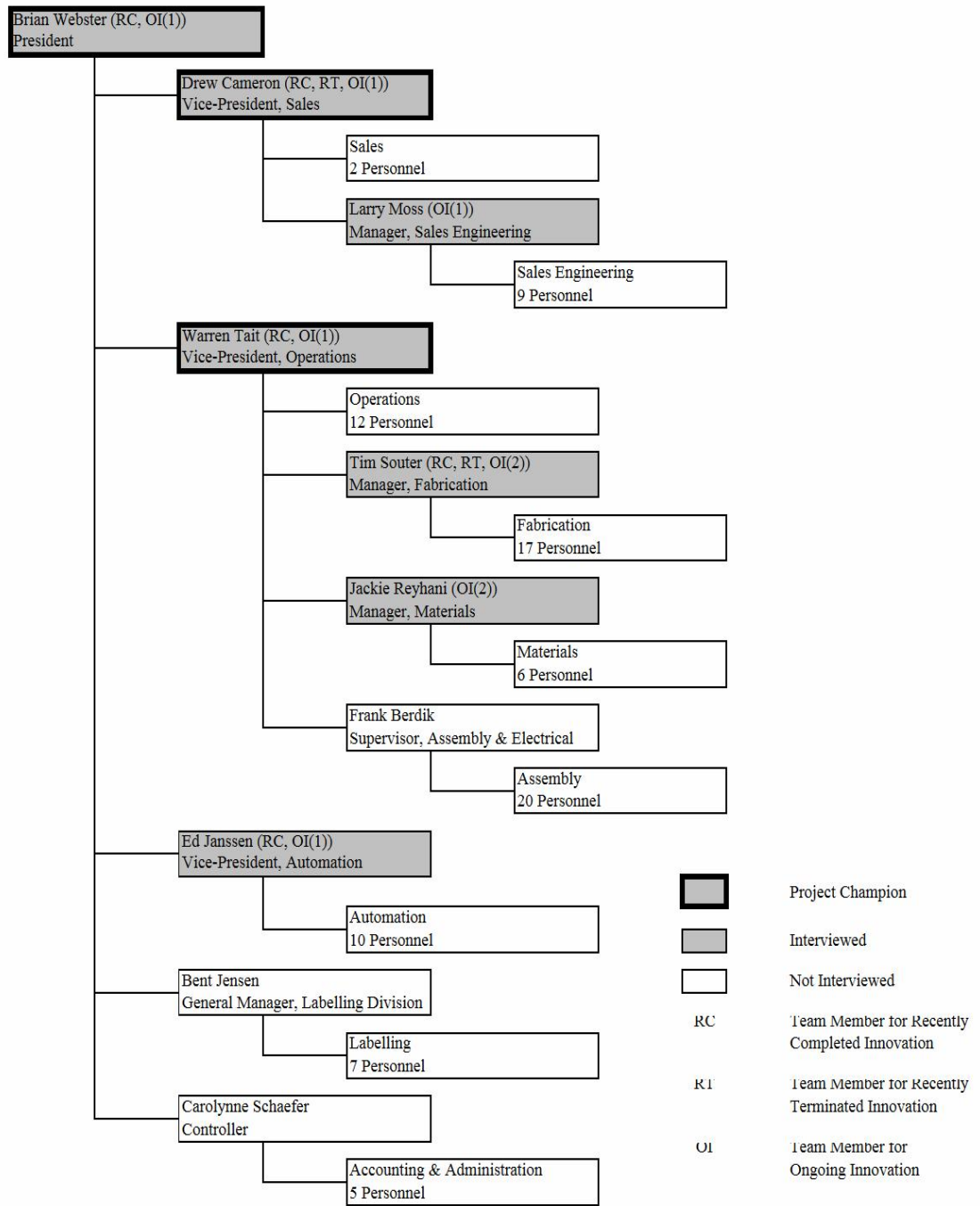
**Appendix D2 In-plant organisation chart illustrating positions of respondents and project champions within CylDiv**



*Appendix D3 In-plant organisation chart illustrating positions of respondents and project champions within Wepackit*



**Appendix D4 In-plant organisation chart illustrating positions of respondents and project champions for P1**



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