Innovation

in

Australian Manufacturing SMEs:

Exploring the Interaction between External and Internal Innovation Factors

By

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Certificate of original authorship

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Signed: On: 28 April 2016

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Megha Sachdeva
Sydney

In the loving memory of my *Bauji* (Grand Pa), Sh. Satya Paul Sachdeva.

~ I miss you and I wish you were with me to feel proud of my achievement ~

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Abstract

This thesis examines the relationship between internal and external drivers of innovation in Australian manufacturing small and medium enterprises (SMEs). A mixed methods approach was employed to study this relationship, combining survey data and case studies to investigate the effect of technological change on innovative activities, an effect potentially mediated by SMEs' particular characteristics. Results indicate that the absorptive capacity model of innovation is applicable to Australian manufacturing SMEs but there is also evidence that non-knowledge management characteristics of SMEs affect the impact that internal factors and technological changes can have on innovation. When employees have the freedom to trial new approaches to their work in a family-like culture, risk-taking behaviour is nurtured, leading to innovation. SMEs that exploit opportunities across different sectors and/or co-create with their customers are also more innovative. There may however be a limit to a firm's ability to consume new technology with a responsive approach in meeting customer needs. The findings are of value especially to policy makers, academics, management practitioners, as it brings forward the antecedents of innovation in the Australian manufacturing context.

Chapter 1: Introduction

1.1 Innovation, productivity growth and small manufacturing firms

Innovation is currently at the centre of policy debate in Australia. The reason for this is the connection between innovation and productivity growth. Considerable attention has been given in recent decades to the productivity component of economic growth. This has been true in terms of both theoretical investigation and policy formulation. Productivity growth is certainly on the economic policy agenda of most governments in the developed world, and it has been proposed as a major part of strategies to close the growth gap between the world's developed and developing economies (see Sachs et al. 2004).

Globalisation has contributed strongly to this trend. In Australia, for example, the relatively high cost of labour compared to that in developing countries has slowly reduced the competitiveness of labour-intensive industries and has resulted in the relocation of many production facilities, especially to developing nations. This has resulted in a decline in the significance of the manufacturing sector within the Australian economy over the last twenty years. Australia greatly expanded its manufacturing sector in the 1950s and 1960s under the protection of tariffs and quotas, with most of its output being exported to the UK. Beginning in the mid-1950s, the direction of Australian trade began to change when Japan started to import coal and other mineral and agricultural resources from Australia. By 1995 the Australian economy was dependent on East Asia for up to 60% of its exports. Barry Jones, a Labor elder who had portfolio responsibility for Science & Innovation during this period, described Australia as a *volatile follower economy* as its earning capacity was dependent upon factors such as *"currency and price fluctuations, interest rates and seasonal variations in crop yields"* (Jones 1989, p. 21). He stressed then the need for diversification into more stable industries which would need to be competitive given the development that was occurring in the productive capacity of its trading partners, and the gradual opening up of trade that eventually flourished into full-scale globalisation.

Ciro, Mascitelli and Muthaly (2009) more recently used Jones' (1989) idea of the *volatile follower economy* to characterise Australia's current relationship with China. While Australia has greatly benefited from the spectacular growth of China, particularly by supplying it with natural resources at record high prices, the development of Chinese manufacturing also represents a serious competitive threat to Australian manufacturing. Like Jones, Ciro, Mascitelli and Muthaly argue that a shift from this resource-focused viewpoint is required to ensure Australia's future economic success. The current Australian government has argued that such an adjustment lies not simply in reducing the cost of Australian labour (which underpins the living standards of Australian workers) and not in accepting the decline of manufacturing but in lifting manufacturing productivity growth (see also Green 2013; Green et al. 2009).

While Australia has traditionally been home to a number of large manufacturing firms, small to medium enterprises (SMEs) collectively make up a significant proportion of Australia's manufacturing capability. Recent Australian Bureau of Statistics (2014) data indicate that manufacturing SMEs accounted for 6.69% of GDP in December 2014. However, the indirect contribution of the manufacturing sector to the economy should also be recognised. For instance, a recent Commonwealth of Australia (2012) report states: "*when a manufacturing sector opens, it attracts local services… when a supermarket opens it doesn't attract a manufacturing plant*." This means in a service economy like Australia, manufacturing plays an important role in the creation of service industries. Any policy designed to grow the economy would thus benefit from attention to manufacturing SMEs. But enhancing productivity in this sector depends crucially on understanding how it functions, what drives productivity improvements, and whether the factors that drive productivity in manufacturing SMEs are the same as in other sectors of the economy.

The economics and management literature has long articulated a vital connection between productivity growth and innovation. Innovation is *"the creative application of knowledge to increase the set of techniques and products commercially available in the economy"* (Courvisanos 2007, p. 46). Jones (1998, pp. 81-82, 95-96) points out that high rates of economic growth are a relatively recent historical phenomenon essentially inaugurated by the industrial revolution where scientific and technical innovation significantly increased labour productivity, and thus economic growth. This suggests that fostering innovation is an important precondition for lifting productivity performance (Hyland, Mellor & Sloan 2007). Thus, if an important objective of Australian economic policy is to lift productivity growth, enhancing innovation in SMEs has the potential to contribute to this objective.

1.2 The state of play in innovation research

While the beginnings of mainstream growth theory in economics assumed that the pace of innovation and technological change was given (see, for example, Solow 1956), this assumption was later dropped with the emergence of endogenous growth models (Aghion & Howitt 1992; Romer 1986, 1990) in which the pace of technological innovation was explained as the outcome of deliberate decisions by firm managers.

These later developments drew heavily on the much earlier work of Joseph Schumpeter (see, for example, Schumpeter 1934 and 1942) which the Solow tradition had essentially ignored. For Schumpeter, innovation played a much more central role in the dynamics of economic development than for other economists of his time. He saw the process of innovation as being closely tied to the behaviour of entrepreneurs and especially to their creative and risk-taking characteristics. While Schumpeter's work was initially ignored by leading minds in the economics discipline, it was embraced within the management discipline. Work by Penrose (1955, 1959), Rogers and Shoemaker (1971), Nelson and Winter (1982) and von Hippel (1988) developed Schumpeter's ideas about the forces that drive innovation from a management perspective, providing the foundation for an enormous amount of empirical work on the subject.

This research identified a range of factors that drive innovation. These include: profit; the need for survival in highly competitive markets; the need for increasing responsiveness to customer demand; pressure to increase market share; the possibility of establishing new markets; the constant need to manage and integrate technology and to improve information technology (IT) capabilities; coping with improvements in the supply and delivery of goods; demands to improve environmental impacts of products and process, and to improve safety or work conditions; and the need to respond to government regulations, and to adhere to industry standards.

It is common within this innovation literature to divide these factors into two types: those that are external and those that are internal to the firm. External factors include such things as general technological change, competition, consumer demand, and government policies. Internal factors might include such things as firm size, structure, culture, finance, resources, human capital, collaborative linkages, and the knowledge and learning ability of individuals within the firm. The role played by these factors and how they affect innovative outcomes is now reasonably well understood within the fields of management and industrial economics.

A significant feature of innovation research on both large corporations and small firms is that it mostly examines the effect of internal and external factors on innovation outcomes separately. We thus have a very good understanding of some of the important individual factors driving innovation but a less clear understanding of how these factors interact with one another. An important exception to this is the work done since the early 1990s on the role of new knowledge as an innovation driver. New knowledge is an important product of research and development activity that can lead to significant technological change, innovation and productivity growth. This knowledge is typically generated externally to most firms, leading to the impact such knowledge has on the innovation practices of any particular firm being dependant on that firm's ability to engage with and adapt the new knowledge. The interaction of this external factor with internal firm characteristics, particularly internal knowledge characteristics, will determine how much innovation is produced by the firm. Cohen and Levinthal (1990) coined the term *absorptive capacity* to describe the degree of interaction between these external and internal drivers of innovation at the firm level. Little attention has been paid, however, to the interaction between other internal and external innovation drivers, particularly for SMEs. This is certainly the case in the Australian manufacturing context. Filling this gap would provide potential for firm managers to learn from high-performing firms in order to enhance their own innovation. It would also be an important source of information for the framing of policy to lift productivity in the Australian manufacturing sector.

1.3 Objectives and contribution of this study

This study attempts to fill this gap in the innovation literature. Specifically, it examines the degree of interaction between a range of internal and external factors in their impact on innovation in Australian manufacturing SMEs. While the focus is on factors *other than* knowledge-related factors, the study includes these factors and so provides potential verification of the existing evidence on absorptive capacity in the Australian manufacturing SME context. But it also examines the role of internal factors such as firm marketing agility and organisational characteristics in mediating the impact that external drivers of innovation have on innovation outcomes at the firm level. For its external drivers, this thesis principally considers technological change. Here, technological change is the process of innovation occurring in an economy, which includes the continuous development of new technologies, improvement of existing technologies (which has the potential to lower costs or increase efficiencies), diffusion of said technologies within an economy, and their commercialisation (Ruttan 1959; Silva & Teixeira 2008).

A conceptual model was developed to explain innovation in Australian manufacturing SMEs, classifying the drivers of innovation as *external* and *internal*. Cross-sectional data was then collected from a sample of firms on the Enterprise Connect database using a survey instrument designed for the purpose. This data was used to econometrically estimate the innovation model for Australian manufacturing SMEs which contained terms showing the degree of interaction between specific internal and external factors, including those between a range of external factors and non-knowledge-related internal factors. To extend insights from the *quantitative* findings of the econometric model, the study subsequently identified a small number of firms for whom key internal factors enhanced the effect of external factors on innovation outcomes. From this group of firms four case studies were chosen that examined how certain internal factors mediated the influence of external factors on firm-level innovation. The study thus explores *which* internal factors enhance the effect of external factors on SME manufacturing innovation, *how* these factors have this effect, and *how these are managed* by firm owners.

The research reported in this thesis contributes to knowledge about SME innovation in a number of ways. *Firstly,* it contributes to our empirical understanding of SME innovation by examining whether the effect of external factors is modified by interaction with particular internal factors, including non-knowledge-related internal factors. This has not been investigated to date *for any type of firm*. *Secondly,* it provides information about how these effects operate, and how they can be managed. This is likely to generate hypotheses for further theoretical and/or empirical work. *Thirdly,* the study provides specific insights into innovation processes of Australian manufacturing SMEs, information useful for the framing of government policy designed to enhance innovation and productivity growth in this sector of the Australian economy – an explicit policy objective of the current Australian government.

1.4 Outline of the thesis

The remainder of the thesis is structured as follows. Chapter 2 provides important economic context for the Australian manufacturing sector. This sets the scene for understanding the position of Australian manufacturing SMEs discussed in the rest of the thesis. Chapter 3 provides a comprehensive survey of the relevant literature on innovation both at a general level and with particular attention to SMEs. Special attention is paid to the distinctive factors affecting innovation at the SME level.

Chapter 4 develops a conceptual model of innovation in Australian manufacturing SMEs. This model identifies specific internal and external innovation drivers for Australian manufacturing SMEs, as well as some insights into how these factors might interact. Chapter 4 thus reconsiders appropriate segments of the literature from this more practical perspective and provides a comprehensive theoretical justification for the model to be evaluated using data from Australian manufacturing SMEs.

Chapter 5 discusses the conceptual design and research methodology to be used in the empirical part of the study. The structure of the regression equations and estimation methodology is outlined, a detailed draft of the survey instrument is provided, the source of firms to be used in the survey is discussed, and the role of the case studies is explained in adding further insight into the dynamics of the factors identified as important from the quantitative part of the project.

Chapter 6 describes the data collected from the survey and reports the results of regressions of SME innovation behaviour on various internal and external factors using this data.

Chapter 7 presents the case study evidence. It explains how four firms were chosen from the survey discussed in Chapter 6 to explore the ways in which key internal characteristics of the firm mediate the influence of external innovation drivers on the extent to which innovation actually occurs within the firm. These case studies make use of primary and secondary data, including interviews, archival documents, newsletters, company accounts, and web information. Various themes for each case are identified.

Chapter 8 reviews the evidence presented in Chapter 6 and 7 and draws a series of conclusions from this evidence. It also considers some implications of these findings across SME innovation, and for industry policy formulation. Furthermore, this concluding chapter discusses additional research questions that arose during the research but were not answerable from the available data but may form the basis of future studies.

Chapter 2: Setting the Scene - The Importance of Australia's Manufacturing Sector

2.1 Introduction

Since this thesis studies the innovation practices of Australian manufacturing SMEs, it is valuable to provide some information about the economic context in which these firms operate, which is the objective of this chapter. As suggested in chapter 1, Australian manufacturing has been in decline for a number of years partly because of its reduced competitiveness in an increasingly globalised international economy. Section 2.2 documents the relative contribution to Australia's production and income from the manufacturing sector over the last twenty-five years (1990-2014).

2.2 Contribution of manufacturing to the Australian economy

The Australian manufacturing sector has been in a transition phase for a number of decades. This phase has been characterised by the reduction of tariffs, changing technology, and outsourcing of tasks to offshore, low-cost production economies. The contribution of manufacturing to Australian GDP, as well to total employment, provides an indication of the nature of this transition.

Figure 2-1 shows the contribution to gross value added (GVA) of various sectors in the Australian economy from 1990 to 2014. The contribution of the manufacturing sector to GVA in December 2014 was only 6.7%, compared to double this figure in 1990. While manufacturing made the biggest contribution to GVA in 1990, Panel A of Figure 2-1 indicates that the mining, construction, and financial services sectors each made contributions in December 2014 that exceeded that of manufacturing (9.16%, 8.38%, and 9.19% respectively). Panels B to D of Figure 2-1 indicate that the decline in the significance of manufacturing to Australian industry was roughly matched by an increase in the significance of telecommunications, financial services, and professional services (which rose by roughly 1%, 3% and 1% respectively between 1990 and 2014).

The manufacturing sector in 1990 was also the biggest contributor to employment in the Australian economy, accounting for around 14.6% of the total workforce. However, this contribution experienced a downward trend over the 25-year period between 1990 and 2014 (although less dramatic than in manufacturing's contribution to GVA). This is depicted in Panel A of Figure 2-2. This panel shows that employment in manufacturing declined by about half over this period, to be only 7.9% in December 2014. Panel A also indicates that the health care, retail, and construction sectors each made contributions to employment in December 2014 that *exceeded* that of manufacturing (12%, 11%, and 9% respectively).

Panels B to D indicate that this decline in manufacturing employment was roughly matched by increases in employment in the professional services and mining sectors (which rose by roughly 4% and 1% respectively between 1990 and 2014). From 2002 onwards, manufacturing shows a significant decline in its employment share (by around 3%) roughly matched by an increase in employment in the health care, construction, professional services and mining sectors (3%, 2%, 2% and 1% respectively).

The behaviour of manufacturing's share in GVA largely matches the behaviour of its share in factor employment over this period. In contrast, panels A to D in Figures 2-1 and 2-2 indicate that the GVA and employment shares of the financial services, mining, and professional services sectors behaved very differently over this period. This suggests that the significance of manufacturing cannot be accounted for simply in terms of its contribution to GVA, its contribution to employment is also important.

Further light is cast on this issue if we compare employment across different Australian states. Gittins (2014) and Borland (2011, p. 193) each discuss how changes in the geographic location of manufacturing in Australia has affected employment patterns across the country. Gittins (2014), for example, describes how 70% of manufacturing employment was located in New South Wales and Victoria in 1984, but only 58% of this employment was located in these states in 2014 (with each state having an equal share of 29%). The share of manufacturing employment in the *mining states* of Western Australia and Queensland, rose to 10% and 21% respectively in 2014, while South Australia's share fell to 8%. This implies that the distribution of manufacturing employment across the country evened out over the 1984-2014 period, making different states less dependent on the manufacturing sector and more dependent on other sectors, especially service industries such as professional, scientific and technical services, health care, and construction.

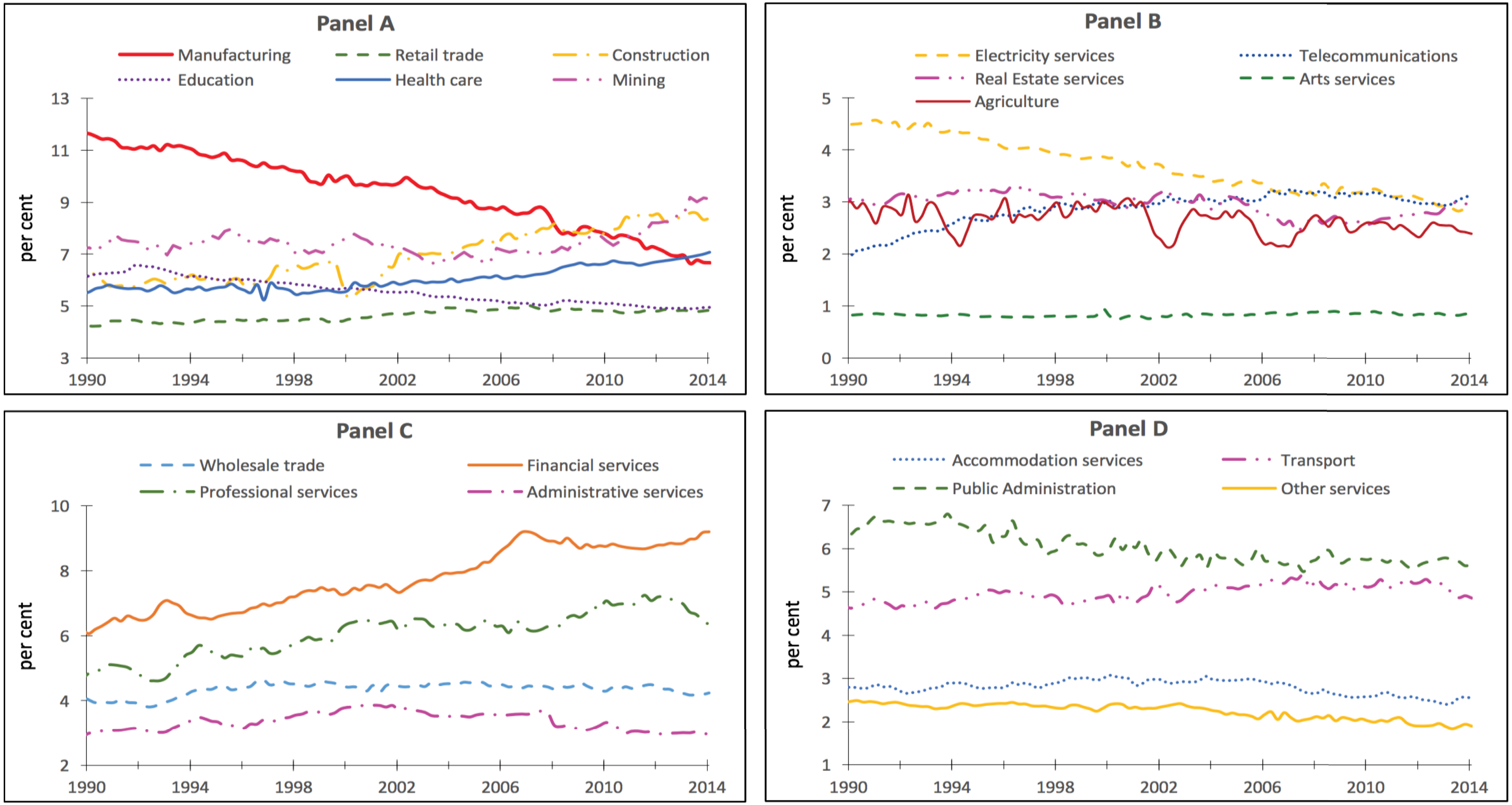

Figure 2-1: Sectoral contributions to total gross value added – 1990-2014.

Source: Australian Bureau of Statistics, Cat. No. 5206.0 *Australian National Accounts: National Income, Expenditure and Product*, Table 6 - Gross Value Added by Industry, chain volume measures, sa.

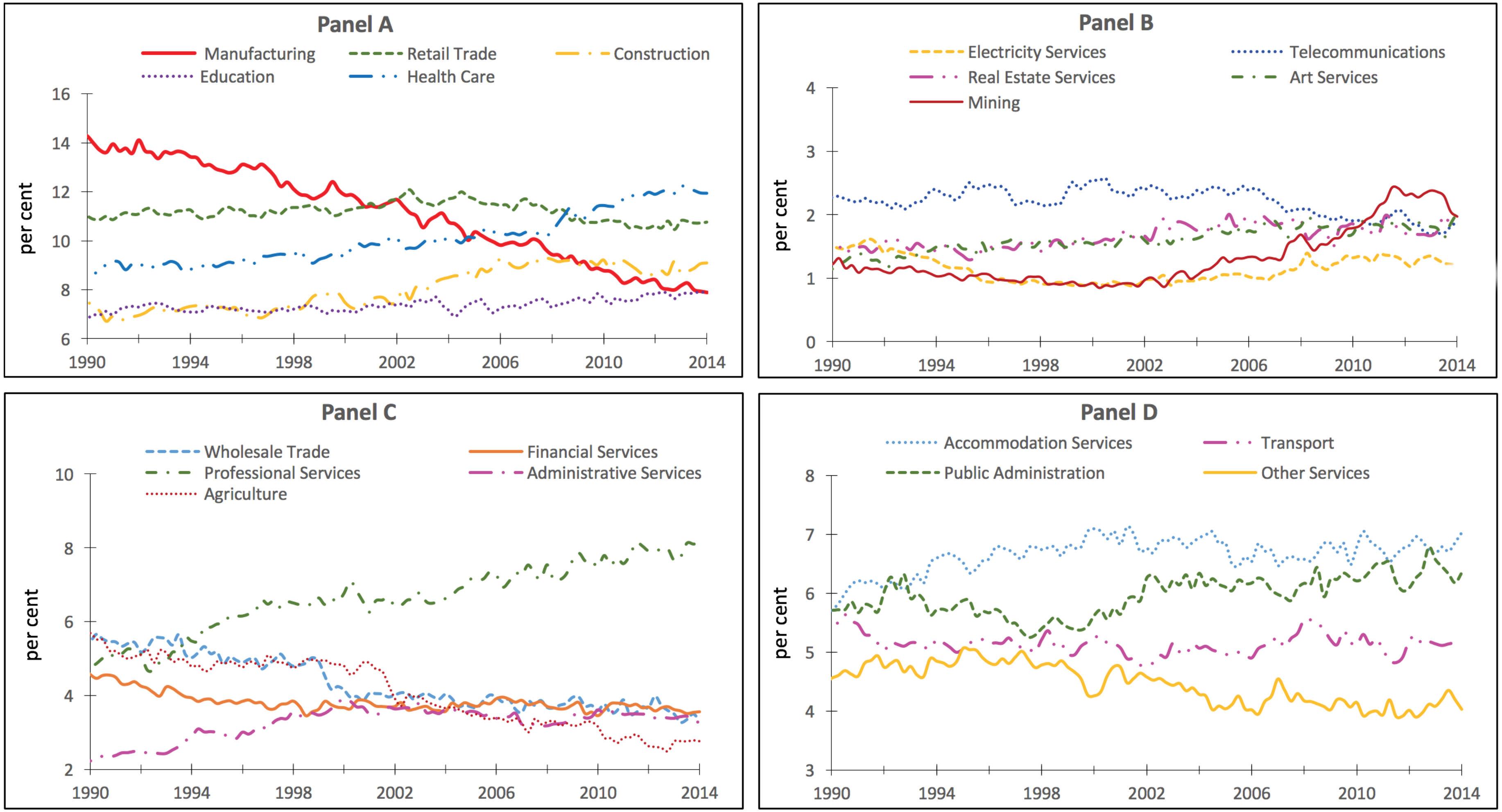

Figure 2-2: Employment shares in the Australian economy by sector – 1990-2014.

Source: Australian Bureau of Statistics, Cat. No. 6291.055.003 *Labour Force, Australia, Detailed, Quarterly*, Table 04 - Employed persons by industry, detailed, sa.

Employment patterns in manufacturing and service industries are however difficult to compare for two reasons. Firstly, service industries are more labour intensive than manufacturing industries. Bradley (2015, p. 100) argues that 9.4 workers employed on a yearly basis are required to produce $1 million worth of services in Australia, while only 5.5 workers employed on a yearly basis are required to produce $1 million worth of manufactured goods. This higher average labour productivity in manufacturing is, of course, partly due to greater use of automation and technology, but it suggests that a fall in manufacturing employment levels does not necessary imply a significant decline in the importance of manufacturing itself. Some account must be taken of trends in productivity before such a conclusion can be reached.

The productivity performance of Australian manufacturing is, therefore, outlined in Figures 2-3 and 2.4. Figure 2-3 indicates the high degree of volatility in labour productivity across all sectors of the economy on a *quality adjusted hour worked*[1] basis. Panel A indicates that labour productivity growth was *less volatile* in the manufacturing sector than in any other sector of the Australian economy, moving between a small negative rate just below zero and about 5% per annum. Other sectors such as agriculture, forestry and fishing, information media and telecommunications, and rental, hiring and real estate services, experienced more pronounced fluctuations, ranging, in the case of agriculture, between minus 20% and 25% per annum.

While labour productivity growth in the manufacturing sector was largely positive over the 1990-2014 period, capital productivity growth, on the other hand, was largely *negative*. This can be seen in Panel A of Figure 2-4. Other sectors such as administrative and support services, professional, scientific and technical services, and rental, hiring and real estate services also experienced negative capital productivity across this period as shown in panels B, C, and D, at the same time as experiencing positive labour productivity growth for at least part of this overall period.

[1] Quality adjusted hour worked – According to the ABS, this index proxies quality change through two components: educational attainment and years of potential work experience. The trend in the Australian labour market is towards becoming more skilled and more qualified. Consequently, the quality adjusted labour input index provides an indication of the overall quality change of the labour force in Australia.

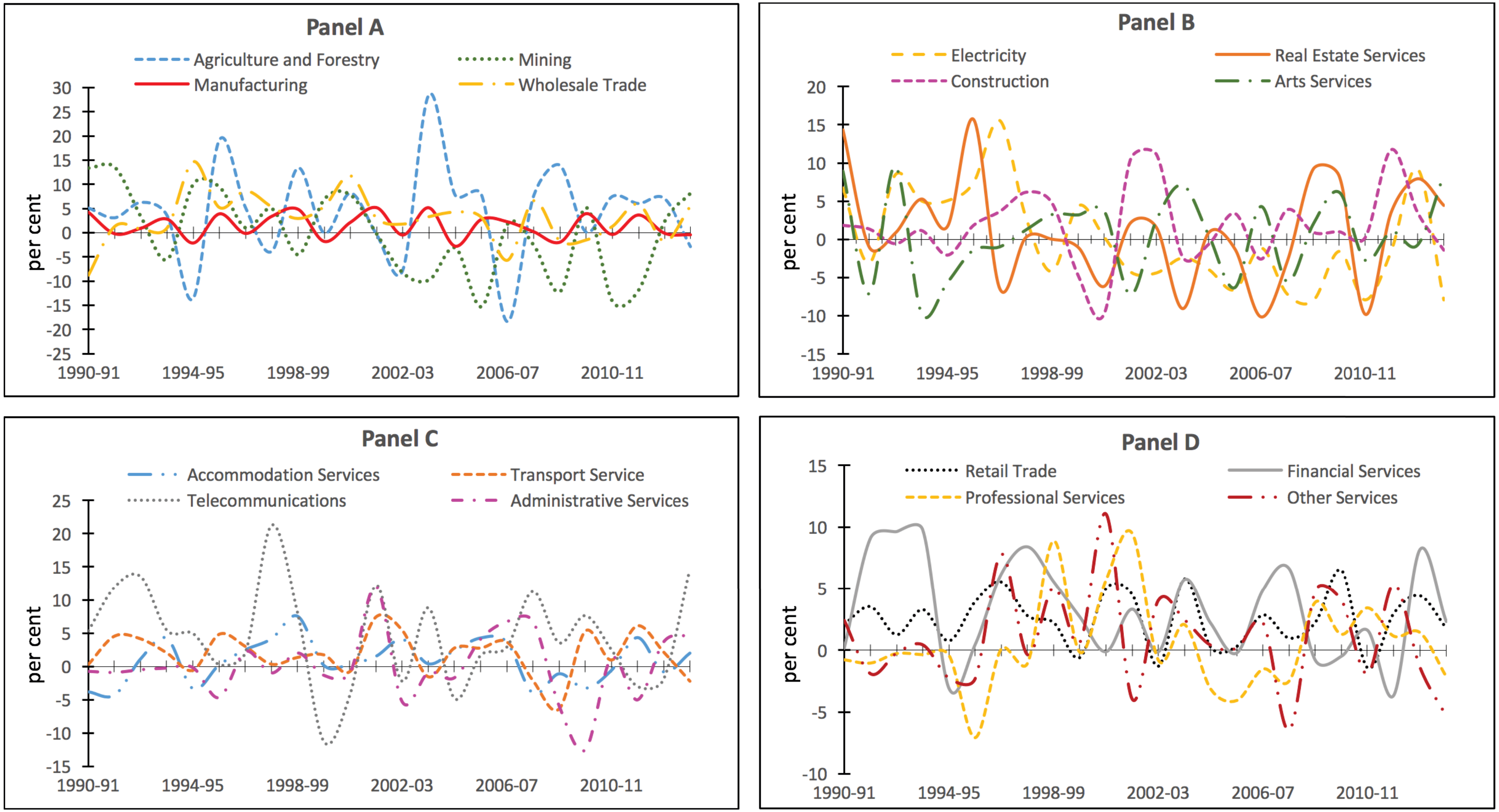

Figure 2-3: Labour productivity growth for the Australian economy – 1990-2014.

Source: Australian Bureau of Statistics, Cat no. 5260.0.55.002 Estimates of Industry Multifactor Productivity, Australia, Table 6 - Labour Productivity Indexes, sa.

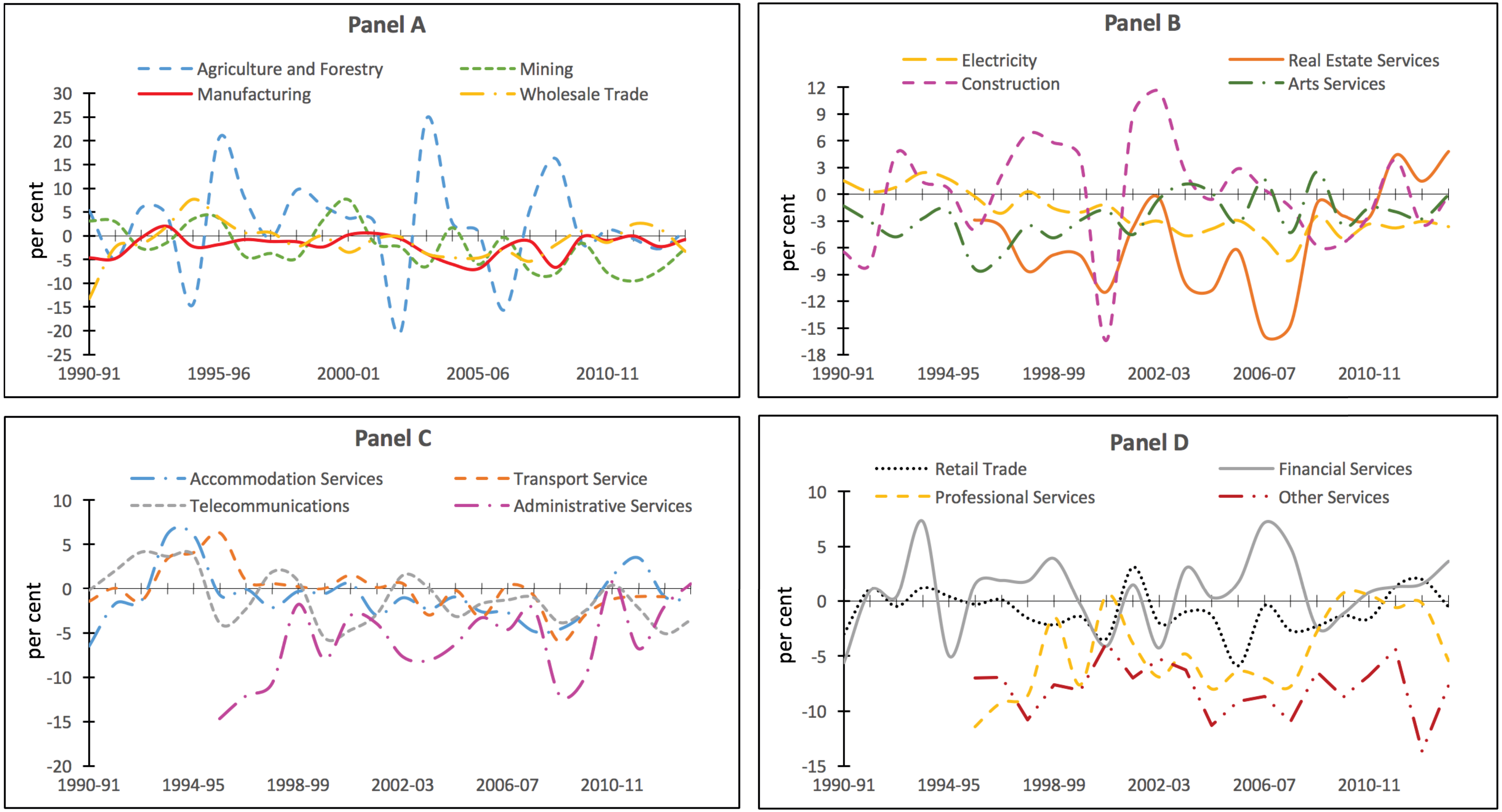

Figure 2-4: Capital productivity growth for the Australian economy – 1990-2014.

Source: Australian Bureau of Statistics of Commonwealth of Australia 2014, Cat no. 5260.0.55.002 *Estimates of Industry Multifactor Productivity*, Australia, Table 7 - Capital Productivity indexes, s.a.

The data in Figures 2-3 and 2-4 indicate that the average labour productivity growth in manufacturing is higher than average capital productivity growth. Figure 2-4 also indicates, however, that there was widespread negative growth in capital productivity in the Australian economy over a long period. Some economists have suggested that this is an artefact of serious problems with the construction of the capital productivity data (see, for example, Dodgson, Hughes, Foster and Metcalfe (2011), Parham (2013) and Foster (2014)). The kinds of poor capital productivity growth indicated by the ABS data would suggest a demotivating influence on company capital investment behaviour. Companies would be unlikely to invest in expanded capital capacity if the productivity of this capital was falling, since this would lead to significant increases in costs per unit of output produced. Parham (2013, p. 470) observes, however, that companies, especially in the mining sector, were investing strongly over this period. He argues that the capital productivity trends apparent in the ABS data do not show a true picture of the underlying real trends. Foster (2014), following Parham (2013), in turn, argues that there may be discrepancies in the capital productivity data caused by a change of scale in some industries, such as mining, over the period. A change in scale would require a significant expansion of capital stock which would *increase* the *denominator* of the average capital productivity measure but not the numerator. The observed change in capital productivity would thus be negative in this case.[2]

These observed changes in productivity measures have led to significant debate over appropriate policy responses. One recommendation was that wages in sectors experiencing low average measures of labour productivity, especially manufacturing, should be reduced. However Dodgson et al. (2011) and Foster (2014) both reject this proposition. Dodgson *et al.* (2011) argue that such pressure could encourage an increase in labour intensity as firms substitute labour for capital and this would represent an impediment to capital and capital-based innovations across sectors whose wages fall. This may well result in further reductions in labour productivity, to the extent that capital-based innovations are productivity-enhancing, and a downward spiral in the prospects for these sectors. Dodgson et al. (2011, p. 1147) thus argue that Australian policies have predominantly been governed by market

[2] However, the increased scale should lead to *higher* productivity from that point onwards. A second source of distortion in capital productivity measurement could be the higher value of the Australian dollar over this period. A stronger dollar reduces the cost of purchasing new capital equipment since much of this capital is imported into the Australian economy. It may thus be the case that a significantly lower dollar could have stimulated a substantial increase in investment spending as firms took advantage of the opportunity to expand productive capacity even where this expansion was not immediately needed by production requirements. Once again the denominator of capital productivity measures would rise as a result of this effect without any corresponding change in the numerator. The result would thus be reduced observable indicators of capital productivity (Foster 2014, p. 15).

failure justifications rather than a Schumpeterian complex-evolutionary approach that facilitate risk-taking and investment in new approaches to productive practice. Dodgson et al. (2011), Parham (2013) and Foster (2014), therefore, all argue that innovation policy would be enhanced if innovation research was informed by better measurement techniques rather than the simple calculation of multi-factor productivity from standard growth accounting.

Despite these qualifications, the picture painted of the Australian manufacturing sector by the available statistical evidence suggests a decline in its contribution to GDP and employment, as well as in its productivity performance. Thomson and Webster (2013) suggest that two things could be done to turn around these trends: increase productivity and create value for customers so that they are willing to pay more for Australian-made products. Both of these solutions are likely to be fostered by innovation of various types, thus the need to enquire into the innovative potential of the Australian manufacturing sector, specifically: to what extent is it currently innovative; to what extent are the preconditions for innovation currently present; and how does any current innovative practice operate so that lessons can be drawn from this practice for broader application across the sector? The following section therefore looks more closely at innovation potential the Australian manufacturing sector.

2.3 Innovation potential in Australian manufacturing

The previous section examined the contribution of manufacturing to Australian GDP and employment, and compared broad measures of productivity growth in manufacturing to other sectors of the Australian economy. This section looks more closely at the manufacturing sector and at the performance of its various sub-sectors to build a picture of the innovation potential in this part of the Australian economy. Figure 2-5 breaks down

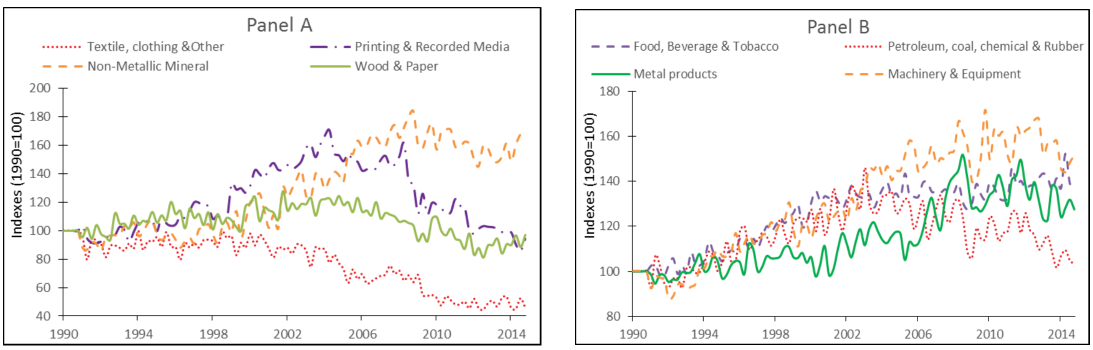

Figure 2-5: Quarterly industrial production in manufacturing sub-sectors.

Source: Australian Bureau of Statistics, Cat. No. 5206.0, *Australian National Accounts: National Income, Expenditure and Product*, Table 41 - Indexes of Industrial Production, s.a.

manufacturing production for the period March 1990 to December 2014 (with the index set at 100 for March 1990) into the contributions of its eight sub-sectors.

Panel A of Figure 2-5 suggests that the strongest growth in industrial production occurred in the non-metallic minerals sub-sector of manufacturing which grew consistently across the period, reached its peak production level in 2009 and then plateaued once the Global Financial Crisis (GFC) hit the real economy. In Panel B, the machinery and equipment sub-sector also experienced strong growth across the period, however it reached its peak only *after* the GFC. The metal products sub-sector (also in Panel B) grew strongly but only from 2006, while the printing and recorded media sub-sector (Panel A) experienced strong growth between 1998 and 2004, plateaued until 2007, and then declined strongly. Of the eight manufacturing sub-sectors, half of them (printing and recorded media, wood and paper products, textiles and clothing, and petroleum, coal, chemicals and rubber) consistently declined in terms of industrial production after the onset of the GFC until 2014. The production declines in printing and recorded media, as well as wood and paper products may be due to a shift to various online systems across the period.

Figure 2-6 shows the labour productivity performance of the same manufacturing sub-sectors over the same 1990-2014 period (again setting the index value in 1990 to 100). While labour productivity is clearly subject to regular fluctuations in all sub-sectors, Panel D

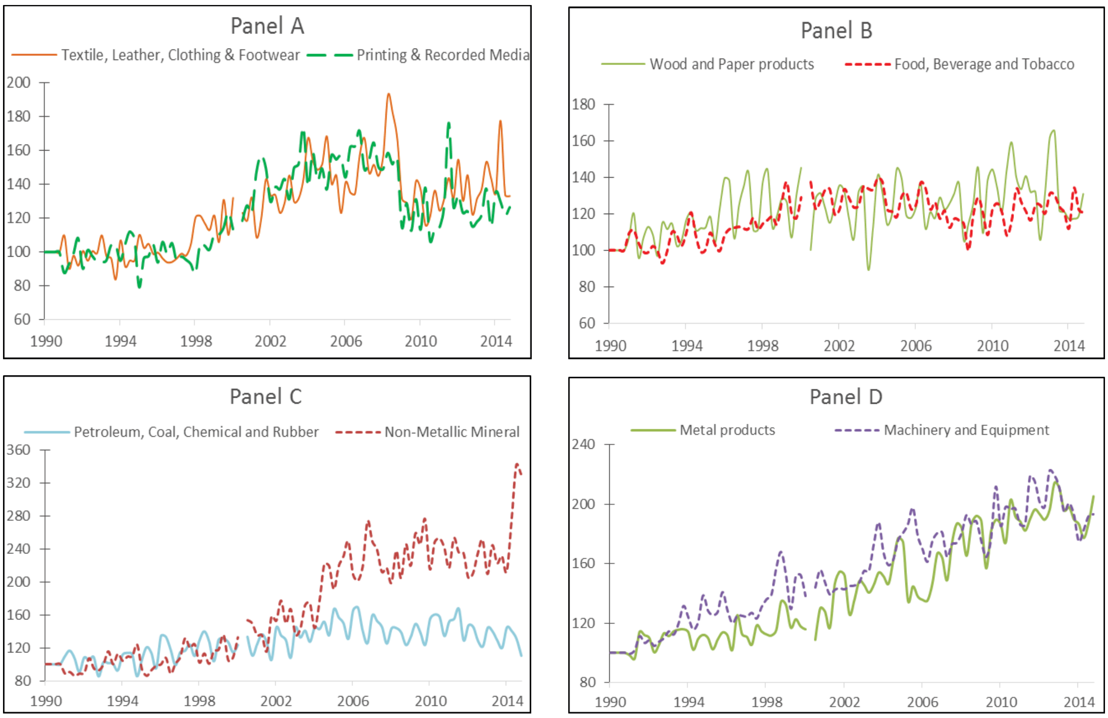

Figure 2-6: Labour productivity for manufacturing sub-sectors - 1990-2014.

Source: Australian Bureau of Statistics, Cat. No. 5206.0, Australian National Accounts: National Income, Expenditure and Product, Table 41 - Indexes of Industrial Production, s.a. Cat. No. 6291.055.003 Labour Force, Australia, Detailed, Quarterly, Table 04 - Employed persons by Industry, Detailed, s.a.

indicates that a consistent upward trend is evident in the metal products sub-sector and the machinery and equipment sub-sector. There is a significant productivity jump in the non-metallic minerals sub-sector after 2002, while the textile, clothing and footwear sub-sector, the printed and recording media sub-sector, the wood and paper products sub-sector and the food beverage and tobacco sub-sectors all indicate periods of labour productivity growth. The worst performing sub-sector was the petroleum, coal, chemical and rubber sub-sector which showed virtually no increase in labour productivity right across the 1990-2014 period (see Panel C). It is interesting to observe that the machinery and equipment sub-sector performed strongly in terms of both its production and labour productivity levels over the 1990-2014 period. These figures suggest that sections of the manufacturing sector have the potential to perform more strongly than popular perception of the sector as a whole might indicate and that exploring innovation possibilities within the sector might provide an indication of the likely future of Australian manufacturing.

Figure 2-7 presents evidence on the proportion of firms by firm size within the broad range of Australian production sectors that engaged in some kind of innovative practice in 2012-13. This suggests that for all firm sizes, manufacturing firms in Australia engaged in innovative practices as much, if not more than, firms in other productive sectors.

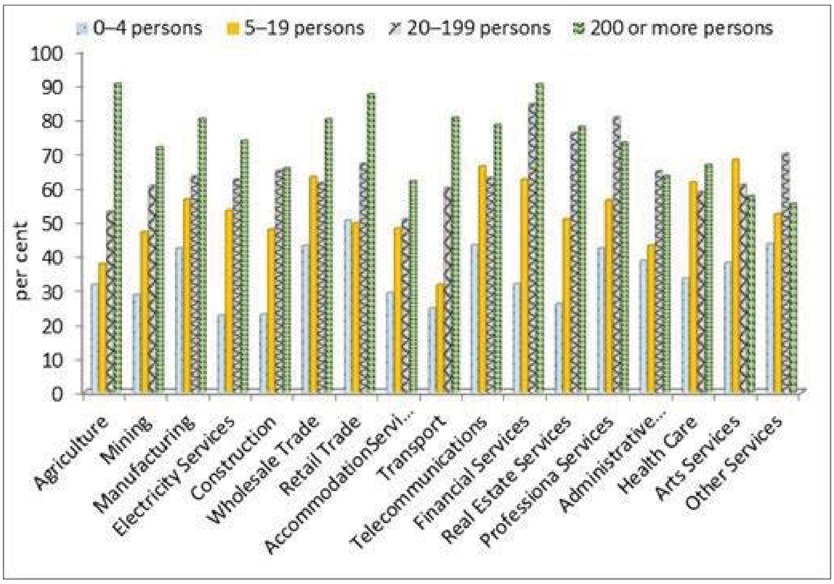

Figure 2-7: Proportion of firms engaging in innovative activities by sector and firm size.

Source: Australian Bureau of Statistics, Catalogue No. 81580DO001 *201213 Innovation in Australian Business, 2012-13*, Table 2-Summary of innovative activity in Australian business, by status, industry by employment size, 2012-13, All items.

The above figure indicates that innovative activities are not practised at equal rates in Australian businesses, and are strongly correlated with firm size. Innovation in Australian manufacturing may thus play a different role, and may be engaged with differently, across businesses of various sizes (i.e., small, medium, and large). A study of innovation in manufacturing businesses should thus be specific regarding the size of the firms considered, as outcomes may be dependent on this factor.

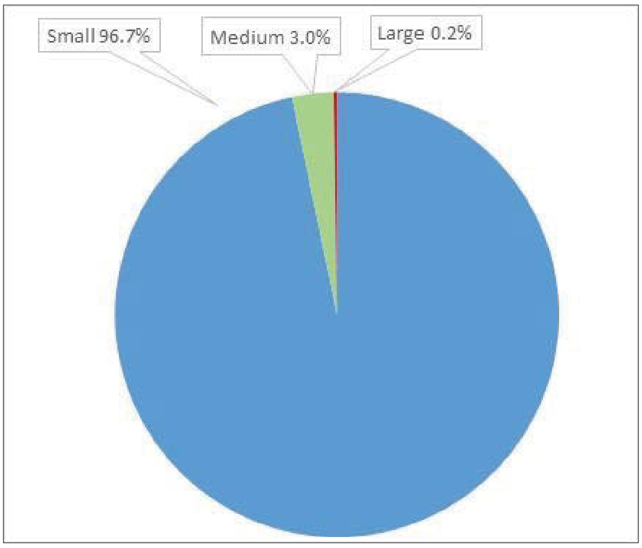

Figure 2-8: Proportion of businesses by employment size.

Source: Australian Bureau of Statistics, Catalogue No. 81650DO001 2010201406 *Counts of Australian Business including Entries and Exits, Jun 2010 to Jun 2014*, Table 15 –Survival of Businesses by Employment Size Ranges: June 2010-June 2014, All items.

Of the actively trading businesses in Australia as of March 2015, most employ fewer than 200 employees. Figure 2-8 reports that of these, around 96% are small businesses (1,267,510 with less than 20 employees)[3], 3% are medium-sized businesses (39,876 with 20-199 employees) and 0.22 % are large businesses (2,888 with 200 employees or more). Considering Australia mainly comprises small and medium enterprises, it is reasonable for a study of the manufacturing sector to focus on enterprises with fewer than 200 employees.

In studying SMEs, it is important to understand what comprises a SME. What follows is a deeper analysis of the definition of SMEs, and supporting evidence of manufacturing SMEs in the Australian economy.

[3] Small businesses includes the following sub categories that survived to June 2014. Non-employing (727,966), 1-4 (394, 271) and 5-19 (145, 273) employees.

2.4 Small and medium enterprises (SMEs) within Australia

SMEs constitute a diverse, heterogeneous group of enterprises belonging to different sectors. Consequently, there is no agreement in the literature on a standard definition for SMEs (Jabara & Cardenas 2010). In addition, no single definition of SMEs suits the needs of both the government and the private sectors. Thus, different countries, different government agencies, and different sectors tend to define SMEs in different ways.

Two dimensions, quantitative and qualitative, are used to define SMEs (von der Heidt 2008). Given their diversity, most countries use quantitative definitions to capture the basic characteristics of a SME. One of the common ways of defining SMEs is by the number of employees. For example, in the USA a SME is defined as an enterprise which consists of fewer than 500 employees (Jabara & Cardenas 2010). Eurostat consider an enterprise as a SME when there are fewer than 250 employees (Wymenga et al. 2012). For Japan, a SME is an enterprise of fewer than 300 employees (Nagano & Takato 2010). The Australian Bureau of Statistics (ABS) defines a small enterprise as an actively trading business with 0-19 employees, and a medium-sized business as an actively trading business with 20-199 employees (Australian Bureau of Statistics 2001). Some other quantitative definitions base their classifications on revenue/turnover or a combination of both. Quantitative dimensions also include total payroll, balance sheet total, and net profit, as the measures of distinction between SMEs and large enterprises. A qualitative dimension for defining SMEs acknowledges the correspondence between ownership and management of an enterprise. For example, if 50% or more of the equity lies within the hands of the company management it is considered a SME (von der Heidt 2008). For this thesis, a quantitative dimension was used, where the number of employees was taken into account.

2.4.1 The importance of SMEs

SMEs, within national economies, assist in reshaping the productive sectors, employment and innovation (Badulescu 2010; Boldrini, Schieb-Bienfait & Chéné 2011; Rodgers 2010). SMEs are promoted as an important component in OECD economies as evidenced by the increasing number of policies directed at SMEs in these economies (Cutler 2008; OECD 1985, 1996, 1997, 2010b). SMEs have their capabilities built on the roots of creativity, flexibility and closeness to customers (Bauchet & Morduch 2012; Carree & Thurik 2010; Robson & Bennett 2000), thus providing a competitive edge to these enterprises over large firms. Due to the increasing importance of SMEs, governments around the world are increasingly supporting SME growth through the implementation and design of SME development strategies (Abdullah & bin Bakar 2000; Commonwealth of Australia 2009c, 2012). Every business starts as a SME (Hammann, Habisch & Pechlaner 2009), and some grow sufficiently to become multinational corporations through the implementation of appropriate innovative practices and strategies (Ahmad 2012). Some examples include Toyota, Apple Inc., and Facebook, which all started as small enterprises, and expanded into large enterprises due to their capabilities and competencies.

SMEs contribute to the economic development of nations primarily through the creation of employment opportunities (Mohannak 2007) and their contribution to the Gross Domestic Product (GDP). In other words they are the motor driving an economy (Abor & Quartey 2010; Ayyagari, Beck & Demirguc-Kunt 2007) by providing productivity gains, growth and prosperity (Baumol, Litan & Schramm 2009). Recent empirical studies suggest that SMEs comprised 99.8% of enterprises within the European economy in 2011, employing 67.4% of the population (Wymenga et al. 2012). Similarly, SMEs account for 99% of total businesses in both the US (Jabara & Cardenas 2010) and Japan (Nagano & Takato 2010). During 2010-11, the total contribution of SMEs within the Australian economy was 57.1%, with small enterprises contributing 33.7%, and medium businesses contributing the rest (Clark et al. 2012).

SMEs assist in increasing the exports of a nation through their exploration of global markets. The expansion of global value chains through different types of cross-border activities helps various entrepreneurs explore opportunities for further development of their businesses (Lukas 2005). The opportunities are large: "*new niche markets; possibilities to exploit scale and technological advantages; upgrading of technological capability; ways of spreading risk; lowering and sharing costs, including R&D costs; and in many cases, improving access to finance*" (Lukas 2005, pp. 10-11). Therefore, access to global markets can assist prospective high-growth SMEs to realise their potential. A characteristic seen in many SMEs possessing potential is a large investment in intellectual property. One such example is Gilmac Pty Ltd., which started its export business in 1987 in Perth, Western Australia. Currently, Gilmac is a leading supplier of cereal hay to Taiwan, Korea, and Japan. Gilmac lifted the company from an agriculture business to a pressing plant in 1993, in South Australia, and then further to a fodder business investing in a feed pellet mill in 1999 at New Norcia (Gilmac Pty Ltd 2011). Investments in plant building and supplier development programs allowed Gilmac to keep pace with the export market to Japan. Peter McHardy, the owner of Gilmac, made a significant impact by investing in technology and strategic innovation strategies, used his technical and relational skills when working with his Japanese customers, and contributed to the expansion of his business. Thus, the skills of an entrepreneur are an essential component for small businesses to progress.

2.4.2 SMEs and government policy

Government support has manifested itself through policies and business support agencies. One such program is Enterprise Connect, now replaced with the Entrepreneur's Program run by the Department of Industry and Science. However, the limited funding and staff resources devoted to the program reduces its effectiveness in providing training to SMEs and in tailoring this to individual businesses/market segments.

It can be argued that the Australian government has neglected its support for manufacturing while relying on the mining sector for the economy's growth, and that this is a factor in the decline of manufacturing (Milne 2010). The closure of Enterprise Connect due to funding cuts in December 2014, may be one such example of a lack support for entrepreneurship. In the words of the Committee for Economic Development of Australia:

> *"Again, reductions in funding to the successful Enterprise Connect Program are disguised by the merging of this program with Commercialisation Australia and Researchers in Business, and the efficiencies gained by the new combined 'Entrepreneurs' Infrastructure Program' are unlikely to make up for the loss in overall effectiveness in the absence of proper resourcing"* (Green, Marsh & Pitelis 2015, p. 222).

Recently appointed Prime Minister, Malcolm Turnbull, has voiced support for embracing innovation, commercialisation of innovation, and being agile in response to the development of new technologies, while concentrating on promoting small and medium enterprises (SMEs) (Featherstone 2015). Through technological advancements, the convergence of nanotechnology, biotechnology, and cognitive neuroscience with ICT, is expected to cause disruptive changes (Australian Business Foundation 2011) within the manufacturing sector. The Prime Minister believes improving the bottom line of SMEs is an important component for the productivity and innovation growth of our economy.

However, some have argued in the media that fighting a major decline in manufacturing requires more investment in the Australian economy including its infrastructure (Gittins 2015). Although the analysis earlier in this chapter provides a more nuanced view on the position of manufacturing, the interrelation between economic benefit and large infrastructural projects remains relevant.

Large national projects such as the National Broadband Network in 2013 play a major role in the development of SME infrastructure (Australian Government 2013). Further investment by the Federal Government in public policy initiatives targeting SMEs, through programs such as capability development, advisory services to boost performance, ICT reviews for SMEs, or strengthening regulations for SME growth, shows an ongoing government focus (Commonwealth of Australia 2009c). The benefits from these programs are twofold – being a supplier to the firms and contractors implementing the projects, and as customers and receivers of these services. The Australian Government's policy decisions are designed for *"… reinforcement of the Government's… SME policies, with support from relevant policy agencies, a cross-section of user agencies and representative industry bodies*" (Commonwealth of Australia 2009c, p. 7). Further evidence for the recognition of the contribution of SMEs is seen in the *foresighting discussion paper 2020* by the Department of Innovation Industry Science and Research:

> *"It is very difficult to establish and develop new and innovative industries in isolation from the rest of the industrial ecosystem. For example, in scaling up start-up businesses that will hopefully become future SMEs and ultimately successor industries, there is a need to cost-effectively access many ancillary capabilities … which [while] not necessarily 'high-tech', can only exist where there is a deep and long term market for their services that will justify their establishment in a specific location"* (Department of Innovation Industry Science and Research 2011, p. 4).

By way of example, comparable high-labour costs countries such as Germany have proven that building one's capabilities and skills can be effective, irrespective of the labour costs. One of the techniques practised there has been a dual system of initial vocational education and training, which promotes apprentices to gain practical experience. This helps in creating a better qualified workforce in which these graduates help in improving productivity through the generation and implementation of new ideas (Hummelsheim & Baur 2014).

In short, while opinions vary and success may be mixed and/or difficult to measure, the Australian government's orientation is largely to support innovative activities within enterprises of all sizes. Innovation plays a role in increasing productivity and economic growth so, by extension, it is a key component in the government's focus on an economically healthy and prosperous Australia.

2.5 Conclusion

This chapter has outlined the position of manufacturing in Australia and its relevance for the wider economy. It has shown that the Australian manufacturing sector has been in decline in terms of both its contribution GDP and to employment over the last 25 years. But it has also drawn attention to the varied expense of productivity growth within the manufacturing sector and the potential for lessons to be learnt from high productivity growth firms within the sector. To the extent that innovation drives changes in productivity this comes down to explaining the innovation performance of these firms. This chapter has also given consideration to the role of SMEs within the manufacturing sector. Since a significant proportion of manufacturing firms are SMEs, attention to manufacturing SMEs is a worthy focus on innovation research in Australia, and is addressed by this thesis. The chapter has thus begun a discussion on the importance of innovation as a driver for an individual firm's growth and for national growth as a whole. This position will be covered in much more depth in the following chapter which thoroughly reviews scholarly work on innovation.

Chapter 3: Literature Review

3.1 Introduction

The literature on innovation may be divided into five broad segments. *Firstly* the mainstream economics literature on economic growth establishes a link between innovation, technological change, productivity improvements and the economic growth of a nation. While this literature initially took innovation as a given, and ignored work by Joseph Schumpeter on the role of entrepreneurs, innovation and economic development, a *second* segment of the literature took up and developed the main themes of Schumpeter's work. This segment fell mainly within the management literature and eventually focused on innovation in large corporations.

A *third* segment of the literature began in the early 1990s. This segment was concerned primarily with the role of knowledge as a determinant of innovation but it examined the interplay between new knowledge generated externally to the firm and how the knowledge capabilities within the firm adapt and use externally produced knowledge to generate innovation. This is the concept of *absorptive capacity* and a clear segment of the innovation literature has explored this idea.

A *fourth* segment also began to develop in the early 1990s and drew attention to the unique role of SMEs in both the economy generally and in generating innovation. This literature has some similar features to the literature on innovation in large corporations, for example, it draws an important distinction between internal and external drivers of innovation, but those features take a different form due to the characteristics that make SMEs distinct from large corporations.

A *fifth* segment of the literature argues that firms, whether large or small, do not innovate in a social vacuum but draw on a range of supporting social structures in the process of making productive change. Such social structures include communications and transportation networks, education institutions, and financial systems. Because these social structures are the result of public policy decisions over time, this segment of the literature explicitly recognises the role of policy-making in the innovation process, and reflects this role in the concept of national innovation systems.

This chapter examines each of these five segments of the literature after various definitions of innovation are considered. The final section summarises the discussion and identifies a gap in the literature which the current research proposes to address.

3.2 The definition of 'innovation'

The word innovation stems from the Latin word *innovatus*, which originally referred to *making changes*. Today, and especially so in a business sense, innovation refers to the *creation* or *improvement* of products, processes, technologies or ideas. Differences in emphasis may be observed in the definition of innovation used in different segments of the innovation literature. The different fields of engineering, management, marketing and even economics, attach unique meanings to the definition of innovation.

Thompson (1965, p. 2)defined innovation as *"... generation, acceptance and implementation of new ideas, processes products or services".* Similarly Zaltman, Duncan and Holbek (1973) proposed innovation as a process, divided into two stages of an idea, namely initiation and implementation. The Organisation for Economic Co-operation and Development (OECD) (1991) defines innovation as an *iterative* process initiated through the perception of a new market and/or a new service opportunity in which a technology-related invention is developed, produced and marketed for the commercial success of the invention. Rogers (1998, p. 9) takes the perspective of understanding innovation as a value creation process where *"the creation of abstract knowledge, or invention of new products or processes, is not normally considered innovation until it has been productively incorporated into the enterprises' activities."* Rogers' definition is similar to that of Schumpeter (1942) who considers innovation as *the commercialisation of ideas.* Christensen (2008) argues that these ideas may or may not be full-fledged business plans, and range in their level of refinement (e.g., simple *fragmented plans*).

Baregheh, Rowley and Sambrook (2009)conducted a review of 60 definitions in search of a cross-disciplinary definition through content analysis. They came up with six different attributes of innovation: nature, type, stages, social context, means and aim. The *nature* of an innovation classified the innovation as something new or improved. The *type* of innovation classified innovation with its outcome – product or service, while *stages* categorised innovation in various steps taken from the generation of an idea to its commercialisation. *Social context* divided innovation into categories of social entities, systems or people involved in an innovation process, or environmental factors affecting this process. The *means* of innovation classified innovation under necessary resources such as technical, creative and financial, that are required for innovation. Last, the *aim* of innovation categorised it by the reasons for undertaking innovation such as competition, success, economy, differentiation, value, superiority or having an advantage.

The Oslo Manual recommends a composite definition of innovation:

> *"[Innovation is]…implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations" (Oslo 2005, p.46).*

This is the basic definition of innovation used in this study. However, further refinements see innovation as involving the generation, derivation, and interpretation of new or improved ideas or policies in an organisation or industry. Innovation in an organisation is also seen as following a paradigm that includes: acquirement of new products and/or processes (technological and non-technological); inclination towards adoption of engineering techniques to enhance productivity; appropriation of existing ideas or techniques in new ways; investment in research and development (R&D) to derive new knowledge, and to further utilise that knowledge for the development of new methods or ideas (Huang, Arundel & Hollanders 2010).

3.3 Innovation in the Theory of Economic Growth

The first segment of the innovation literature to be considered examines the link between innovation and economic growth. So-called modern growth theory is usually dated to the contribution of Robert Solow (1956) and Trevor Swan (1956). Prior to this, growth was understood in terms of the dual nature of investment spending by firms. Investment spending added to an economy's level of aggregate demand and so could be a source of growth understood within a Keynesian framework (Keynes 1936). At the same time, investment spending expanded the amount of physical capital available to firms and whether they needed this capital depended upon their perceptions of growth in demand. The famous Harrod-Domar model showed that, for plausible mechanisms by which firms might form expectations of growth in aggregate demand, interaction of the dual nature of investment spending could lead to economic instability (Jones 1975; Pasinetti 1979). The major contribution of Solow was to show that growth could be understood in a way that rendered the economic system stable. For Solow, economic growth could be divided into three sources: growth in an economy's total stock of capital; growth in an economy's labour force; and changes in the productivity of techniques by which labour and capital are combined to produce goods and services. For Solow, an economy's standard of living, its output of goods and services per person, depended only on the last of these sources, growth in the productivity of productive processes. Solow accepted that productivity growth could be related to innovation but he treated it as exogenous to the processes he was examining.

Solow's model was the benchmark approach for understanding economic growth until the contribution of Romer (1990) who argued that technological change could be explained endogenously as the result of firms' decisions about investing resources in research and development activities. This approach was subsequently developed by Aghion and Howitt (1992)and spurred the large endogenous growth literature.

The two broad approaches of Solow and Romer, differ regarding the role of the entrepreneur. Solow did not really recognise the role of the entrepreneur in economic growth, while Romer (1990) allowed a more explicit role for these economic agents since did he modelled the process of invention, identifying the motives for invention at a microeconomic level.

Modern growth theory is thus based on the idea that innovation is an outcome of the purposeful research efforts within an economy (Szostak 2009, p. 65). However, an overlooked contribution within the economics literature, the work of Schumpeter and Penrose had a much bigger impact in the management literature. I consider this in the following section.

3.4 Schumpeterian innovation theory

3.4.1 Role of innovation in a capitalist society

Schumpeter's (1942) contribution to the theory of growth and innovation is widely recognised in the management field and cited extensively within the literature on innovation. His overall thesis begins with the evolution of capitalism, which is described as a process of *creative destruction*. Creative destruction is a process where something new brings the demise of old methods, techniques or products while the overall objective is to achieve economic growth. These new products and processes compete with the old methods, not on equal terms, but with a decisive advantage that may lead to the destruction of the latter (Schumpeter 1942, p. 42).

This Schumpeterian growth model encompasses various dimensions including learning-by-doing, human capital accumulation and physical capital accumulation. Schumpeter sees capitalist societies as operating whereby:

> *"… revolutions periodically reshape the existing structure of industry by introducing new methods of production – the mechanized factory, the electrified factory, chemical synthesis and the like: new commodities, such as railroad service, motorcars, electrical appliances; new forms of organization – the merger moment; new sources of supply … and so on" (Schumpeter 1954, p. 68).*

In this way, capitalism is seen as an evolutionary process where a form or method of economic change alters an economic action, leading to industrial revolutions. The evolutionary process assists in the exploitation of opportunities (resources) within the market environment of an enterprise. Schumpeter considers technological progress, and newly acquired land, as factors that may affect exploitation of these opportunities. These opportunities are then exploited with the purpose of creating inventions or technological novelties, rather than just earning business profits.

In his early writing, Schumpeter recognised that the role of the innovative entrepreneur in developing *new combinations* of productive resources was an essential part of an economic system, and of growth (Schumpeter 1934, p. 66). Economic systems are inherently dynamic rather than static, and entrepreneurs and innovations are the drivers central to this dynamic expanding nature. With the capitalist engine in motion, innovation arises in the form of new consumer goods, new methods of production or transportation, new markets and new forms of industrial organisation (Schumpeter 1934; Schumpeter 1954, p. 132).

Schumpeter's followers (Caballero 2006; Drucker 1999b; Fagerberg 2009; Klaus 2010; McGraw 2009; Rose 2002) classified his thinking into *Schumpeter Mark I* and *Schumpeter Mark II*. Schumpeter Mark I focused on the role of the entrepreneur as essential for innovation, while Schumpeter Mark II shifted emphasis to the role of large corporations as drivers of innovation. Considering the role of an enterprise within a capitalist society, Schumpeter Mark I emphasised the importance of the individual entrepreneur in the *creative destruction* process which was driven by competition central to the operation of a capitalist society.

For Schumpeter competition was not about reducing price to below that of competitors, but about using technology in ways that are somehow better than one's competitors. He claims it is the monopoly profits that are the motivation for innovators to invest in businesses. However, he further argues that the profits generated by technological competition are temporary in nature, and in the long run the actual motivation of competitors' shifts from earning profits to creative destruction of innovations.

Schumpeter's model of capitalism suggests that macro-level changes in an economy are the outcome of micro-level entrepreneurial activities. When entrepreneurs involve themselves in the development of novel ideas and the introduction of superior technologies, it affects both existing firms and new market entries. The introduction of a superior technology affects a firm's economic behaviour even if the threat of losing market share to competitors is not realised (Schumpeter 1942). Schumpeter claims that the role of entrepreneurs is the critical factor in the development of capitalist economic systems, competition that exists outside firms and thus an important driver of the creation of novel innovations or ideas.

3.4.2 Role of entrepreneurial leadership in the process of innovation

Entrepreneurs are important role using only in determining new combinations of productive resources, but also in using them to create novel outcomes. The creativity and initiative with which an organisation implements innovative strategies depends therefore on *entrepreneurial leadership*. Schumpeter (1934) argues that this role is a complex and a competitive process which is affected by both internal and external factors to the firm. He believed that the *intuition* of an entrepreneur was essential for innovation, and that undue attention to logical analysis could be hindrance towards successful innovation.

The entrepreneur's strategy towards innovation in Schumpeter's early work aligns the vision of an individual and an enterprise. He claims that the contribution of an entrepreneur is to be creative and to make major contributions to the decision-making process that underpins to innovation. He argues that the creation of *new combinations* is essential in the process of innovation. But once an entrepreneur achieves competitive advantage, the innovation does not stop. Other entrepreneurs may introduce better and more innovative products. To sustain a business in the competitive market, a *continuous* process of new combinations is required. Schumpeter suggests that demand for new products creates new markets and, therefore, a major part of being an entrepreneur is to identify new markets (Schumpeter 1934, p. 132).

A weakness of Schumpeter's early approach was that he considered the role of the entrepreneur without identifying the context within which the entrepreneur was placed or how the entrepreneur interacted with that context. For example, did it matter whether the entrepreneur was located within a small firm or a large firm? None of these issues were addressed by Schumpeter in his earlier work. In addition, Varis and Littunen (2010, p. 130) have suggested that Schumpeter did not consider the extent of newness or radicalness entailed in innovation in this early work. His focus was instead simply the object of change. These feature were however transformed in his later work especially the issue of firm size.

3.4.3 The role of large corporations in the process of innovation

Schumpeter's later work moves away from a concentration on entrepreneurial action in the process of creative construction (Schumpeter 1934), towards creative application, an effective trigger for entrepreneurial actions by individuals (1942). He depersonalises and deconstructs the entrepreneurial function, in order it constituent parts can be replicated by anyone. This would allow big corporations to create the conditions whereby their employees were enabled to carry out the entrepreneurial function. Entrepreneurship thus migrated from an individual person to large corporations as capitalism developed, according to Schumpeter's view of economic development. He concluded that large corporations were inherently innovative because they are continuously involved in the process of *creative destruction* driven by technological competition. Schumpeter (1954) extends this argument to the point where innovation itself could become *routinized*, so that individual entrepreneurs could become less important and the *mechanized corporate laboratories* more important. He extends the corporate laboratories argument to the point that *economic progress* itself could become depersonalised and automatised, with bureaus and large institutions replacing individuals (Schumpeter 1954, p. 133). These bureaus would have more resources, such as teams of trained specialists who could work towards achieving innovative outcomes more effectively than could individual entrepreneurs. Another reason given for the rise of large corporations was a change in capitalist societies due to the expansion of economic and political environments (Schumpeter 1942).

The above analysis indicates that the role of the entrepreneur was key to innovation in Schumpeter's work. He stressed the creative aspects of entrepreneurship, and even if the results of entrepreneurship were negative, such as failure of, or economic loss because of an innovation, he argued that its positive effects would offset these failure and losses. According to Becker, Kudsen and Swedberg (2011, p. 20) Schumpeter idolised the entrepreneur as an *economic hero*, and treated the individual entrepreneur as the only source of entrepreneurship. This is especially true of Schumpeter Mark I, but it can be argued that even in Schumpeter Mark II where the emphasis is on the entire corporation, the entrepreneurial function lies at the heart of innovation with the contribution of the other with agents such as customers, employees, and managers to the innovative process, downplayed or ignored.

3.4.4 The role of managers

Penrose (1959) placed much greater emphasis on managers in the process of innovation and differentiated their function from that of the entrepreneur. While the Schumpeterian concept of the entrepreneur focused on the generation of new ideas and identification of opportunities, the manager in Penrose's schema contributed to innovation by effectively implementing strategies to realise the opportunities presented by the entrepreneur's activities. The manager, for Penrose, was therefore an effective organiser of the resources available to the firm, including entrepreneurial talent. Since resources could be effectively organised in any sized firm to deliver innovative outcomes, Penrose effectively shifted attention away from the size of the organisation as a factor driving innovation onto the role of managers. Penrose thus sees the role of managers as being significantly more important than that of entrepreneurs. This approach naturally shifts attention to managerial competencies and how these might be developed. Penrose posited previous experience and the practical or operational knowledge of managing resources as being essential to innovation and the growth of a firm. This early innovation theory is thus characterised by the evolution of thinking which moves from emphasising entrepreneurs (Schumpeter 1934) to large corporations (Schumpeter 1942) to managers (Penrose 1959) over a 25-year period.

A recent meta-analysis by Sarooghi, Libaers, and Burkemper (2015) confirms Penrose's ideas on the role of managers. In their study of 52 earlier studies on the link between creativity and innovation, the authors find that "*managers and entrepreneurs have a certain degree of control over factors that facilitate the conversion of creative ideas into new innovations*" (p. 715). Managers and entrepreneurs have control over, for example, firm size, R&D facilities, and the allocation of human capital to manage the innovation process. The authors also conclude that smaller firms are not, as is often assumed, more capable in leveraging their creativity investments, as larger firms may bring more experience, resources, and related capabilities to do so. Furthermore, successfully converting creative ideas into innovations is relatively easy for individuals who manage to sustain a level of ambidexterity towards the creative process and critical reflection. Managers may be able to instil such a mentality, or identify those individuals with an aptitude to strengthen a firm's innovative capabilities.

3.4.5 The role of rent-seeking activities

Penrose's work on the growth of a modern firm largely then built upon the foundation laid by Schumpeter with respect to the nature of innovation itself. But it also used Schumpeter's theory of profits which distinguished between the two conceptions of profit based on two realms of economic analysis. In the first realm, the traditional conceptions of firm behaviour employed the two concepts of profit maximisation and perfect competition. Here the object of the firm is to maximise profits, and this is done by selecting level of production given demand constraints and cost structures. It is also assumed that a large number of firms operates in the industry and that there are no impediments to new firms entering the industry or existing firms exiting. Hence if some technological development substantially reduces costs and boost profits, new firms will be attracted to the industry and they will compete price downwards to the point where any above normal profits is extinguished. In the long run only normal profits will be earned (those that can be earned in any other market). Above normal profits can only be earned in the short run or where some impediment to the free entry of competitors confers some degree of market power on existing firms to keep prices higher than they would be under perfect competition (cf. Cantwell 2002). This view of the firm and market behaviour is consistent with a macroeconomic situation where the circular flow of income is maintained at its current level and firms simply produce the goods and services they have always produced. It is in many ways a static view of the economic system.

Schumpeter, however, challenged this hypothetical state of the perfectly competitive market arguing that it did not exist in reality. His second realm of economic analysis was a much more dynamic one in which novel economic activities generate value-adding productive measures that shake up the circular flow of income by adding new products and markets and making some existing products and markets redundant. This second realm of analysis is thus characterised by his concept of creative destruction[4]. In this realm, the creative process that adds new value to the income stream is a source of profits. Firms earn additional profits by creating new products and new markets ahead of their competitors. But competitors eventually enter these new markets and compete profits away so that the firm must continually engage in the development of new products and markets in order to stay ahead of its competitors and maintain its ability to earn superior profits. In the long run, above normal profits may thus be earned not by the exercise of pure market power in the static sense of impeding competition by the firm's ability to continuously innovate and invent new sources of profit in the face of pressure from its competitors. Profits are thus driven by competition not removed by it. But this view require an understanding of the dynamic nature of the economy and the role of innovation as opposed to the traditionally static neoclassical conception of perfect competition and profit maximisation.

Like Schumpeter, Penrose employs the idea of two realms of profits. The first is the conventional theory of profit maximisation and perfect competition where higher profits can be earned through market power. But, like Schumpeter, Penrose is mainly interested in the second realm where a firm is "*a device for innovation, problem solving and cumulative learning in production, the incentive for which is to generate higher profits through creating new areas of social or productive capability*." This highlights Penrose's theories in two

[4] Cantwell and Fai (1999) and Cantwell (2002) argue that the creative destruction is often misunderstood in the literature. Destruction relates to the disruption caused to the circular flow of income and established market structures while creative process of innovation was cumulative and incremental.

ways. First the firm is a device for learning, posing and solving new problems in its relevant field of expertise and production. Second profits are derived from *adapting* innovation and extending a firm's *resource base* and *technological based capabilities*.

Penrose thus see profits as arising from rent-seeking behaviour in the form of continuous focus on managing the firm's resources and capabilities in a way that generates new markets and revenue streams rather than as a result of standard profit maximising behaviour aor the static exercise of market power.

In summary, both Schumpeter's and Penrose's analysis stressed innovation as a source of profits in contrast to the static neoclassical conceptions of profit maximisation or the exercise of pure market power. Managing a firm thus became an exercise in problem, solving and learning new approaches to engaging with the market power rather than mechanical manipulation of levers to achieve the optimal point or a mathematical profit function. In this conception of firm management science and technology become interdependent tools of the trade (Chandler 1990). Dosi (1982) and Freeman (1987) call this the techno-economic paradigm and argued that due to greater international competition, protected market power was under threat and therefore firms must rely on the more complex combination of technologies to narrowly define their product markets. A by-product of these changes was that it encouraged inter-company cooperation and collaboration to generate learning opportunities, and enabled knowledge spillover between organisations.

3.4.6 The role of competition in innovation

As the analysis of Schumpeter and Penrose highlight, in a competitive and technologically-driven market, a firm can maintain its competitive advantage by continuous development of products or processes, supported by technological expertise or marketing strategy. Competition forces firms to invest in R&D, market testing, and experimentation which produce new lines of product and generate additional profits. Where competition affects R&D investment, Scherer (1967) argues that every firm takes into account its rival's capability, whilst formulating its own strategy.

Kamien and Schwartz (1976) claim that if the number of competitors increases, the optimal time to decide on a strategy to introduce a particular innovation becomes shorter. Making decisions to innovate includes assessing different factors such as: the timing of launching a product or implementing a process, exploring the existing competition, and potential for attracting future competition. The degree of intensity of the competition is dependent upon the timing of a product launch. Loury (1979) argues that establishing policies can provide assistance in controlling the impact of competition and of a firm's R&D. Loury (1979) also presents the view that competition is not socially desirable, as diminishing returns on R&D investment may make innovation prone to failures. He suggests that limiting entry to markets through licensing and patent fee activities would be beneficial to an economy, and would thus improve social welfare outcomes. On the other hand, Stigler (1956) argues that limiting markets improve would decrease competition and in turn decrease innovation.

3.4.7 The knowledge diffusion process

The process of entities learning and disseminating knowledge in an economic context is known as *knowledge diffusion*. The significance of the knowledge-diffusion process, and its impact on the development and implementation of innovation plans, arose from the work of Rogers and Shoemaker (1971). They argued that innovation is all about communication – communication of new ideas and new practices and a major point of differentiation for their work was their emphasis on how firms *perceive* innovation.

The perceived newness of an idea determines an individual's reaction to the innovation. This reaction can be expressed through embracing the idea intellectually and allowing ones knowledge to be expanded, through changes to attitude or through the decision to use that particular idea. Further, reactions to innovation are important as Rogers and Shoemaker (1971) argue that people are naturally afraid of new ideas and are hostile to persons who bring them. Therefore a *change agent*, a person who is responsible for influencing *"innovation-decisions in a direction deemed desirable by the change agency"* (p. 35) is of considerable importance in the innovation process.

Rogers and Shoemaker claim that the innovation-decision process is a continuous process that consists of a series of actions to adopt or reject, and to confirm, a decision that relates to an innovation. They designed and contextualised a four-stage model to understand this process. The facets of this four-stage model are: knowledge, persuasion, decision and confirmation. Knowledge exists in an individual's personal, social, and perceived characteristics where social-cultural variables play an important role in shaping the norms, tolerance deviation and communication of these individuals. Persuasion includes all the perceived characteristics of innovation such as *relative advantage*, *compatibility*, *complexity*, *trialability*, and *observability*. Concerning decision-making, Rogers and Shoemaker argued that their model fitted optional decisions best, but it could be adapted for collective and authoritative decisions with some modification. They developed this model to identify the degree of difference in the nature of decision-making in the case of different types of innovators, such as early adopters and laggards. The confirmation diffusion effect – the cumulative increase in the degree of influence that affects an individual to adopt or reject an innovation in a social system – is described by this model.

Rogers (1962) had previously argued that the intention of a change agent was to ensure that clients understood the implications of an innovation before they thoroughly committed to it. Thus the basis for decision making was a dialogue between change agent and client, while the outcome of adoption never existed. This could be called an authoritative approach to change management. Rogers and Shoemaker (1971) sought to evolve the frontier of thinking from an authoritative approach to a participative approach, targeting the sharing of power and decisions about change with those affected by it (Rogers & Shoemaker 1971, p. 314). A limitation of this approach was that it was found to be valid primarily in Western, rather than in developing countries (Rogers 1983).

It can be further argued that Rogers and Shoemaker (1971) shifted the decision-making process from being close to an ultimate customer (Rogers 1962) to a remote point, by using a change agent, thus those responsible for making change decisions could do so from anywhere in the world. Change agents would implement change, regardless of whether a targeted client expressed or perceived a need for the innovation(s). While Rogers and Shoemaker (1971) argued for the desirability of de-emphasising the authoritative approach, their new approach nevertheless endowed change agents with considerable authority implying *top-down* communication orientation which could also be interpreted being authoritative. Hence, the essence of the participative approach was missing.

Rogers' (1983) third edition of *Diffusion of Innovations* moved away from the four-stage model as well as from the authoritative versus participative distinction. A degree of self-criticism was evident in his argument of using unidirectional and linear diffusion from one-to-many communication: *"many diffusion scholars have conceptualised the diffusion process as one-way persuasion"* (Rogers 1983, pp. xvii-xix). Rogers (1983) described diffusion of two types. The first time of diffusion is when a change agent communicates a new idea to a potential adopter (Rogers 1983, p. xviii). The *"other types of diffusion are more accurately described by a convergence model, in which communication is defined as a process in which the participants create and share information with one another to reach a mutual understanding".* However, he never explicitly clarifies what is meant by this convergence model (Dagron & Tufte 2006). Within the models described by Rogers (1962, 1983; Rogers & Shoemaker 1971) one major contradiction concerns the role of change agents, which was left unresolved.

The knowledge diffusion process aims to create knowledge and learning for both individuals and within social systems, firms and the economy. Within this diffusion process the role of an agent who helps to implement decisions, as well as the person who takes innovation decisions, is of immense importance. This means resistance from either decision maker or an agent could affect the innovative activities undertaken in an organisation. On the other hand, the support of a decision maker and an agent can lead to a continuous flow of novels ideas, from conception to being put into practice. This continuous flow of ideas can become repetitive (Schumpeter 1942) and these repetitive tasks can form a sequence of repetitive activities over time which helps in building patterns within a firm, and therefore can be stored within the knowledge repository of a firm.

3.4.8 Routines and skills developed for innovation

While Rogers concentrated on communicating ideas to a client, Nelson and Winter (1982) looked into the evolution of a firm and how routines, captured through organisational memories, helped in decision making. A decision-making process is a behavioural function that takes into account both rational arguments and learnings from the past. These learnings are created through repeated tasks that further help in developing the skills of individuals, mainly through enhancing tacit knowledge. This process is known as *routinisation* (Nelson & Winter 1982). Routinisation is an important part of storaging the organisation's specific *operational knowledge* and this knowledge represents successful solutions to particular problems (Nelson & Winter 1982, p. 99; Winter 1995, p. 152). The knowledge in routinisation also helps in adaptive learning (i.e., finding solutions to new problems).

Nelson and Winter (1982) argue that the routines of technical, inventory, recruitment, R&D, marketing and business strategy-related skills possessed by the individuals helps in creating adaptive learning. The authors restrict adaptive learning to individuals only, and ignore collective forms of adaptive learning, which limits their analysis. It may be that Nelson and Winter (1982), while determining their theory of economic exchange, ignore the plausible capability of collective processes with regard to innovative learning.

Another important virtue of routines is resistance to change. Nelson and Winter (2002) argue that rationales may be influenced by the change resistance of employees, and this can affect decision-makers' intent to adapt routines. First, the cost of learning and re-learning routines is high and therefore decision makers tend to adhere to prevailing routines. Next, routines are mechanisms to cope with conflicts between people at work and their role is important in an organisation. Departure from routines can provoke resistance (for example between organisation and unions), thereby increasing conflicts. Thus to avoid conflict people stick with old routines.

Further, routines are not about executing tasks in the same manner, rather the question is whether a repeated task is more efficient than the previous one, thus inherently generating novel routines. This means routines include implementing incremental changes in an organisation based on experiential learning that can help in creating novel opportunities. Most importantly, the diffusion of routines, where a company relies on reproducing the same practices, is another important virtue within this process of routinisation.

The process of routinisation reinforces that both knowledge and learning are important factors that contribute towards innovation. While adaptive learning was important for employees, collective adapting learning started to emerge in the literature. This is where a firms' customers co-create learning opportunities.

3.4.9 The role of customers in innovation

Just as Nelson and Winter demonstrated how new innovation-supporting knowledge can be developed by interactions between a firm's employees, von Hippel (1988) argues that interaction between a firm's employees and *customers* can generate such knowledge. By providing feedback to a firm on previous experience with its products, customers can enable a firm's employees to develop ideas or knowledge that can be used to make improvements in these products. Within the management literature, the customer's role is not restricted to demand only, but is treated as a generator and facilitator of innovative activities more generally (von Hippel 1988). Urban and von Hippel (1988), for example, report that 24.3% of a sample of US firms using printed circuit design software either modified or redesigned that software to meet their own particular needs. Morrison, Roberts and von Hippel (2000) report that, from a sample of 102 Australian libraries, 26% of respondents who used software-based library search systems either designed their own system or modified purchased systems.

We saw in section 3.4.5 that a firm's motivation to engage in innovation were the rent-seeking activities, meaning a firm would constantly look out for opportunities for creating novel ideas. Von Hippel (1988), building on Penrose's (1959) work on rent seeking activities, argues that engaging one's customers within innovation processes and learning from their feedback could help these firms commercialise novel ideas created essentially by customers. He argues that customers could be motivated to be part of this innovation process for various reasons (von Hippel 2005):

- They believe that it is often the best, or the only practical, option available to them. Hiding an innovation as a trade secret is unlikely to be successful for long: too many people generally know similar things, and some holders of the *secret* information stand to lose little or nothing by revealing what they know;

- Being involved as a first user to reveal the innovation carries the prestige of being involved in the first inventive product;
- Sharing information with like-minded people within the same community is personally satisfying.

This process of customer engagement benefits firms in two ways. First, innovative adaptions of existing product lines can lock a customer into an on-going relationship with the firm that allows some level of monopoly rent to be built into the price of resulting products. Most importantly, it gives firms ideas that they could develop into innovative products for the creation of rent seeking activities.

In the 1970s, and early 1980s, customers were treated as passive players and their influence on products was limited to that of *buyer*. However, in the late 80s and early 90s there was a significant shift by firms from *selling* towards *helping*, allowing customer feedback to redesign products. In the 1990s, managers realised that building relationships and trust with customers could lead to lifetime bonds. This process became known as *relationship marketing*. The period beyond 2000 saw customers considered as active players. These active players use social media and communication technologies to help redesign products, thus contributing to an *emergent social and cultural fabric* enhancing value for firms that engage with customers in this way. Prahalad & Ramaswamy (2000; 2004) go further to describe customers who provide feedback that leads to some kind of innovation as *co-creators* or supporters of innovation.

Along with the role of customers, social interaction and its collaborative practices became an important component for innovative activities (Rogers 2003). A new theme started to emerge – the importance of collaborative networks, through which novel ideas of new products and processes were easily accessible with the help of technology. Social media, acting as a catalyst between technology and interaction with the public, supported innovation creation. Because these innovations occur in an open space, and leverage knowledge in a social space, whilst increasing competitive advantage, they are known as open innovation.

Open innovation is a new paradigm within the *management of innovation* field. Chesbrough (2004) differentiates between open and closed systems of innovation. A closed system means that every activity that enforces new or improved products or processes is undertaken only within the firm. An open system, on the other hand, involves both inward and outward movements of knowledge across the firm's boundaries in order to undertake innovative activities. Open innovation involves the generation of new ideas that are able to harness lower costs in a short span of time due to the collective use of R&D resources with other organisations. Chesbrough identified a difference between these two systems, and the difference in types of resources and innovations generated through these systems, by studying Procter & Gamble and Xerox Parc. He noted that Procter & Gamble achieved success due to their open system model of sharing knowledge and opportunities with customers, suppliers, and business partners. Xerox Parc, in contrast, followed a closed model and failed to commercialise their inventions (ranging from the computer mouse to graphical user interfaces). Open innovation, it appears, helps to accelerate both internal innovation and the expansion of markets through inflow and outflow of knowledge, assisted by technology (Chesbrough, Vanhaverbeke & West 2008). Technology can be acquired from outside and exploited within an organisation (Lichtenthaler 2008). The factors affecting open innovations are: external knowledge, and technological and market uncertainty (Chesbrough 2004, 2007b).

3.4.10 Summary of the Schumpeterian theories of innovation

Our survey of the evolution of thinking about innovation makes clear that innovation theorists have highlighted a range of drivers that affect innovation. In Schumpeter's early work (1934), the focus was on the entrepreneur whose creativity, ability to think strategically, and capacity for risk-taking enabled him or her to identify new combinations of productive resources that give rise to new products, processes, or markets. In Schumpeter's later work the focus shifted to the de-personalisation of entrepreneurial functions so that big corporations can perform these functions. Penrose (1959) argues for the important role of managers towards innovative activities, given her emphasis on continuous managing of a firm's resources and capabilities in a way that generates new markets and revenue streams.

Both Schumpeter and Penrose pointed to the value of identifying and solving problems faced by the entrepreneur/organisation and capitalising on the knowledge gained in the process. Rogers and Shoemaker (1971) built on this argument and examined the diffusion of knowledge in the innovation process where communication of innovative ideas within the firm is an important factor that underpins continuous innovation. In addition, complementarity with competitors and /or collaborators can improve transfer of knowledge between such external entities and a firm. Von Hippel (1988) stressed the role of the *users* of a firm's products as important contributors to the innovation process. This eventually led to the idea of *open innovation* where customers are co-creators of innovation in partnership with firms (Chesbrough 2006; Prahalad & Ramaswamy 2000).

3.5 Absorptive capacity

The perspectives of economic growth theory and Schumpeterian innovation theory each highlight the importance of technological change, and the characteristics of entrepreneurs, managers and other firm stakeholders, in driving the process of innovation at the firm level. The first of these drivers is external to the majority of firms that exist in the Western economic system. Periodic breakthroughs in technology such as the computer chip, semiconductors, and digital technology have been generated in a small number of firms but represent innovations taken up right across the business world. The second set of drivers focuses on the personal characteristics of business leaders that can lead an individual firm to make profit-enhancing changes to the products it offers or the processes used to produce those products.

The third segment of literature to which consideration is given in this thesis examines how these two drivers of innovation interact with one another. How do the characteristics of personnel within an individual firm allow that firm to make use of externally developed technological breakthroughs and profit-enhancing innovations? The concept developed by Cohen and Levinthal (1990) to describe this interaction of external and internal factors is that of *absorptive capacity* which focuses particularly on a firm's internal ability to comprehend and adapt technical knowledge developed externally to the firm. Cohen and Levinthal (1990) specified three dimensions of a firm's response to the external emergence of new knowledge: *identify*, *assimilate*, and *exploit*.

Identification refers to the ability of an organisation to value knowledge gained through past experience and investments. The routines and processes of a firm that allows them to analyse, process, and interpret any external information, including technological change, helps an organisation to assimilate knowledge. Exploitation covers an organisation's ability to utilise external technological opportunities and knowledge spillovers gained through competitor interdependence. Cohen and Levinthal (1990, p. 139) refers this exploitation as effects of appropriability.

Huang and Rice (2009, p. 213) argue that absorptive capacity contains two elements: *"the ability to identify and access external opportunities, and the ability to assimilate the exogenous know-how and incorporate it into the internal knowledge base".* This suggests that knowledge and learning is created from both internal and external sources, with the former referring to the capability of an organisation to exploit such knowledge whilst putting it into practice. Within the literature, implementation is often referred to as the capabilities of an organisation. This means the implementation part of absorptive capacity helps to turn an original idea into a product or a service, so that ideas can be put into practice to earn rent (Den Hertog, Van der Aa & de Jong 2010).

Other researchers have explored and added new dimensions to this model. Zahra and George (2002), for example, define absorptive capacity as *"a set of organisational routines and processes by which firms acquire, assimilate, transform and exploit knowledge to produce a dynamic organisational capability"*. Note their addition of the word *transform* to this definition. According to Zahra and George (2002) the capability to transform arises from a *bisociation process* where two incongruous sets of information (existing and acquired knowledge) are combined to arrive at a new schema of capabilities. Thus the process of transformation can help a firm to both facilitate recognition of opportunities as well as alter ways to see itself in a competitive landscape. Another aspect of Zahra and George's (2002) definition is a focus on the process of knowledge creation as becoming routinised in organisations, which is consistent with the arguments of Nelson and Winter (1982) and Winter (1995). A routinised process as discussed in section 3.4.8 helps in creating a repository of knowledge which could assist in the creation of novel ideas and in improving existing tasks (Nelson & Winter 1982; Winter 2003).

Lane and Lubatkin (1998) reconceptualised Cohen and Levinthal's firm-level construct of absorptive capacity as a *learning* construct and argued that inter-organisational learning within organisations is an important factor in that the knowledge capacity of an organisation increases. While others such as Cassiman and Veugelers (2006) and Vega-Jurado et al. (2008) found that the complementarity effect of external sources of technical expertise, combined with in-house R&D activities, helps in generating successful innovation outcomes. External knowledge spillovers help to gain freely available public information from patents, publications, conferences, customers and suppliers. This means that in-house R&D is stimulated by, and capitalises on, these knowledge spillovers, while acquisition of external knowledge helps in a better understanding of the technology in the market (Cassiman & Veugelers 2006, p. 77).

Escribano, Fosfuri and Tribó (2009) high levels of absorptive capacity in a firm help to manage external knowledge more efficiently, thus generating innovation outcomes based on a study of 2265 Spanish firms. They find that absorptive capacity was a source of competitive advantage in terms of growing *turbulent knowledge* and strong intellectual property rights protection. Knowledge is critical to innovation as is the environment within which such knowledge grows: this can vary from stable to turbulent environments. The distinction between these environments is based on the relative importance of exploration and exploitation of learning processes within them (March 1991). *Exploration* means developing new routines by using scarce resources, and this is a risky and experimental process which can increase skills but reduce the speed of current processes (Crossan 2008; March 1991). *Exploitation*, on the other hand, means learning from the existing routines by using scarce resources, and this process focuses on improving productivity or efficiency, and is less risky and less costly than exploration (Crossan 2008; March 1991). Escribano et al. (2009) argue that in a turbulent environment firms are more active in exploration since the new technical knowledge might be far different from existing knowledge. Therefore, internal R&D becomes of immense importance as it helps a firm to increase its capacity to absorb external knowledge.

Exploration and exploitation of opportunities thus helps in the creation of knowledge and learning (March 1991). Such generated knowledge can be classified under two categories – tacit or explicit. Nonaka and Takeuchi (1995) explicitly codified their knowledge model in terms of exploring how the transfer of individual knowledge occurs within an individual and an organisation. This transfer occurs when the subjective knowledge and practical *know-how* is converted into explicit codified knowledge. On the other hand, Helfat et al. (2007) argue that deployment of capabilities relies more on tacit knowledge, rather than codified knowledge. Thus, it may be appropriate to argue that the intangible forms of knowledge resources form the basis for developing competitive advantage to increase a firm's performance (Newbert 2007).

Escribano et al. (2009) followed the work of van den Bosch et al. (2006). Escribano et al. (2009) added that absorptive capacity helps to achieve competitive advantage and furthermore helped to increase financial performance, innovative performance and new product development and wealth creation. This occurs through the knowledge flows within a firm and learning opportunities created through collaborative alliances within an organisation, as well as with other organisations.

The above discussion suggests that absorptive capacity has been particularly related to the learning that is gained through some areas of science and technology; learning that is frequently patented. However, the concept of absorptive capacity within manufacturing SMEs may be different, as they do not necessarily patent their innovations (Romijn & Albaladejo 2002). As SMEs have limited resources, Porter and Ketels (2003) argue that collaborating through organisational networking can translate into innovative outcomes, and that such collaboration with other enterprises or clusters helps in acquiring new resources, especially new technology in the market. While the literature on absorptive capacity focuses mainly on innovation in large corporations, some work has been done to apply the concept to SMEs. Liao, Welsch and Stoica (2003) were among the first who tested absorptive capacity in SMEs in the USA and argued that the growth-oriented SMEs tend to develop the firm's capabilities through external knowledge acquisition and intra-firm knowledge disseminations. Romijn and Albaladejo (2002) argue that capabilities to innovate are the result of the accumulation of both internal and external inputs of an organisation. The internal inputs include the background and skills of founder(s) or manager(s) and the efforts of these people to improve technology. On the other hand, external sources include the intensity and proximity advantages that relate to networking, and support by the government through policy and regulations (Romijn & Albaladejo 2002, p. 1056). They argue that both inputs interact with each other, which in turn affects the capabilities of a SME to innovate. Teece's (2007) definition on capabilities "*firm's capacity to sense and shape the opportunities and threats, seize opportunities and maintain competitiveness through enhancing, combining, protecting and when necessary, reconfiguring the business enterprise intangible and tangible assets*" (pp.1320-22) , as well as the view of Romijn and Albaladejo (2002), suggests an overlapping of features centred on absorptive capacity and capabilities. Words such as *sensing* and *enhancing* describe building knowledge, while *shaping* and *seizing* opportunities are seen by Teece (2007) as the implementation ability of the knowledge acquired.

Gray (2006, pp. 345, 48) saw the role of absorptive capacity and knowledge management as a prior condition for the successful adoption of innovations and entrepreneurial growth. He argued that technical skills, gained through technical education and training, assist entrepreneurs in managing the growth of their SMEs. Gimeno et al. (1997) and Le (1999) argue that education not only helps to develop skills that can be useful for both owners and employees in the SME sector but assists in in-house knowledge creation.

This section on absorptive capacity has highlighted the importance of knowledge and learning through which factors such as education, training and collaboration contribute to building the capabilities of an organisation. Absorptive capacity links back to the innovation theory discussed previously, in particular because it provides a way of thinking about knowledge diffusion (i.e., perception, absorption, and transformation) on an inter-organisational level. The notion of absorptive capacity thus provides a framework through which new knowledge spreads and interacts with existing ways of knowing and doing, potentially generating innovation in the process. The next section discusses such processes of innovation in the context of small and medium enterprises.

3.6 Innovation in SMEs

The issues considered in the previous sections identify drivers of innovation that affect all firms. However, SMEs face particular challenges with innovation largely because they have limited resources with which to undertake their own R&D and thus are more dependent upon externally generated knowledge than larger firms.

In the late 1980s to the early 1990s Commonwealth nations began to deregulate trade policies. At the same time there was a transition in economic activity from large to small organisations. The role of SMEs, and their contribution to economic growth and development, was therefore crucial to these economies (OECD 1985, 1996). Small businesses started to explore clientele overseas (Ross 2010) and to innovate and contribute towards growth. During the 1990s, large organisations recognised the flexibility that SMEs have, and their less bureaucratic nature (Storey 1994). Therefore it was attractive for large organisations, in the context of innovative design implementation, to have as their own subsidiary a small enterprise entirely funded by them, but performing independent innovation-related activities (Acs & Audretsch 1988).

From a SME perspective, innovation is a strategy for long-term survival focusing on enhancing competitiveness and no longer limited to the reduction of cost related to short-term decisions (Department of Innovation Industry Science and Research 2011; Laforet & Tann 2006). For the long-term survival of SMEs, their innovation capacity needs to be raised. Innovation capacity is the potential of an enterprise to produce innovative outcomes such as product and process innovations through the capabilities of its employees (including managers and owners), and to recognise, assimilate, and apply that knowledge (Prajogo & Ahmed 2006).

The roots of the theories of innovation in SMEs are based in management and economics. Some of the SME growth factors explored within the management field include the resource-based view (Penrose 1959, 2009), an examination of the contribution of an owner/entrepreneur (Gibb & Davies 1990), managers' skills (Smallbone, Leig & North 1995), knowledge and learning (McAdam & Armstrong 2001; O'Regan, Ghobadian & Gallear 2006), and networks with outside institutions (Bougrain & Haudeville 2002; Gibb & Davies 1990). The theory of innovation in SMEs is also underpinned by endogenous growth theory, where innovative activities occur inside an economy facilitated by human capital, knowledge, and learning and other resources of a firm, which in turn determine innovation output. For this research, innovation output is a dependent variable, while all the above factors that contribute to growth, are independent variables (Romero & Martínez-Román 2012).

Gibb and Davies (1990) were among the first theorists to explore the *small business growth model*. They identified four management approaches that enhanced small business growth: the *personality dominated approach*, the *organisational development approach*, the *business management approach*, and the *sectoral and broader market approach*. In the first approach, Gibbs and Davies assert that within a small business the vision of an entrepreneur is one of a risk taker, planner, organiser, a creative destructor who disrupts the markets with his/her novel ideas, or an arbitrator; and all of these are important to the growth of SMEs. The organisational development approach concentrates on identifying the role of networks, and their impact on the entrepreneurial behaviour, that bridges a gap between personal objectives and business goals. The business management approach involves analysing a firm's financial performance, and its ability to operate at maximum efficiency, in order to understand the rationale of decision-making within SMEs. This approach also focuses on the power of large organisations in the same sector to affect SME markets. Finally, the sectoral and broader market approach takes into account external factors, such as taxation, regulation, and labour relations, and how these affect SME growth.

Gibb and Davies (1990) see these four approaches as interacting with each other rather than existing in isolation. As SMEs are heterogeneous in nature, that is, one firm differs from others in its characteristics and resources (Gibb & Davies 1990; Smallbone et al. 1995), Gibb and Davies realised there was a gap in the literature exploring a single growth theory relating to SMEs. As businesses interact differently with each other under varying circumstances, they acknowledge the difficulty in developing a single theory. Gibb and Davies (1990) identified barriers to growth within a SME, including the structure of the industry, the division of power between large and small enterprises in that industry, and the lack of well-trained labour. They based their findings on large bureaucratic organisations, and given the significant differences in how such organisations operate, their theory on SME growth could be questioned. As they approached the topic from a theoretical perspective, and concentrated on defining the impact of a broad range of growth factors, their work does not provide any empirical evidence.

Storey (1994) provides a comprehensive review of small UK businesses, and focuses on understanding successful UK SMEs so that government policies are informed and effective for both the businesses and the economy. He agrees with Gibb and Davies' (1990) that it is difficult to devise a single growth theory model for a diverse set of firms. The diversity of SMEs requires a diversity of policy responses to encourage SME growth. This could be done by *soft-pedalling initiatives* such as training, information, and simplifying business administration. He emphasises creating a macro-economic technology policy environment that assists SME growth by providing grants and training to existing and start-up firms, and policymaking strategies driven by both external conditions and the internal circumstances of a firm. External conditions according to Storey (1994) are influenced by the sector in which a SME operates, where the sector creates opportunities and constraints for the growth of a firm through both demand and supply. A common theme linking the work of Gibbs and Davies, and Storey, is a concentration on understanding the policy implications within a sector or an economy.

In contrast, Smallbone et al. (1995) describe the characteristics and strategies of high-growth SMEs from a micro-level. These strategies are considered with respect to "*products and markets; production processes; employment and use of labour; changes in ownership; and organisation and management changes*" (p. 45). The research involved interviewing the owners and managers of 307 firms from eight different manufacturing industries during 1979-90 to examine the experience of the group of firms that grew strongly over a ten-year period. The data for 70 high-performance SMEs were compared with that of the other 236 surviving organisations based on rapid growth, firm size by 1990, and financial stability. The results of the study emphasise the importance of the SME industry sector and found that the adaptation of technological change, government funding and external assistance were important SME growth factors, and access to these elements was a characteristic of strongly growing firms. Therefore, Smallbone et al.'s study provides empirical evidence to support Storey's argument of the benefit of government intervention in providing external advice and assistance to SMEs, and financial assistance for their growth. Smallbone et al. (1995) argue that high-growth firms are more likely to introduce new technology than other firms. The growth performance development of eight sectors was studied through variations between product innovations, competitiveness, and type of growth strategies. Smallbone et al. (1995) found that a number of ongoing strategies makes it difficult to manage both products and markets. The most successful firms were ones that had the ability to change from a *production-led strategy* to a *market development strategy*. A market development strategy is influenced by the internal capabilities of a firm and is adjusted according to customer demand, rather than driven by capital or technology. The customer demand was met, in high growth sectors, by controlling costs, improving product quality, and intensifying the use of labour by creating flexible work practices, providing greater incentives, and close supervision.

While growth factors were found to be contributing to innovation in SMEs, none of the theorists (Gibb & Davies 1990; Smallbone et al. 1995; Storey 1994) thematically segregated the different types of innovations in various sectors. This may be due to the difficulty of researching the diversely heterogeneous SMEs, however, it can be argued that a sector-based strategy that focuses on improving productivity or growth, classified under the sector-based innovations, is needed.

Brown (1998) classifies the types of innovation by SMEs in terms of the success achieved with these approaches. He identified the patterns of innovation within SMEs as *economic-oriented*, *organisation-oriented* or *project-oriented*. In the economic-oriented pattern, he contends SMEs, when compared to large enterprises, can be as innovative as big corporations, and with proper strategies and project-oriented teams, can continue their economic growth. An organisation-oriented pattern identifies various ways by which SME owners can enhance performance through networks, regional centres, and explicit strategy development to enhance innovation. The project-oriented pattern focuses on the importance of customers. His research does not classify innovations *per se*, but focuses on classifying the orientations of SMEs towards innovation in terms of finance, networks, and customers.

The typologies of innovation were not limited to Brown's (1998) classification. The more commonly used typologies to study innovation in SMEs have been product and process innovations (Alegre, Lapiedra & Chiva 2006; Axtell et al. 2000; Brown & Eisenhardt 1995; Oke, Burke & Myers 2007), technological innovations (Castro et al. 2010; Dodgson, Gann & Salter 2008; Le Blanc et al. 1997), while Johne (1999), Avermaete et al. (2003) and Varis and Littunen (2010) have suggested market and organisational innovations to traditional product and process innovations to examine relationship between different types of innovation and firms' performance. The discussion on typologies of innovation in SMEs is limited but fascinating for further research. However, this research is conducted to study drivers that affect innovation rather than being limited to typologies. Therefore, other studies exploring drivers or factors that affect innovation were also considered.

McAdam and Armstrong (2001) analyse innovation in Irish SMEs (both manufacturing and services) using ten in-depth case studies. Their study also detail a factor not previously identified as important for innovation in SMEs, namely quality practices. They distinguish quality practices of SMEs from those of large enterprises, and argue that SMEs have a continuous improvement approach rather than a structured approach, such as business excellence models or ISO (International Organisation for Standardisation) standards. Their study also found that encouraging employees to be creative, and to participate in the firm, generated new knowledge used for further improvements. McAdam and Armstrong's (2001) work, recalling that of von Hippel (1988), argues that the role of the customer is as an *arbitrator* for all products and services offered by a SME. Thus, the role of customer feedback is of immense importance in the improvement of quality practices.

One of the weaknesses in McAdams and Armstrong's work is that they fail to outline in their case studies the strategies used by the SMEs to implement creative employee behaviour. Further, the definition of *continuous improvements* is an ambiguous measurement of quality practices.

Bougrain and Haudeville (2002) see the role of managers as an important growth factor of SMEs. These thoughts can be compared to those of Penrose (1959) who considered that managers can be a catalyst for growth of a firm, where management interacts with resources while encouraging continuous growth. Bougrain and Haudeville (2002) characterise SME managers as *institutional agents* who try to strengthen the external networks with large multi-national corporations (MNCs), and public sector companies, in such a way that the scientific and technical capabilities of SMEs are enhanced. These researchers bring a new consideration to the study of the theory of innovation in SMEs by categorising the importance of both the *successes and failures* of innovation. They conclude that there is a positive relationship between innovation success and design-offices or collaborative projects. However, they do not specify how failures can create learning opportunities for new innovative projects, an idea noted previously by Rogers and Shoemaker (1971).

Beaver and Prince (2002) looked at how development of managers and strategic thinking affected SME growth and innovation using a case study methodology in the pharmaceutical and fibre-optics sectors. Utilising these case studies, they focused on determining the principal differences between the two SME sectors engaged in the innovation process. They found the competitive advantage of these SMEs, gained through excellent negotiation, technological expertise and rarity of their available services, was what made them successful. They identified a number of characteristics that seemed to be associated with firms that successfully engaged in profit-making innovations. These were the experience of the SME owner in the same industry, development of new products, accountability of managers for monthly budgets, collaboration, use of ICT for communication with employees, employing people with similar values as the organisation, and understanding their competition. The identified challenges were to maintain their brand in the market, keeping on par with technological change, and redefining the jobs of the existing staff to keep up with the continuous change in the business environment. The reasons for the success of the business model of the fibre-optic SME studied were: the value creation of the product, strategies such as capturing a wider market before providing the right product solutions to specific market segments, and customer feedback to deliver the best quality product. These two SME case studies, showing different characteristics of success, reveal why it is so challenging to determine a single growth formula for SMEs. Further, it could be noted that a new innovation typology – business model innovation – started to emerge within SMEs.

From a strategic perspective, Beaver and Prince (2002; 2004) argue a flat organisational structure and excellent client relationship skills assists in the development of innovations in a SME. Their work supports Storey (1994) that governments help to create the macro-economic environment through integrating the different aspects of economic, fiscal, and regulatory realms in the form of policies, which in turn help to facilitate innovation within SMEs (Beaver & Prince 2004, p. 37).

Simpson et al. (2004) added a new cultural perspective to Beaver and Prince's (2002) approach. Simpson et al. (2004) argue that, within a strategic perspective, there is no association between the SME owners/entrepreneurs' or managers' perceived success and the measures they used to design or quantify innovation performance. This indicates that uncountable benefits from innovation may be a demotivating factor for SMEs to involve themselves in innovation. Therefore, adding a cultural lens meant categorising the personal characteristics of owners or managers into *empire builder*, *happiness seeker*, *vision developer*, or *challenge achiever*, along with understanding the contribution of the firm and its management within SME growth. Other characteristics that supported SME-related innovation identified in their research include a collaborative culture, internal communication, and a positive work environment.

Research by Laforet and Tann (2006) supports the argument by Simpson et al. (2004) that the culture in manufacturing SMEs affects the innovativeness of a company. They used ten different indicators to measure this innovativeness. These were: the number of new product ideas, new products, improved products, new or improved processes in the last five years, innovation prize(s), newest product introduced, percentage of sales from the product, the extent to which major customers provide specifications for new product(s), and the level of investment in systems and technology for the office and shopfloor (pp. 368-369). One of the main contributions of the Laforet and Tann (2006) study to the literature on innovations in SMEs is the empirical test that, in this case, showed the importance of the organisation's culture as a promoter for innovation; this can give SMEs an edge as faster innovators over large corporations. The researchers came up to this conclusion through a survey questionnaire sent to 1000 West-Midlands manufacturers. Ninety-five usable responses were collected. The gathered data was divided into two sets, where the top 20% of companies who were high in innovativeness were compared with the rest of the cohort in terms of product innovation management, process and work organisation. The researchers compared higher and lower innovative companies through factors such as culture and ways of working, strategic orientation and process innovation. The companies that are more innovative tend to have higher commitment to innovation, their CEO/owner has a personal commitment to develop new products, processes, and better ways to undertake innovations, and the company provides regular training to their managers. The research also found that, to cultivate innovation, the culture of an organisation has three main elements – project champions, a good working environment, and staff training. The strategic orientation of the more innovative companies included better goal orientation with the company's objectives, and publicly available documents, while process innovation involved better systems and technology, such as computer-aided design and computer-aided manufacturing processes. Other factors such as a lack of bureaucracy, close relations with customers, flexibility to adapt and change quickly, and close analysis of competitors, were determinants that made SMEs more innovative than larger corporations. The emphasis on the importance of the commitment of leaders to innovation was a new dimension explored within the manufacturing SME context.

The findings of Laforet and Tann's study are weakened, to some extent, by their use of the abstract concept of *more innovative* companies and *less innovative* companies. The differentiation is based on questionnaire answers where the first 20% are considered high performing and the lower 80% as being from less innovative companies. How they determined these boundaries in their study is not specified. In addition, Laforet and Tann (2006) tend to focus on internal factors affecting the success of innovations within a firm, while ignoring external factors.

Another study conducted by Kenny and Reedy (2006) focused on identifying the impact of organisational culture on innovation in SMEs. The authors adopted as their dependant variable the *number of new products and services launched in five years*. They had a wider definition of culture, which they divided into two segments: *general organisational culture* and *specific organisational culture*. General organisational culture was measured based on *the existence and familiarity with a company mission statement and R&D aspects of the company*. The specific organisational culture included *a company's innovation strategy, the type of innovation engaged in, and drivers and constraints of innovation.* With such a broad definition, it could be argued that the study was more about factors of innovation rather than just about culture. The more interesting part of this study were the elements which contributed towards innovation: *"commitment to R&D, adequate resources, adequate* *funding, supportive management, technically competent team, good strategic direction and a non-constraining environment"* (p. 137). This study further concluded that the biggest drivers of innovation were the type of markets served (that is both domestic and overseas) and customers. Although this study was conducted at a smaller scale, it shares some similarity with Laforet and Tann's (2006) study, the outcomes of which pointed to customers and having a strategic direction and commitment from a supportive management as the key factors affecting innovative activities of a SME.

The SME literature discussed above such as Bougrain and Haudeville (2002), Beaver and Prince (2002; 2004), Simpson et al. (2004) and Laforet and Tann (2006) tends to focus on innovation drivers internal to the firm. O'Regan et al. (2006) focus on a combination of internal and external factors and their effect on high growth firms. High growth firms are those with at least 30% sales growth over the past three or more consecutive years. A random sampling technique was used to select 802 SMEs out of a possible pool of 15000 electronic/engineering UK SMEs established for over five years. They received a response of 257 usable survey questionnaires. From this, it was concluded that high growth firms are driven more by external features, such as strategic orientation, operating business environment, and e-commerce, than by internal attributes such as new products and processes, firm ownership, and organisational capabilities. O'Regan et al. (2006) further discuss future managerial implications and point out that the sales growth contribution in the past three years for most of the SMEs studied would not be sufficient for them to maintain their competitive advantage as the products offered were at a maturing stage. Thus, the importance of innovation and greater spending on R&D activities is of significant importance for the long-term survival of a SME. Their work provides a holistic, but not exhaustive, view of the factors that affect SMEs, and the relationship between the high growth firms and growth factors was tested. The significance of any failure in knowledge and learning, as a factor in innovation, was not previously tested empirically in SMEs until this study.

Van De Vrande, de Jong, Vanhaverbeke and De Rochemont (2009) follow up this work and look at the importance of knowledge and learning from another context – open innovation within medium-size enterprises. Other key concepts involving knowledge and learning emerged including knowledge acquisition (O'Regan et al. 2006; OECD 2010b), collaboration with external stakeholders (Laforet & Tann 2006; Van De Vrande et al. 2009), and interactive learning processes (OECD 2010b). This refocusing has moved attention away from managing industry competition and onto exploring relationship strategies for users, SME employees, and external stakeholders.

As previously noted, some authors (Penrose 1955; Schumpeter 1942; Teece, Pisano & Shuen 1997) put forth the proposition that the interactions of external factors and internal factors affect innovations, but did not test this empirically. Cassiman and Veugelers (2006) were among the few management theorists to explore the complementarity effect between innovation activities and internal R&D and external knowledge acquisition. Although they tested *knowledge* development and acquisition from internal and external perspectives, this acted as a lead in to developing further theories of interaction.

Cassiman and Veugelers (2006) examined the interactions between a SME's internal resources and externally generated changes in R&D innovation-enhancing knowledge. Their theory was based on the *supermodularity* effect as a performance measure. Supermodularity is a study of complementarities between various activities where the addition of one activity, while the other is already being performed, leads to a higher incremental effect on performance than just adding an activity in isolation. They concluded that complementarity is context specific and the innovation process relies on basic R&D activities that affect the strength of complementarity between various innovation activities. The right context in which these R&D activities are combined is an organisational decision within a firm's innovation process. They adapted this concept of complementarity from Cohen and Levinthal's (1990) treatment of the concept of absorptive capacity.

The networking within organisations creates learning opportunities, while collaborating with outside institutions overcomes the difficulty of limited resources (Mohannak 2007), and assists in creating channels for collaboration (Scott-Kemmis et al. 2007). These institutions can be companies or public research institutions that collaborate through technological cooperation (Bougrain & Haudeville 2002). Knowledge is often localised by the transfer of learning experiences, which involve the transfer of arrangements and relationships that can enable both the learning mechanisms as well as innovative activities (Scott-Kemmis et al. 2007). Collaboration, therefore, is not limited at the firm level, but is also increasingly becoming an important economic agenda in industrialised economies such as Australia, as evidenced in Australian innovation policies and reports (Commonwealth of Australia 2009a, 2009b, 2011, 2012; Cutler 2008; Department of Industry 2014).

Mohannak (2007, p. 238) emphasises the *network of relationships* that influences the capacity of single firms to innovate. The business environment plays an essential role in encouraging networks to cooperate so that innovative activities can be undertaken. Mohannak (2007) examined innovation networks in high-technology Australian SMEs to explore how organisational linkages adopted by small businesses helps them to learn, adapt and innovate. He studied the importance of tacit and explicit knowledge and its associated process of creation, organisation, diffusion and application, using two key concepts for SME development: knowledge clusters and cooperation networks. These concepts recognise that the promotion of the regional development of an economy, and technological innovations, are important for improved innovation. Whilst using the network-based approach, Mohannak argues that networks facilitate interactive learning and assist in activating, diffusing, and generating knowledge so the innovative capacity and capability of a single firm increases. He supports the fact that the knowledge-based economy is essential for undertaking innovations, as also proposed by Drucker (1999a) and Romer (1990). A sample from 44 biotechnology companies in Sydney and 48 Information Communication and Technology (ICT) firms in Melbourne was chosen for the study. Findings from a structured questionnaire mapped the *perceived* importance of innovation, associated linkages, and cooperative networks. The link between the Rogers (2003) study and Mohannak's (2007) study is obvious – the innovation process is understood as a *perceived* perspective – but the former perceives it from a customer's view and the latter from a manager's or owner's view. Another commonality between Mohannak and other studies (O'Regan, Ghobadian & Gallear 2006; Simpson, Tuck & Bellamy 2004; von Hippel 1988) was the idea of collaboration. Mohannak (2007) sees collaboration with customers, suppliers, universities, and training institutions as assisting both regional policy makers and firm managers to effectively make decisions so that competitive capabilities are promoted. Customers, suppliers, and SMEs can be geographically dispersed, yet maintain their relationship intact through tacit knowledge captured when dealing with partners face-to-face. Interactions with universities and other networks tend to occur in closer vicinity (Mohannak 2007).

The collaboration of resources assists SMEs to exploit their internal capabilities and undertake innovations (Bougrain & Haudeville 2002). Collaborative alliances with customers help to effectively use limited resources of a firm (Chesbrough 2004; Chesbrough 2006). This increasing significance of open innovation makes it an essential factor of SME growth to be tested. Collaboration is not limited towards meeting a resource gap, but also assists in creating an understanding of a firm's competitors, customers and suppliers, while raising opportunities for future projects and growth (Sawang & Matthews 2010). Mohannak (2007) noted the networks and tacit knowledge in a SME contribute to innovations, knowledge and learning and thereby leads to SME growth. The resource-based view (Teece 2000, 2009; Teece et al. 1997) tested this significance and concluded a positive relationship between networks and knowledge and learning, although the degree of this relationship needs further inquiry.

Whereas the notion of SME growth was previously limited to exploration of growth factors (Gibb & Davies 1990; McAdam & Armstrong 2001; Mohannak 2007; O'Regan, Ghobadian & Gallear 2006; Smallbone et al. 1995), a study by Huang and Rice (2009) broadened the concept and tested the role of absorptive capacity within an organisation, supporting open innovation. Absorptive capacity reflects the effective integration of the knowledge acquired, and prior knowledge gained, as a way of facilitating open innovation processes in SMEs. The authors describe the role of absorptive capacity through an analogy: *"both a sponge and a sieve attract fluids, but only a sponge, with its strong absorptive nature, can retain fluids for later use"* (Huang & Rice 2009, p. 203). Thus, due to absorptive capacity, both external research activities and in-house R&D help to improve overall knowledge and assist in the development of innovation processes. This argument, where both internal and external knowledge assimilate together and facilitate innovative processes, is similar to the Cassiman and Veugelers (2006) study, although Huang and Rice do not mention the former authors in their study. Huang and Rice also include independent variables other than those noted in the similar studies mentioned above – networks, technology, and absorptive capacity – to obtain a metric of innovation performance measured through R&D intensity.

The Huang and Rice (2009) study of absorptive capacity raises new issues in the theory of innovation in SMEs. One proposition is that, with existing resources of an organisation and availability of external factors, the role of the absorptive capacity of a SME determines not only the process of innovation, but also the types and levels of innovation (see Appendix 3A). This means that if a SME's absorptive capacity – the ability of a firm to identify trends and acquire new technology, so that knowledge and information is explored and exploited (Tidd & Bessant 2011) – is limited, this restricts a SME's ability to innovate. The absorptive capacity of SMEs, therefore, is an important linking factor between growth factors and innovation performance, meriting further exploration.

While previous literature saw a differing influence of internal and external factors on SME innovation and linked them with absorptive capabilities, Romero and Martinez Roman (2012) concentrate on how external and internal factors relate to each other. Like previous studies (Cassiman & Veugelers 2006; Huang & Rice 2009), Romero and Martínez-Román (2012) tested the factors through examining additional determinants of innovation within a small business context. They used cross-sectional data from a survey of 747 self-employed Spanish Andalusian entrepreneurs to measure the impact of 18 potential factors on innovative behaviour. These potential factors were classified into three types: a) personal characteristics of the entrepreneur, b) organisational characteristics of the entrepreneur's firm, and c) characteristics of the business environment within which the firm operates.

Personal characteristics included, among others, the entrepreneur's level of tertiary and business education, the extent of their business experience, and their degree of motivation. Organisational characteristics included the number of employees of the firm, the industrial sector in which the firm operated, the nature of its relationship with clients and suppliers, and the approach to within-firm collaboration. The external environment was measured by the level of provincial income, amongst other metrics.

Romero and Martínez-Román also classified innovative behaviour into three types. Product innovation was measured by a binary variable that took a value of 1, if a new product was produced for sale within the previous three years, and 0 otherwise. Similarly, a process innovation variable took the value of 1 if a new production process had been adopted by the firm within the previous 3 years, and 0 otherwise. If firms have both produced a new product and adopted a new process with the previous 3 years, a third innovation variable took the value of 1, and 0 otherwise. Innovative behaviour is classified previously in the literature as innovation performance (Huang & Rice 2009) or types of innovation. Through regression analysis of the most significant determinants of innovative behaviour, Romero and Martínez-Román found these to be the entrepreneur's level of education and the extent of their intrinsic motivation. These variables have a significantly positive influence on all types of innovative behaviour. Extrinsic motivation has a significantly positive effect on process innovation, but not on the product or combined innovative behaviour. Firms located in high per-capita areas were also more likely to innovate than the firms located in other areas.

Romero and Martínez-Román also examined the relationship between explanatory variables. They found that an entrepreneur's management style is correlated with the level of in-firm cooperation, business planning, and control, although their measure of management style is imprecise. They also found that firm size is positively correlated with provincial per-capita income.

At one point in their analysis Romero and Martínez-Román assume that all explanatory variables are independent of each other, and later find evidence that some explanatory variables are interrelated. These observations raise an important concern about the Romero and Martínez-Román study. If this is correct, it is likely to generate statistical multi-collinearity that will affect the accuracy of the co-efficient estimates in their regressions.

Rosenbusch, Brinckmann and Bausch (2011) examined both internal and external factors that affect the innovation-performance relationship through a meta-analysis of 42 empirical studies conducted on 21,270 SMEs. Within internal factors they found that the potential for innovations in an organisation was maximised by having ambitious goals for a company, efficient resource allocation to maximise value creation, culture, SME proactivity in finding opportunities, effective risk analysis and risk taking. Rosenbusch et al. support the work of Penrose (1954) and argue that the role of a manager was crucial for the allocation of resources. Further, one of the main contributions of their study was that the collective culture of SMEs helps them to commercialise their products and improve them over time. They touched on one of the other dimensions of culture, namely national culture, that supported product innovation diffusion; however, they do not discuss this in detail. The external factors that affected innovation were customers' perception of a higher brand equity, collaboration, and ability to attract high-skilled employees. Their work supports Mohannak (2007) findings on collaboration and they argue that collaboration within an organisation could be more profitable to a SME as it can reduce administrative costs, speed up projects, and enable a SME to build on its capabilities.

Rosenbusch et al. (2011) argue that extensive literature exists on external collaboration but whether such collaboration is effective or not shows mixed results. On one hand, collaborating with external partners can help SMEs to gain market insights, and on the other, it can be challenging to work with different companies because of differences in work styles. Therefore, they argue that radical innovations would be easier to undertake by collaborating internally, while external collaboration was an effective solution for incremental innovations, although the success of innovation is dependent on the type of the external partners and their compatibility with SMEs.

The limitation of the Rosenbusch's et al. (2011) study was that it helped in contextualising variables rather than in explaining processes. It provides an idea of the existing factors, but one of the major limitations of this contribution is that all empirical studies in the meta-analysis measure these variables differently.

Evanschitzky et al. (2012) and Mueller, Rosenbusch and Bausch (2013) conducted a meta-analysis on the importance of national culture for the development and success of new product developments. Although these two meta-analyses did not distinguish between SMEs and large enterprises, their argument was similar to Rosenbusch et al.'s (2011) work. Findings from the meta-analyses indicate that national culture has an ability to affect potential customer behaviour and affects the allocation of resources to exploratory and exploitative innovation projects. Mueller et al. (2013) argue that *"attitudes towards innovation and change and the resulting willingness of actors at various organisational levels … to specific innovation projects are largely determined by national culture"* (p.1608).

While the value of culture was firmly established along with other internal factors such as entrepreneur's education and looking for opportunities, the exact relation between other external and internal factors were not convincing. For example, mixed results were found in regard with the importance of collaboration.

A recent study on the factors that contribute to innovation capabilities in the Australian manufacturing sector identified several innovation drivers among which was the perception and management of quality. Samson and Gloet (2014) used in-depth qualitative comparative cases for which they conducted semi-structured interviews with managers to understand the attributes of innovation and used secondary data when the responses of these managers contradicted previous research findings. Their findings suggest that manufacturing companies that were constantly involved in a *series of innovations* to meet their *business values* were given an overarching holistic and integrated approach called *sustained innovation capability*. The authors found that each case was involved in innovative activities, such as the introduction of new products and/or services, process improvements (for cost reduction), and introduction of new business models and methods. They identified that companies that were involved in innovations were focused on developing solutions to meet customer needs through collaboration and open innovation. A willingness for customers to pay a premium price for their products motivated the firm to develop new solutions. This in turn meant that the focus on total quality management was an important philosophy for the companies interviewed. In addition, the authors observed that a supportive innovation-oriented culture was a reason for organisations to innovate. Several practices were observed that led towards such a culture, including an emphasis on strategic direction by company leaders, and human resource programs to train, develop, and motivate its employees (e.g., through rewards and recognition). This observation was similar to Simpson et al. (2004) and Ramus (2001).

Interestingly, Samson and Gloet (2014, p. 6462) put an emphasis on quality management practices, where doing *right the first time* was a shared philosophy. Their study indicates that quality measurement is done from the supplier's perceptive. This means companies used process improvement as a standard measurement technique with an objective *"to focus strongly on customer outcomes and value creation"* (p. 6463). The observation by Samson and Gloet (2014) that the studied companies measured quality practices from a supplier's perspective rather than a customer's perspective contradicted a previous argument by Drucker (1985a) who states that quality is in the eye of a customer:

> *"'Quality' in a product or service is not what the supplier puts in. It is what the customer gets out and is willing to pay for. A product is not quality because it is hard to make and costs a lot of money, as manufacturers typically believe. That is*

> *incompetence. Customers pay for only for what is of use to them and gives them value. Nothing else constitutes quality" (Drucker 1985a, p. 228).*

Another recent mixed-method study by McAdam, Reid and Shevlin (2014) explored determinants for implementation of innovation in SMEs and emphasised knowledge, total quality management, and culture as several of the main factors which contributed to innovation. They classified the role of a supportive government policy, or government action programs based on mentoring and learning-by-doing, as effective tools to facilitate innovation in SMEs. However, their study focuses on internal drivers that affect innovation rather than external ones. The only external factors they consider are knowledge gained from external networks and the role of government. Another limitation is that, like, Samson and Gloet (2014), they opted to measure the construct *total quality management* through the supplier's perspective rather than a customer's needs. The above studies show exploring quality management practices and related perspectives within a SME is an important factor that could contribute towards innovation.

The study found that SME growth was dependant on the innovation process, which could be further studied under two categories. One category comprises factors internal to a firm, such as: organisational culture; management support for employees to come up with and implement ideas; quality management practices; financial stability; collaborating both internally within an organisation and externally (e.g., similar companies, institutions such as governments or universities); and knowledge of the employees and management gained through education, training, or experience. These internal factors are controllable by the management, for example if they aim to develop and/or encourage ideas which could be implemented. The other type of factor was found to exist external to an SME. This means any changes that occur outside an organisation but can or may have a direct or an indirect impact on the growth of an SME. These factors can be classified as changes in the technology in the same or different industries; changes in customer demands; national culture to innovate; competition; and government policies. Far less research has been conducted at a firm level to gain a thorough understanding of these external factors on SME innovation, however, there is enough evidence from the existing body of knowledge (some of it included in section 3.3) that external factors do contribute to innovative activities and economic growth. When any of the internal or external factors are not favourable towards an SME's growth, these are considered as barriers to innovation (OECD 2010a).

3.7 Summary

The mainstream economics literature established the link between innovation, technological change, productivity improvements and the economic growth of a nation. While the economics literature (as discussed in section 3.3) initially took innovation as a given, and ignored work by Joseph Schumpeter on the role of entrepreneurs, innovation and economic development, a second segment of the literature took up and developed the main themes of Schumpeter's work. This segment fell mainly within the management literature and eventually focused on innovation in large corporations. Innovation in this segment is considered as the outcome of processes that centre around the entrepreneur and the individual firm. In Schumpeter's early work, the focus was on the entrepreneur whose creativity, ability to think strategically, and capacity for risk-taking enabled him or her to identify new combinations of productive resources that give rise to new products, processes, or markets. In Schumpeter's later work the focus shifted to the de-personalisation of entrepreneurial functions so that big corporations can perform these functions. These corporations then motivate their employees to perform particular aspects of the entrepreneurial function identified in Schumpeter Mark I.

This perspective was later developed by Penrose (1955, 1959) who stressed the role of managers in performing entrepreneurial functions and the significance of rent-seeking as a motivation for innovative behaviour. Rogers and Shoemaker (1971) examined the diffusion of knowledge in the innovation process where communication of innovative ideas within the firm is an important factor that underpins continuous innovation. Rogers (2003) reaffirmed that innovation within an organisation is dependent on how knowledge gained externally diffuses within the firm. Nelson and Winter (1982) identified the role of routinisation and adaptive learning within large firms as drivers of *incremental* innovation. Von Hippel (1988) stressed the role of the *users* of a firm's products as important contributors to the innovation process. This eventually led to the idea of *open innovation* where customers are co-creators of innovation in partnership with firms (see Chesbrough 2006).

In the early 1990s, Gibbs and Davies (1990) were seminal in establishing a segment of the innovation literature by shifted attention to the forces driving innovation processes within SMEs. This constituted the second segment of the literature considered in this chapter. Gibbs and Davies pointed out the significance of SMEs for the overall growth performance of an economic system and the relative lack of theoretical attention paid to this aspect of innovation in the literature. They also developed a range of models for how innovation can be fostered to enhance SME growth. The significant literature that grew out of this contribution concentrated on exploring SME growth factors. The factors identified in this literature may be divided into those that are *internal* to the SME and those that are *external*. *Internal* factors include such things as the personal characteristics of SME owners and managers, the organisational characteristics of particular SMEs, knowledge, learning and other human capital resources within the firm, and the availability of finance to facilitate new innovations.

Smallbone et al. (1995), Beck, Demirguc-Kunt and Levine (2005), and Romero and Martínez-Román (2012) provide evidence that the personal characteristics of SME owners and managers, and organisational characteristics of particular SMEs, play an important role in explaining SME innovation. McAdam and Armstrong (2001), Beaver and Prince (2002), O'Regan et al. (2006) and Mohannak (2007) demonstrate that knowledge, learning and other human capital resources within the firm, as well as the availability of finance, improve innovation outcomes. *External* factors include improved technology, knowledge spillovers from improved technology, and tougher competitive environments. Evidence for the importance of these kinds of factors is provided by studies such as Beaver and Prince (2002), Bougrain and Haudeville (2002), and Romero and Martínez-Román (2012), OECD (2005), Lucas (2005) and Lichtenthaler (2008).

While a plethora of studies empirically examined the link between external factors such as technological change, and innovation outcomes on the one hand, and between internal factors and innovation outcomes on the other, less attention has been paid to the way these factors *interact* with each other to produce innovation outcomes. Cohen and Levinthal's (1990) concept of *absorptive capacity* does examine this interaction, and their work has given rise to substantial literature that further investigates absorptive capacity (see, for example, Keller (1996), Lane and Lubatkin (1998), Zahra and George (2002), and Cassiman and Veugelers (2006), among others). However, this concept deals exclusively with the interaction between external *knowledge developments* and internal *knowledge generating and processing capacities*. The interaction between *other* internal and external innovation drivers is completely ignored by this literature. With the exception of Bougrain and Haudeville (2002), Liao et al. (2003) and Muscio (2007) who examine the importance of absorptive capacity for innovation in SMEs, and Huang and Rice (2009) who investigate this issue for Australian SMEs, the literature focuses primarily on large corporations.

As discussed in the previous section there have been only a few studies on the relationship between internal and external factors, apart from knowledge, that drive innovation in Australian manufacturing SMEs. The present review argues the value of such an inquiry. This leads to the main research gap and questions to be further explored for this study:

1) What are the main internal factors that drive innovation in Australian manufacturing SMEs?
2) Do internal factors, including non-knowledge-related factors, mediate the effect of external factors on the degree of innovation that occurs in Australian manufacturing SMEs, and if so, how?

Chapter 4: Building a Conceptual Model of Innovation in Australian SMEs

4.1 Introduction

A key feature of the innovation literature (as discussed in the previous chapter) is its identification of firm characteristics conducive to successful innovation and, more particularly, how the knowledge capabilities of firms, including SMEs, are important drivers of such innovation. These knowledge capabilities are important because they determine the extent to which SMEs are able to make effective use of externally generated technological developments in creating new profit-enhancing products or processes.

As the previous chapter indicated, while some attention has been paid in the absorptive capacity literature to the interaction between external factors and a firm's internal characteristics for generating innovation outcomes, this attention has mainly focused on the *knowledge-related* characteristics of firms, so that the relationship between other internal characteristics and external factors has been largely unexamined. An example of where this kind of internal-external interaction might be important, however, is where a firm's managers create a culture of trust and collaboration within the firm so that ideas about how the use of external developments in technology might enhance the firm's operations are more likely to be developed because employees are given space to take risks without recriminations if their ideas fail. An examination of these internal-external interactions is, therefore, the focus of this thesis.

In this chapter, a model of SME innovation that can be used to explore these interactions is systematically developed. This model requires the identification of specific internal and external innovation drivers for Australian manufacturing SMEs, as well as insight into how these factors might interact. Sections of the literature considered in the previous chapter will be re-visited to provide justification for the construction of this model and a number of subsidiary research questions are developed as part of this process. Sections 4.2, 4.3 and 4.4, therefore, explain innovation outcomes and identify appropriate external and internal factors of relevance for Australian manufacturing SMEs. Section 4.5 then uses the factors identified in the two previous sections to construct the overall model of SME innovation, and Section 4.6 concludes.

4.2 Innovation Outcomes

Innovation outcomes are associated with any resultant activities of an action or a combination of resources undertaken by an individual or an organisation/institution. For SMEs, such outcomes can be classified as any resultant activities that are a combination of its resources, such as financial, human, knowledge, or physical inputs. These innovation outcomes can be tangible such as products, or intangible such as a change in methods or mechanisms in which a particular task can be carried out. The change in methods or mechanisms can be further classified under process, administration, marketing, or business model innovation, where the changes pertain to the related tasks or activities.

The literature review in Chapter 3 suggests that different typologies for innovation are used, namely: product, process, market, administration (Brown & Katz 2011), technological (Zaltman et al. 1973), and business model innovation (Chesbrough 2006; Chesbrough & Rosenbloom 2002; Moser, Wenstrup & Slywotzky 2007; Teece 2010). The literature applies these typologies to measure innovation outcomes (McMahon 2002; Romijn & Albaladejo 2002), innovative activities (Worren, Moore & Cardona 2002), and innovative behaviour (Romero & Martínez-Román 2012). For this study product and process of these typologies were used to measure the innovation outcomes.

Raymond and St-Pierre (2010) conducted a study on innovation in manufacturing SMEs and used product and process innovations as a dependant variable to understand the impact of R&D upon innovation. Product innovations were measured through the average percentage of sales attributed to new or modified products over the last 2 years. For process innovations, production managers were asked to evaluate an organisation's efficiency on a scale of 0-5 (where 0 was no proficiency and 5 was high). Additionally, the evaluations of four product development technologies and five process technologies were used to collect two aggregate measures of process innovations. Their study used a unique approach to measure both product and process innovations, however, the study assumed that all innovations were successful and generated some sort of extra sales or improved efficiency. It can be argued that the aim for any business is that innovative products or services generate extra profits (or lower costs), however, this cannot be the sole measure to account for product or process innovations.

A study by Madrid-Guijarro, Garcia and van Auken (2009) on manufacturing SMEs identified barriers to innovation and restrictions on the competitiveness in a market. This study used questionnaires (with responses measured on a Likert scale of 1 to 5) to study the importance of the innovative activities measured through product, process and management innovation. Product innovation was measured via any changes in products or commercialisation of new products. Similarly, process innovation included changes in the manufacturing processes or acquisition of new equipment. Management innovation measures included changes or improvements in a) management issues, b) purchasing or provisioning, and c) commercial/sales. If the company did not introduce any innovation it was given a value equal to zero. The improvement in the innovation measures brings a subjective view from the respondent for its dependant variables to be successful and hence no innovations which were implemented but failed were accounted.

Having summed up some of the various approaches to measuring innovation outcomes, this thesis adapted the approach used by Romero and Martínez-Román (2012). Similar to their work, this study attempted to observe whether SMEs introduced any product and process innovations, rather than only judging the improvement measures. This does not mean that success of the innovations were not of interest but rather, that facet was covered by a separate question(s). This is further discussed in the following chapter on methodology.

Innovation outcomes are an important part of the process of innovation. For this reason, this section discussed outcomes ahead of other aspects as it will form a key building block of the model to be tested.

4.3 External factors

SMEs operate in a business environment in which they are affected by the external conditions existing outside their enterprise. This business environment is a consequence of many factors including: technological changes (Stock, Greis & Fischer 2002; Tan 2000), competitors' strategies, government initiatives to support SMEs (Storey 1994), and the influence of other economies (OECD 1996, 2009). The innovation literature identifies external conditions, or external *factors*, as those affecting innovation outcomes measured through innovation performance variables (Vega-Jurado et al. 2008). Edwards et al. (2005) argue that the relationship between the innovation performance of SMEs and their external environment, although recognised in literature, lacks empirical evidence, especially in the context of Australian manufacturing SMEs.

Traditionally, external factors have been studied from an economics point of view and treated as structural change. Schumpeter (1942) identified two components of structural change – technological change and competition – both of which affect innovation as well as economic growth. Later, Pasinetti (1981) argued that structural change also includes another dimension, consumer demand, affecting innovation and the economic growth of a nation.

This traditional economics focus was extended, without much change, to the context of management studies.

For this thesis, technological change was chosen as the sole external factor to test the interactions. Its importance has been recognised by ABS, which has extensive data on it in contrast to other measures such as consumer demand. Furthermore, the use of technological change lines up with prior management literature that gave attention to technological change, under the guise of technological adaptation.

This thesis argues that the way technological change is mainly described within management studies is limited to the internal aspect of adaptation, that is, it is assumed that every change in the technology is adapted within an organisation. Rogers (2003) contradicts this mainstream approach through his analysis of adopters of innovation who he classified as: *innovators*, *early adopters*, *early majority*, *late majority*, and *laggards*. As it is not necessary that all SMEs adapt to external change by being innovators or early adopters, measuring technological change through technological adaptation may not be appropriate.

The important issue with respect to technological change and innovation is the *adaptation* of technological change *within* the organisation. Dosi (1982) and Nelson and Winter (1982) treated the state of technological advancements as a major factor affecting the development of innovation processes within various firms across different industry sectors. Others, such as Cohen and Levinthal (1990) and Oerlemans, Meeus and Boekema (1998), identified technological opportunities existing in the external environment as an important factor in generating external knowledge, as well as a mechanism to induce successful innovation performance in a firm. Thus, *how* technological change is adapted within the strategies of a firm affects innovation outcomes.

This study focuses on treating external technological change as separate from internal knowledge acquired/gained, including knowledge spillovers. This is supported by the proposition that technological opportunities or adaptation cannot be included as technological change because, once these opportunities are adapted, they become part of knowledge spillovers. Based on the above evidence, there is a need within the management literature to measure technological change within a broader perspective in order to more accurately account for this change.

Rogers and Shoemaker (1971) argue that innovation is something that is *perceived* as newness by the members of a social system and this is determined through its rate of adoption. Modifying the concept of Rogers and Shoemaker (1971), this study, therefore, argues that technological change is a change that exists outside an organisation, and is perceived by the social system of an organisation (e.g., managers, owners, and employees) as technology-related change.

Technological change can be destructive when not adapted within an appropriate time. This makes it important for a firm to be aware of how it is affected by technological change, as it has the ability to make organisational routines and procedures obsolete, unless SMEs have the ability to exploit this change (Abernathy & Clark 1985; Henderson & Clark 1990; Nelson & Winter 1982). Thus, if SMEs do not adapt to the technological change at a right time, they can be forced to exit the market.

To adapt to technological change SMEs require strategies, as well as capabilities, to facilitate the process of internal reallocation, mobilisation and deployment of resources, in order to sustain their effectiveness and efficiency (Teece 2009). Australia is not a typical technology maker (innovator) or a taker (adopter). It is a primarily a technology integrator that generates, acquires and combines technology to develop new opportunities and solutions to intractable problems, resulting in value-adding to products accessible to its customers (Kennedy 2007, p. 207). To integrate these technologies within normal SME business operations requires competencies of human capital as well as higher-order capabilities (Brown & Fai 2006). According to Scott-Kemmis et al. (2005) these SME competencies include: project management skills and problem-solving skills (of employees and managers); the ability to integrate heterogenous sub-systems; and to manage risk and finances, as well as logistic requirements. This means that in order to foster innovative activties through adapating external technological change, human skills are required within the SMEs.

The adaptation of technological change, as well as the enhancement of competencies, requires the exploitation of existing skills and the knowledge-base, as well as expanding them (March 1991; Miller, Zhao & Calantone 2006). However, SMEs find it challenging to develop and foster these capabilities compared to larger organisations, as motivation alone does not necessarily overcome their resource and capacity limitations (Zhang, Macpherson & Jones 2006). Lawson and Samson (2001, p. 380) state that SMEs require the "*ability to mould and manage multiple capabilities*" in order to adapt to technological change. The capabilities required are not just limited to financing but include exploring a SME's knowledge and exploiting it in such a manner that positive innovative outcomes are generated (O'Regan, Ghobadian & Gallear 2006). This process of knowledge acquisition capabilities and deployment helps to build the absorptive capacity of a SME allowing technological change to be processed (Dixon, Meyer & Day 2007; Lu, Tsang & Peng 2008).

As SMEs are small organisations, not having huge R&D departments, they need a way to capture technological change to increase their capacity to innovate (Commonwealth of Australia 2012). An alternative way to gain the necessary knowledge to adapt the technological change is through external knowledge spillovers. External knowledge spillovers can be achieved through partnering with research institutions, government institutions, or universities (Commonwealth of Australia 2009b, 2012), or through available knowledge in the market (Cassiman & Veugelers 2006).

The above discussion suggests that technological change within SMEs not only contributes towards innovation outcomes, but also assists in knowledge acquisition capabilities. Technological change was measured in two ways. First Solow's (1956) growth account measure in economics can assist here (as discussed in more detail in the chapter 6). Second by focusing on technological opportunities or advancements, the *perception* of individuals of technological change within their industry is captured. These individuals know about the technological change from either their competition, or through changing market (customer) needs, or by studying market fluctuations. The reason for a reluctance to address this, to any extent, in the management field may be due to the difficulty of measuring the external change not adapted to.

The first set of sub-research questions (SRQ) are thus designed to clarify the impact of technological change in Australian manufacturing SMEs. These are:

> SRQ1: Does technological change affect the innovation outcomes of Australian manufacturing SMEs?
>
> SRQ2: How does technological change affect the innovation outcomes of Australian manufacturing SMEs?

4.4 Internal factors

Internal factors entail a group of characteristics that exist within a SME and comprise both personal and organisational dimensions of resources and capabilities. SMEs are entities where individuals collectively try to achieve a common goal through shared practices determined and controlled by the owner-manager (Helfat 2007). Personal dimensions are those characteristics possessed by individuals including owners, managers and employees. These individuals conduct innovative activities to improve capabilities and resources so that opportunities, including the use of internal resources, are explored, as well as exploited, to develop new products to meet market needs.

As implied in the term *knowledge economy*, knowledge is the central driver for a firm to achieve competitiveness (Scott-Kemmis et al. 2007). The actual sources available within an organisation that assist it to innovate are argued to *be* knowledge (Du Plessis 2007). Knowledge is thus abstract and tacit, and is held within the individuals that work for a SME. Knowledge integration involves adding, or creating value, by more actively leveraging the know-how and expertise residing in individual minds. With the increase in the complexity of technologies available, individuals and firms tend to master only narrow areas of technology, thus there is a need for acquiring and coordinating SME-specific knowledge to build a firm's capability to innovate (Teece 2007). The knowledge which results in innovation is either generated within an organisation through the cooperative and coordinated activities within individuals (Scott-Kemmis et al. 2007), or can be acquired from outside an organisation as discussed by Cohen and Levinthal (1990), who labelled this *absorptive capacity*. Absorptive capacity suggest that knowledge is the key factor that drives innovation outcomes and performance (Van Den Bosch et al. 2006).

Huang and Rice (2009, p. 213) argued that a firm's absorptive capacity has two dimensions: there is firstly, the firm's ability to identify and access external learning opportunities which expands the firm's knowledge base; and second, there is the firm's the ability to apply this knowledge in its operations (Den Hertog et al. 2010). Huang and Rice suggest that Australian manufacturing SMEs lack the second component of absorptive capacity.

Romijn and Albaladejo (2002) argue that capabilities to innovate are the result of the accumulation of both internal and external inputs. Internal inputs include the background and skills of a founder or manager(s) and the efforts of these people to improve technology. On the other hand, external sources include the intensity and proximity advantages that relate to networking, and support by the government through policy and regulations (Romijn & Albaladejo 2002, p. 1056). They argue that both inputs interact with each other, which in turn affects the capabilities of a SME to innovate.

In summary, the concept of *absorptive capacity* treats knowledge in terms of an absorption perspective and an application perspective. Knowledge is absorbed from external sources with potentially some development through internal R&D processes and then applied internally to modify firm products or processes. But these internal application dimensions of absorptive capacity are *knowledge-related activities* that focus on how the externally obtained knowledge can be used internally *in a technical sense* to drive innovation. This study explores whether there are *additional* dimensions of this application process that focus on *management-related* dimensions of firm behaviour. It will characterise these two internal aspects of applying externally generated knowledge or technological change as *SME* *knowledge capacity* (the absorptive capacity insight) on the one hand and *SME general implementation capabilities* (the new insight under investigation here) on the other. These are shown in Figure 4-1.

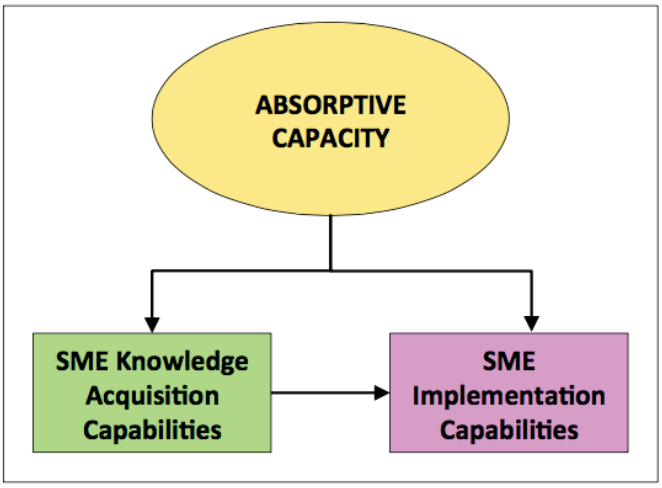

Figure 4-1: Dimensions of internal knowledge application.

4.4.1 SME knowledge acquisition capabilities

In simple terms, the knowledge acquisition of SMEs is the process of collection and storage of knowledge so that the acquired knowledge base facilitates the conduct of innovative activities within the firm. Such knowledge is acquired in various ways: via in-house experimentation; via external acquisition (Cassiman & Veugelers 2006; Scott-Kemmis et al. 2007); or through external knowledge spillovers, that is, when others have carried out R&D activities and the information is publicly available (Cassiman & Veugelers 2006). In-house experimentation is measured through the *number of patents* in the case of large enterprises (Arora & Gambardella 1990), while for SMEs realising internal R&D benefits may be difficult to attain in Australia, and they are more likely to acquire technological opportunities from outside due to their limited resources and capabilities (Kennedy 2007). Hence, acquiring knowledge from external sources is a common practice visible in Australian manufacturing SMEs.

Research tracks chosen by SMEs can be of two types – one is a purely idiosyncratic R&D approach to innovation where firms offset exogenous knowledge spillovers (Kamien & Zang 2000), while the other is the choice to acquire from outside (Kamien & Zang 2000) – where both aim to build implementation abilities. The aim of both research tracks is not only to build knowledge in a SME, but also to support each other, thus to enhance, assimilate, and exploit knowledge, as argued by Cohen and Levinthal (1990).

Further, as knowledge is retained in individuals, especially when it is difficult to codify, these individuals may be treated as *carriers of knowledge* on behalf of their respective enterprises (Kim, Hwang & Suh 2003; Soosay & Hyland 2008). Because SMEs are relatively small enterprises, they are able to coordinate activities with their employees so that technological transformation (change) is accepted within the firm. As SMEs do not often patent, any knowledge creation by employees represents a knowledge layer of the organisation itself. Hence, to explore knowledge acquisition, it is necessary to understand how this knowledge is developed within both individuals and organisations.

4.4.1.1 Education

The benefits of education are not limited to building positive returns for both wage earners and entrepreneurs (Block, Hoogerheide & Thurik 2013). It is also considered to be a major driver for business success (Lussier & Pfeifer 2001; Maes, Sels & Roodhooft 2005) because it helps in creating a strong skills base which is beneficial for innovation (Leiponen 2005, p. 304) and, in turn, creates profitability through commercialisation. The skills acquired are not limited to technical skills but include management, marketing and people skills. These skills may be possessed by a range of people within the organisation who together help to build knowledge capacity (Gimeno et al. 1997; Le 1999).

Technical skills assist more specifically in building an organisation's resource capacity so that it can undertake R&D activities, adapt external technological change or develop an idea into a well-functioning technology (Iansiti & Clark 1994; Kogut & Zander 1992). Given the expectation that technical skills in manufacturing are required for contemporary machinery and equipment knowledge and expertise, technical knowledge is considered to be a factor for implementing innovative practices.

Business education can also assist in creating capabilities within a SME so that survival strategies can be formulated. While Davidsson and Honig (2003) argue that business education increases the cognitive abilities of the owners of SMEs, ongoing up-skilling through training or learning on the job is equally essential for building this capability (Di Zhang & Bruning 2011). Romero and Martínez-Román (2012) argue that business education gained through entrepreneurship, management and business administration, is essential in developing an employee's capabilities to participate in innovation activities.

To acquire knowledge, skills are necessary, and can be developed not only through formal education, but through training provided on the job or off the job: *learning by doing* or *doing by learning.* Laforet and Tann (2006) argue that expenditure spent on in-house training courses can play an important role in assisting SMEs to innovate. They argue that staff training includes any training provided to middle managers or employees to equip them to operate within a changing environment, essential for success in small organisations. Technical training is one component of this broader definition of training, along with technical education (Freeman 1995). People management skills gained through courses held within or outside an organisation that assist an employee in carrying out SME business, as well as in strategic thinking, is treated as business training or management training.

As knowledge acquisition is generally attained through either education or training, it is argued that any collaboration with other enterprises, such as research institutions or universities, will facilitate knowledge spillovers to the advantage of the SME's knowledge base. This is discussed in the following section.

4.4.1.2 Collaboration

Knowledge and practice are closely linked. Knowledge is often localised by the transfer of learning experiences, which involve the transfer of arrangements and relationships that can enable both the learning mechanisms as well as innovative activities (Scott-Kemmis et al. 2007). Networking within organisations creates learning opportunities, while they cluster with outside institutions to overcome the difficulty of limited resources (Mohannak 2007). Such networks also assist in creating channels for collaboration (Scott-Kemmis et al. 2007). Outside institutions can be companies or public research institutions that collaborate through technological cooperation (Bougrain & Haudeville 2002). Collaboration is not limited to meeting a resource gap, but also helps a firm to understand its competitors, customers and suppliers, while raising opportunities for future projects and growth (Sawang & Matthews 2010). Collaboration, therefore, is not limited to the firm level, but is increasingly becoming an important economic agenda in industrialised economies such as Australia, (Commonwealth of Australia 2009a, 2009b, 2011, 2012; Cutler 2008; Department of Industry 2014). Viewed this way, collaboration helps in building knowledge (Zollo & Winter 2002) and in sharing the risk of failure of innovations (Rosenbusch et al. 2011). In this context, it is important to determine the need for collaboration, and the influence of collaborative practices on a SME's knowledge acquisition capabilities.

The theoretical view of this model entails that education and training helps an SME's employees and managers to not only attain knowledge acquisition capabilities but also helps to mediate any changes in the technology in such a manner that has an indirect impact on innovation outcomes. A change in the technology when it occurs in the external environment can impact on innovation in three different ways. First, it can have a direct impact where a company introduces innovative products or services to sustain its competitive advantage.

The second impact which can be indirect on innovation itself, but can be crucial nonetheless, is that employees and/or managers would use their existing education or training to find solutions or responses in a manner to still secure their market share and competitiveness by choosing to develop a new product or service or by creating mechanisms to add value through their offerings. Third, an SME may choose to educate or train its existing employees such that they can gain extra skills via which they could respond by innovating.

It is further argued that any external technological change impacts an SME to collaborate within or outside their institution to create competitiveness, tap into different markets, develop and implement new ideas. If an SME is usually prone to collaborate with others institutions, then any encountered technological change may motivate an SME to contact its existing collaborative partners or search for new partners to find mechanisms to add value to the services or change their strategy of how to offer their products or which products to offer. Furthermore, internal relations between different departments can also be tightened and/or expanded to develop a product when changes in external technology are experienced. To sustain competitiveness and/or market share would be a motivation to collaborate and thereby produce innovative products and processes. Thus collaboration would have a direct impact on innovation outcomes and it can also have an indirect impact. This indirect impact is the manner in which external technological change and collaboration interact such that innovative outcomes can be generated.

Within the present study, it is argued that knowledge acquired through technical expertise assists in adapting technological or external changes in order for innovation outcomes to be undertaken once the knowledge is put into practice. Sub-research questions 3-5 frame how these ideas may be used in the present study:

SRQ3: Which knowledge acquisition characteristics of Australian manufacturing SMEs affect SME innovation?

SRQ4: Do the knowledge acquisition characteristics of Australian manufacturing SMEs mediate the impact of technological change on SME innovation?

SRQ5: How do the knowledge acquisition characteristics of Australian manufacturing SMEs mediate the impact of technological change on SME innovation?

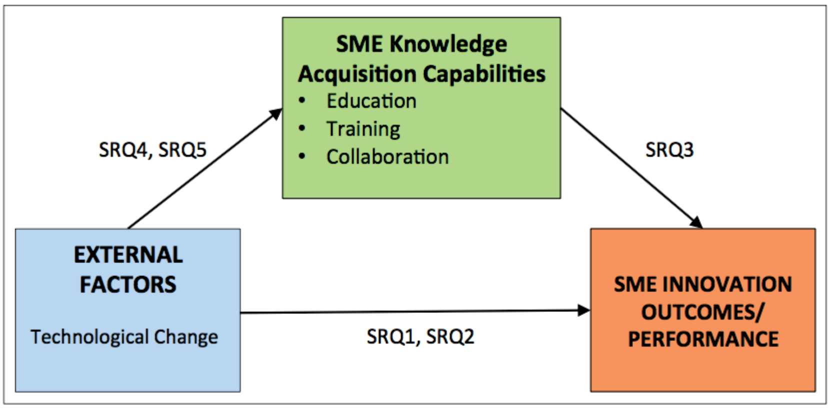

Figure 4-2: Technological change, knowledge capacity and innovation.

4.4.2 SME general implementation capabilities

Lane, Koka and Pathak (2006) developed a model of the sequential process by which SMEs utilise externally-originated knowledge to generate profit-enhancing developments. This process has the following three-stages:

- Recognising and understanding potentially valuable new knowledge outside the firm through exploratory learning;
- Assimilating valuable new knowledge through transformative learning; and
- Using the assimilated knowledge to create new knowledge and commercial outputs through exploitative learning.

This section explores the third component of exploitative learning defined by Lane et al. (2006) where knowledge is put into practice to determine an organisation's *implementation capabilities*. The resource-based view (RBV) recognises that the competitive performance of a firm is comprised of its physical, human and knowledge resources (Eisenhardt 1989). Through the RBV approach, organisations have heterogeneous resources and capabilities to innovate. Similarly, the SME innovation literature has identified heterogeneity of resources and capabilities as underpinning the success of a SME (Smallbone et al. 1995). These resource endowments (or firm-specific assets) are considered to be *sticky*, that is, not easily tradeable due to their tacit nature, and thus the development of a new distinctive resource within a SME is a complex process that consumes time and investment (Scott-Kemmis et al. 2007, p. 37).

To build these resources so that implementation capabilities are enhanced requires use of the available technological or organisational resources. Technology developed internally, or acquired technology, as well as the implementation capabilities of a SME, including skills gained through previous experience or motivation (Romero & Martínez-Román 2012), plus a firm's agility to put the ideas into practice (Sambamurthy, Bharadwaj & Grover 2003) (see Appendix 4A for definitions of agility), are all necessary attributes.

4.4.2.1 Previous experience

Apart from education and training, previous experience is recognised as a contributing factor to innovation in SMEs (Robinson & Sexton 1994; Romero & Martínez-Román 2012; Simpson et al. 2004). Corbett (2007) and Koellinger (2008) both relate that previous experience within a particular field, with the associated accumulation of knowledge, assists in gaining innovative outcomes. Although a large part of the knowledge that is gained through previous experience accounts for the tacit knowledge or unspoken assets (i.e., knowledge that cannot easily be codified) (Tang & Murphy 2012), any learning from previous experiences makes individuals an important asset/resource for undertaking innovation processes (Dosi 1988; OECD 2004). This means that continuous improvements can be attained in existing products from the previous knowledge gained through any incremental innovations (Malerba & Orsenigo 1993).

In this study, it is argued that experience within a work environment not only assists in developing technical know-how, but also assists in maintaining contacts for collaborative alliances to be undertaken later. Experience can also generate learning opportunities from previous innovation successes and failures (Carr 1996). This experience facilitates the implementation capabilities of a SME so that innovative practices can be undertaken.

4.4.2.2 Motivation

Soosay and Hyland (2008), Romero and Martínez-Román (2012) and Sarooghi et al. (2015) argue that manager and leader motivation are important drivers of SME innovation because they set the parameters within which other agents within the firm must operate and because they play an important part in determined the nature of activities valued within the firm. Sarooghi et al. (2015, p. 726) also argue that owners and managers who have an ability to identify talented individuals within the firm, and leverage their efforts, could gain useful and new ideas for product and process innovations. The literature suggest that there are various ways firm leaders may foster innovative practices. Romero and Martínez-Román (2012, p. 179) found significant evidence in defence of the hypothesis that the motivation and personal attitudes of SME employees, managers, and owners contribute significantly towards innovation outcomes.

Motivation to innovate can be driven by the boredom faced by some employees conducting repetitive activities, which might otherwise decrease a SME's efficiency and the productivity of its employees (Commonwealth of Australia 2012). Work can become boring, but individuals who can learn how to regain motivation (Aalbers, Dolfsma & Koppius 2013) can help SMEs to innovate and collaborate better. Looking at the issue of boredom at work, Löfqvist (2012) conducted a study on SMEs and found that the motivation of individuals to innovate is mainly driven by the owner's or manager's support structures. This support was provided through committing resources devoted to innovations, including funds from customers. Customer requests for new products, or threats to lose customers due to a lack of innovation, or technical feasibility, are some of the factors which can also motivate SMEs to innovate (Johansen & Christiansen 2009; Löfqvist 2012, p. 256). This leads to the taxonomies of motivation: intrinsic and extrinsic. Intrinsic motivation relates to the internal satisfaction of the individuals involved in the innovative practices, while extrinsic motivation is derived through economic rewards (Romero & Martínez-Román 2012). Therefore, both intrinsic as well as extrinsic motivation can have an effect on the process of innovation and associated outcomes.

The above gives an overall view of the personal characteristics possessed by employees, managers, and owners conducive to innovation outcomes. Another, major motivating factor encouraging SMEs to implement their knowledge capacity is the need to be agile in order to market products and services.

4.4.2.3 Marketing agility

Within manufacturing, agility is commonly treated as a guiding principle to measure improvements made by managers. As SME manufacturing industries have limited resources, utilising their resources with agility, that is, with an ability to respond quickly and effectively to suit market demand and assist in building manufacturing capabilities is an important characteristic for SMEs (Brown & Bessant 2003, p. 713). Agility is defined as an organisation's ability to seize competitive market opportunities, detect opportunities for innovation by assembling requisite assets, knowledge, and relationships with *speed,* and *surprise* (Clarke 1995; D'Aveni & Gunther 2007; Teece 2009). According to Van Hoek, Harrison and Christopher (2001, p. 127), *"agility is all about customer responsiveness and mastering market turbulence,"* hence it is an essential ingredient for competitiveness (Yusuf, Sarhadi & Gunasekaran 1999). It is a *multidimensional competence* and gives an ability to excel simultaneously on service quality, delivery, flexibility, and cost (Narasimhan & Das 1999). All the above definitions and meanings of agility suggest that it deals with the speed with which opportunities can be explored while using knowledge, relationships, customer responsiveness, and market turbulence. This means that agility assists in providing *operational flexibilit*y to an organisation, defined as the ability of individuals within an organisation to adapt to environmental changes with speed and flexibility (Verdú-Jover, Lloréns-Montes & García-Morales 2004).

It is reasonable to consider that all the above definitions focus on speed to respond to a competitive market as a key feature. Under closer examination, it can be argued that agility is speedily looking for opportunities, rather than responding to a market.

Furthermore, the speed and flexibility with which a particular decision to implement acquired knowledge is undertaken is dependent on the owner/upper management and how they manage individuals and the transformation of knowledge. Therefore, it becomes the responsibility of SME upper management to locate opportunities to both innovate and expand products in a speedy manner. This means that the agility of an organisation is dependent on the leadership qualities possessed by the owner/upper management. Similarly, Joiner and Josephs (2007) label agility which requires a leader's mastery in anticipating and initiating change as *leadership agility*. As this chapter's model has already included the skills of SME owners and managers gained through education, training and experience, to avoid double counting, leadership agility was ignored, although its importance is beyond doubt.

Other theorists such as Sambamurthy et al. (2003, pp. 245-46) classified agility into different forms: *customer agility*, *partnering agility*, and *operational agility*. Customer agility is the ability to co-opt customers in exploration and exploitation of innovation opportunities so that innovation ideas can be generated through the co-creation of innovation. Partnering agility involves the "*leverage [of] assets, knowledge and competencies of suppliers, distributors, contract manufacturers, and logistics providers through alliances, partnerships and joint ventures*" (pp. 246). Operational agility focuses on accomplishing speed, accuracy and economic cost effectiveness, whilst exploiting the innovation opportunities.

The ability to exploit knowledge is not limited to resource exploration and exploitation (March 1991), but also includes finding the right opportunities at the right time and proactively responding to these opportunities with speed. Finding the right opportunities is only possible if a SME is able to listen to its customers. Among others, von Hippel (1988), Prahalad and Ramaswamy (2004) have previously discussed the importance of customers and their needs. Considering Sambamurthy et al. (2003), who also focused on co-creation with customers, customer agility is considered a part of this model. The authors further defined customer participation as a source of building agility. Their definition of customer agility is the ability to co-opt customers in exploration and exploitation of innovation opportunities as sources of innovation ideas, co-creators of innovation, and users in testing ideas or helping other users learn about the idea (p. 246). Customer agility also included marketing techniques used to attract and retain customers – thus they are a part of marketing agility.

Marketing agility includes the ability of a SME to market its product with the assistance of its business strategies and knowledge capacity. Traditionally, marketing functions included understanding the external market threats and opportunities, customer needs, and delivering a product so that it reaches the customer at the right time when demand for that product exists in a market (Porter & Ketels 2003).

Within this thesis a more conventional approach is adopted. It identifies demand by exploring opportunities across different sectors, rather than restricting itself to just one sector, and with the opportunities identified bring built on a SME's capabilities. As most SMEs fail to commercialise their products in a manner that attracts customers (Lee et al. 2010), a potentially effective solution is to involve customers in the production and generation of ideas, known as open innovation (Chesbrough 2004). This approach considers feedback from the customers, and innovating through open innovation ideas. Customer feedback is therefore a way to identify opportunities.

Networks (i.e., external linkages) are already included in the model as a part of knowledge acquisition, so they are not also included here as a part of the implementation capability: hence partnership agility was not used as part of this model.

4.4.2.4 SME culture

An organisational culture which embraces change is an essential attribute that assists businesses increase their overall performance (O'Regan, Ghobadian & Gallear 2006; O'Regan, Ghobadian & Sims 2006), especially in changing, and complex, business environments (Cooper 2008). Before exploring the concept of culture in businesses, it is important to understand how culture has been defined in the literature. The more commonly accepted definition of culture by researchers is: *"a shared and learned world of experiences, meanings, values and understandings which inform people and which are expressed, reproduced and communicated in partly symbolic form"* (Alvesson 1993, pp. 2-3).

The cultural aspect within SMEs in this research is influenced by the Smircich (1983) approach. She examined SMEs and discovered two main dimensions of culture. In the first dimension, culture is treated as a variable, which is easy to manipulate and change. Within this dimension culture is seen as a management tool that helps to increase the effectiveness of an organisation (Alvesson 1993). The second dimension takes a holistic view, where organisations are treated as *cultures* themselves, rather than culture being an organisational overlay. In this sense, organisations do not *have* cultures, rather they *are* cultures (Smircich 1983). Following this stance, Alvesson (1993) argues that the objective of cultural studies is not to provide an overview to managers with a set of cultural tools. Rather, the objective is *"to encourage critical reflection on the beliefs, values and understandings"* of the organisation (Alvesson 1993, pp. 6-7). This research adopts the latter holistic approach, in which SME managers and owners aspire to develop an organisational culture where everyone has a similar set of values, an approach also seen in Laforet and Tann (2006).

Culture, and its significance, was the object of studies into SMEs by Simpson et al. (2004) and O'Regan, Ghobadian and Gallear (2006). Both studies noted that collective interactions and collective learning form part of the culture, and this assists in creating innovations in an organisation. In addition to the technical skills possessed by people, the culture of a SME requires its employees to manage power relations, work without autonomy, manage cultural differences, and manage informal hierarchy (Pozzey, Wrigley & Bucolo 2012; Shane 1992). In this way, both employees and managers develop problem-solving skills, creative skills, team work, and external relation skills (Commonwealth of Australia 2009a). Thus, SME culture is shaped by collaboration both within and outside an enterprise.

Innovation culture provides assistance in new product development (Cooper & Kleinschmidt 1995) and encourages organisational creativity and innovation (McLean 2005). The Commonwealth of Australia (2012) also views culture in this way, treating it as a *mind framework* for the workforce members to raise the level of global productivity, and to help survive international competition. National culture, as mentioned in Chapter 3, affects the attitudes of buyers and the diffusion rate of innovations (Mueller et al. 2013; Rosenbusch et al. 2011). However, the studies reported in this thesis do not include national culture for two reasons. First, national culture is a factor external to the organisation. Its inclusion in the analysis complicates the focus on technological change as the prime external factor. Second, as this work studies innovation within a single national culture (Australia) the inclusion of national culture as a variable would not yield comparative nor covariation benefits.

Organisational culture, it is argued, instils a talent mindset (Commonwealth of Australia 2012) and consists of the goals which are set to promote openness and explicitness (Pozzey et al. 2012) for undertaking innovative activities in a SME.

Hall, Melin and Nordqvist (2001, p. 195) view "*beliefs, norms, traditions… shared by all members of the organisation*" as a *consensus* view, and this idea is found in all the innovation literature when discussing culture. As organisations are *complex entities* (O'Keeffe 2006, p. 23), culture itself is also complex in nature. This complexity is due to the competition, conflicts, politicking, domination, or repression that exists in organisations due to conflicting interests, values, beliefs and norms (Alvesson 1993, p. 7). As culture is influenced by social aspects – power, rights, and obligations (Schoenberger 1997), the transfer of these values and beliefs is what builds culture within organisations (Hall et al. 2001).

As the dominant culture in small firms is a result of the influence of its owner(s), SMEs are not only influenced by the personal characteristics of the owner (Di Zhang & Bruning 2011), but are affected by managers (Damanpour & Schneider 2009) and employees (Björk & Magnusson 2009) as they work closely with each other. Beliefs and values are more easily transferable than in large organisations due to the flat operating structures of SMEs, thus the development of cultural patterns in SMEs is much easier. Exploring these cultural patterns, and their effect on the use of internal resources and innovation outcomes, will provide essential information for small businesses.

The Commonwealth of Australia (2012) report claims that, although skills can be easily gained through higher education, instilling an appropriate innovative culture is challenging for SMEs. The scientific, managerial, and creative skills needed to promote innovation in Australia are available widely through Australian universities, which have strong research backgrounds. However, these institutions, like the government, face a challenge in supporting the fragmented SME sector to understand the importance of these skills, and to apply them in creating smarter and more advanced manufacturing projects. The SME culture not only affects innovation outcomes, but, it is argued, also affects the allocation of internal resources and the deployment of strategies to undertake innovations in an effective manner, especially when confronted with external changes.

There are some benefits which SMEs can share as small enterprises. They can have a non-hierarchical structure that allows them to make decisions quickly when introducing or withdrawing new products and processes (Gibb & Davies 1990). Laforet and Tann (2006) emphasise that informal communication, flexibility, lack of bureaucracy, close relations with customers, and a close analysis of competitors are all characteristics that foster a culture for innovation growth, as well as assist in improving a SME's implementation capabilities. Similarly, Laforet (2008) and Romero and Martínez-Román (2012) argue that the flat operating structure of SMEs facilitates innovations and a knowledge-creating environment, as people tend to interact openly.

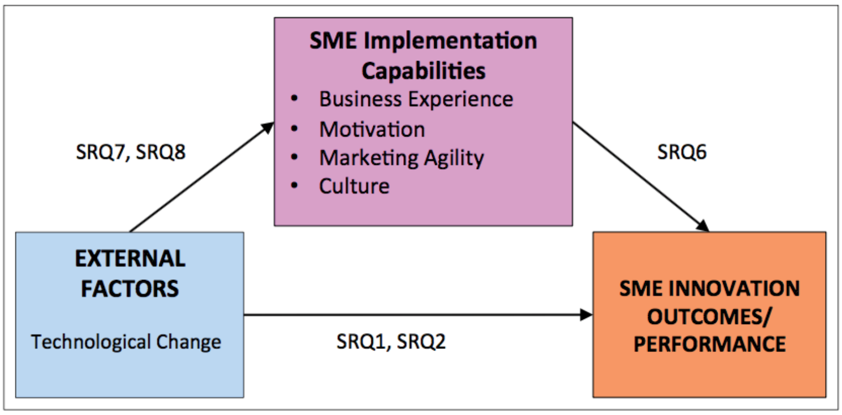

Figure 4-3: Knowledge and innovation outcomes for SMEs.

Thus, a firm's implementation capabilities gained through previous work experience, motivation of individuals to innovate, agility to put ideas into practice, and a culture that supports innovation, all together impact on how innovation knowledge gained is put into practice to create innovation outcomes.

It is argued that apart from a direct impact of the components of implementation capabilities an indirect impact is also possible on innovation outcomes. For instance, when external technological change occurs, the previous experience of employees and managers assist them to make informed decisions or undertake strategies such that new techniques, products, or processes can occur in response to the change. Furthermore, if a change in the external technology interacts with an intrinsic or extrinsic motivation of a manager or employee, this may assist them to see new opportunities to respond (e.g., through generating innovative outcomes). With external technological change, an SME would use its marketing agility to come up with solutions that generate new products, services, or processes that respond to the needs of its customers or tap into new markets. Lastly, technological change could not be adopted until the organisational culture supports the implementation of changes. Thus, the interaction of external technological change and implementation capabilities has an indirect impact on SME innovation outcomes. This leads to our next set of sub-research questions:

SRQ6: Which knowledge implementation characteristics of Australian manufacturing SMEs affect SME innovation?

SRQ7: Do the knowledge implementation characteristics of Australian manufacturing SMEs mediate the impact of technological change on SME innovation?

SRQ8: How do the knowledge implementation characteristics of Australian manufacturing SMEs mediate the impact of technological change on SME innovation?

4.5 Structure of the Model

The above exploration of factors identified in the literature as driving innovation may be combined into a formal model of SME innovation that may then be used to explore the relationship between internal and external innovation factors. A pictorial presentation of this model is presented in Figure 4-4. Our starting point is the idea from absorptive capacity that views SME innovation as being affected by two sorts of factors: *knowledge acquisition capabilities* on the one hand; and *knowledge implementation capabilities* by which the knowledge so acquired is applied within the firm, on the other. The model in Figure 4-4 thus identifies external technological change as an important driver of innovation for the firm on the left hand side of the figure, but the effect of this driver on actual innovation is mediated by the first green box which represents the internal knowledge acquisition and implementation characteristics of the firm identified by the absorptive capacity literature such as education, training and collaboration. But this thesis argues that an *additional* set of firm characteristics needs to be explored in thinking about the mediation of external technological change on SME innovation. This set of forces is represented by the second, darker brown box which captures the effect of other firm characteristics that determine how effectively the knowledge acquired and applied within the firm can be used to develop new products or processes that are profit-enhancing. These characteristics include not only the firm's ability to handle and use knowledge but its ability to position its new products, to motivate its workforce and to create the conditions within which such knowledge can be used *most effectively*. His second set of factors then modifies the outcomes from the knowledge-centred factors in the pink box to generate enhanced innovation outcomes. Thus firms within the *same* sector experiencing the *same* external changes in knowledge and technological change and having the *same* ability to manage and use this knowledge in a technical sense may nonetheless produce *different* innovative outcomes where the firms' owners or managers position the firm differently in the market, motivate their workforce in different ways, take a different view on the appropriate culture to be created within the firm and so on.

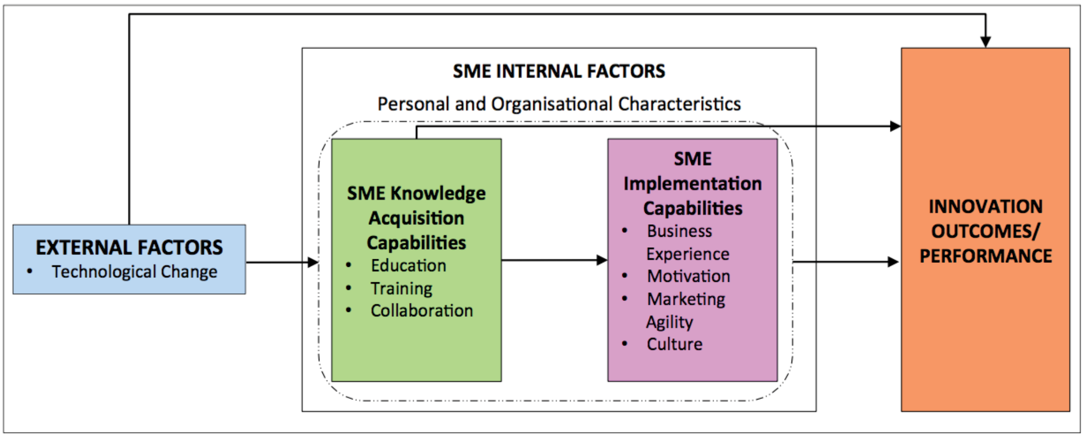

Figure 4-4: Model of SME Innovation (as developed in this chapter).

We may also represent the model in Figure 4-4 in mathematical terms and this is done in equation (4.1). In this equation, Y_i represents the innovation outcomes for each firm i, X_i represents the external technological change experienced by each firm, $\boldsymbol{Z_i}$ is a vector of knowledge-related characteristics for each firm, $\boldsymbol{M_i}$ is a vector of other management-related characteristics for each firm, $\boldsymbol{C_i}$ is a vector of control variables such as firm size and age, ε_i is a random error term, and α, $\beta, \boldsymbol{\gamma}, \boldsymbol{\mu}, \boldsymbol{\nu}, \boldsymbol{\vartheta}$ and $\boldsymbol{\varphi}$ are parameters or vectors of parameters to be estimated.

$$Y_i = \alpha + \beta X_i + \boldsymbol{\gamma Z_i} + \boldsymbol{\mu M_i} + \boldsymbol{\nu C_i} + \boldsymbol{\vartheta}(X_i * \boldsymbol{Z_i}) + \boldsymbol{\varphi}(X_i * \boldsymbol{M_i}) + \varepsilon_i \qquad (4.1)$$

The β parameter captures the direct effect that technological change may have on firm innovation indicated by the arrow in Figure 4-4 that moves upward from the *External Factors* box on the left hand side of the figure around the *SME Internal Factors* box to *Innovative Outcomes* on the right hand side of the figure. This is due to the fact that the state of technology determines the broad parameters within which firms must operate. The γ parameter captures the captures the *knowledge acquisition* aspect of absorptive capacity that internal knowledge acquisition characteristics have on innovation and is shown by the arrow that moves directly from the *SME Knowledge Acquisition and Implementation* box to the *Innovation Outcomes* box in Figure 4-4. The $\boldsymbol{\vartheta}(X_i * \boldsymbol{Z_i})$ term in equation (4.1) captures the *knowledge implementation* dimension of absorptive capacity which is represented by the arrow from the light brown *SME Knowledge Acquisition and Implementation* box in Figure 4-4 towards the *Innovation Outcomes* box. The $\boldsymbol{\mu}$ parameter captures the direct effect of the broader non-knowledge management characteristics of the firm on innovation outcomes. We are particularly interested in the $\boldsymbol{\varphi}$ terms which capture the interactions between technological change and these management characteristics of the firm for determining innovation outcomes.

Equation (4.1) can thus be used to frame the collection of data via an appropriately designed survey and then estimated to test the hypotheses and research questions outlined in this chapter. From the discussion earlier in this chapter we will focus on technological change as the main variable included in the X_i term. The $\boldsymbol{Z_i}$ vector will include various measures of the firm's educational profile including that of its owners, managers and employees more generally with a focus on education and training, and the degree to which the firm collaborates with other parties in acquiring and using knowledge. The $\boldsymbol{M_i}$ vector will include measures of the nature of CEO motivation, the previous experience of firm employees, the degree of the firm's marketing agility, and the nature of the firm's culture with respect to risk-taking and engagement with new ideas.

4.6 Conclusion

This chapter has developed a model of innovation for Australian manufacturing SMEs that can be used to explore the extent to which interaction between internal and external factors are important for SME innovation outcomes in Australian manufacturing. An overall framework was presented, important internal and external innovation drivers identified in the literature were considered for inclusion in the model, and the structure of the model was outlined in diagrammatic and mathematical form. A set of finer sub-research questions was also proposed to complement and facilitate exploration of the central research question outlined earlier in the thesis which focuses on examining the impact of internal-external interactions on SME innovation. The following chapter outlines the methodology that will guide the use of this model in the investigation of this interaction.

Chapter 5: Methodology

5.1 Introduction

The previous chapter developed a formal model of SME innovation that can be used to explore interactions between internal and external drivers in the innovation process. This chapter outlines the methodology to be used in employing this model to explore these interactions. Subsidiary questions were designed to answer the two main research questions:

> 1: What are the main internal factors that drive innovation in Australian manufacturing SMEs?
>
> 2: Do internal factors, including non-knowledge-related factors, mediate the effect of external factors on the degree of innovation that occurs in Australian manufacturing SMEs, and if so, how?

The formal model also outlined a set of sub research questions which will facilitate the exploration of these issues. Specifically, these subsidiary questions were as follows:

> SRQ1: Does technological change affect the innovation outcomes of Australian manufacturing SMEs?
>
> SRQ2: How does technological change affect the innovation outcomes of Australian manufacturing SMEs?
>
> SRQ3: Which knowledge acquisition characteristics of Australian manufacturing SMEs affect SME innovation?
>
> SRQ4: Do the knowledge acquisition characteristics of Australian manufacturing SMEs mediate the impact of technological change on SME innovation?
>
> SRQ5: How do the knowledge acquisition characteristics of Australian manufacturing SMEs mediate the impact of technological change on SME innovation?
>
> SRQ6: Which knowledge implementation characteristics of Australian manufacturing SMEs affect SME innovation?
>
> SRQ7: Do the knowledge implementation characteristics of Australian manufacturing SMEs mediate the impact of technological change on SME innovation?
>
> SRQ8: How do the knowledge implementation characteristics of Australian manufacturing SMEs mediate the impact of technological change on SME innovation?

In this chapter, the model of Chapter 4 and its constituent factors are operationalised alongside a well-founded exposition of the approach and methods employed to answer the above questions. This thesis adopts a mixed methods approach to best capture and cross-validate findings of interest. The sections below provide a detailed examination of this research process.

The *first* section of this chapter discusses why a mixed methods approach was adopted. This discussion is followed by the research design of this thesis.

The *second* section considers the meaning, advantages and disadvantages of using a survey method. It also details the survey design and respondents.

The *third* section examines the case study component of this research. The selection of case studies was based on the survey, where respondents were encouraged to volunteer for further case analysis. The metal and machinery sector was particularly interesting to study because of the structural challenges it faces both in Australia and internationally.

The *last* section of this chapter draws conclusions and summarises the appropriateness of the methodology used for answering the research questions. It also discusses the limitations of this study.

5.2 Mixed methods approach

Quantitative and qualitative methodologies have their strengths and weaknesses. Each also tends to be more suited to answering particular kinds of questions. Rather than choosing a single approach, some research questions suggest that both approaches can be relevant. Combining these methodologies is now common in the literature (Teddlie & Tashakkori 2009, 2010) and has come to be called *mixed methods* research (Creswell 2014; Creswell et al. 2011; Creswell & Plano Clark 2007). Before giving a full justification for using mixed methods in this thesis, the methodological underpinnings of this approach are briefly discussed.

Mixed methods research draws upon two different epistemologies: positivism and constructivism (Table 5-1) (Gray 2009). The first part of the present study uses a *classical science* quantitative method in a deductive manner with appropriate statistical analysis (Kuhn 1962), where reality is explored through the doctrines of natural laws and mechanisms, known as naturalism. The latter developed into positivism, which assumes a universal objective reality underlies all phenomena (Benson 1977; Guba & Lincoln 1994; Hart 1958, p. 619). Positivistic studies are able to measure and predict behaviour based on formal propositions and experimental controls through quantification (Donaldson 1996; Lee 1991). Positivist views help in extracting logical deductions from a data set that is *perfectly* *apprehendable*[5] (Guba & Lincoln 1994, p. 110). However, positivist approaches have limitations, in particular, the inability to study the richness of individuals and their environments (Alvesson & Sköldberg 2009, p. 15; Silverman 2011). The second part of the present study, aimed at identifying interacting factors of innovation, is based on the socially constructed meanings of individuals interviewed at Australian SMEs. This constitutes a constructivist epistemology through the analysis of narratives. Within the constructivist view, social and mental constructions of individuals with their diverse realities of how innovation was conducted in their business was explored through various interpretations (Berger & Luckmann 1966; Veal & Burton 2014). Unlike positivist approaches, constructivists do not believe in a *single* reality but rely on multiple realities (Guba & Lincoln 1994). Thus the present study is influenced by a dualist approach, where two epistemologies are used sequentially in the same research (Gray 2009).

Table 5-1: Different paradigms in research.

Issue	Positivism	Post-positivism	Critical Theory	Constructivism
Ontology	Naïve realism –*real* reality but apprehendable	Critical realism – real reality but only imperfectly and probabilistically apprehendable	Historically realism – virtual reality shaped by social, political, cultural, economic, ethnic, and gender values crystallised over time	Relativism – local and specific constructed realities
Epistemology	Dualist/objectivist; findings true	Modified dualist/objectivist; critical tradition/ community; findings probably true	Transactional/subjectivist; value mediated findings	Transactional/ subjectivist; created findings
Methodology	Experimental/ manipulative; verification of hypothesis; chiefly quantitative methods	Modified experimental/ manipulative; critical multiplism; falsification of hypothesis; may include qualitative methods	Dialogic/dialectic	hermeneutic/dialectic

Source: Adapted from Lincoln and Guba (2000, p. 165).

Positivist and constructivist views are not mutually exclusive as argued by Lakatos (1978) who brings them together under a common umbrella of *critical realism* (Alvesson & Sköldberg 2009; Guba & Lincoln 1994). Table 5-1 positions critical realism relative to other

[5] *Perfectly apprehendable* means perfectly suitable.

approaches. Alvesson and Sköldberg (2009, pp. 47-49) argue that critical realism exhibits a strong tendency to array the world in *objective and sturdy categories,* determined through factual conditions and empirical phenomena. In this research, factors that point towards having a causal relationship are identified through a positivist view while the intervening factors of innovation are understood from a constructivist view. Thus the notion of reality is treated as *actual* rather than objective. To understand the actual reality, an iterative path was taken. Edmondson and Mcmanus (2007, p. 1155) reflect this view in explaining that the "*research journey can be messy and inefficient, fraught with logistical hurdles and unexpected events."*

In mixed methods research two or more methods are employed either concurrently or sequentially (Figure 5-1 and Appendix 5A) with the objective of looking at the phenomena being studied from more than one perspective (Schulenberg 2007). Data is collected in various ways and integrated together within a single study to address the same phenomenon of interest (Creswell & Plano Clark 2007; Creswell et al. 2003; Johnson, Onwuegbuzie & Turner 2007, p. 122; Morse 1991, p. 120). Johnson et al. (2007, p. 113) emphasised that mixed methods is "*an approach to knowledge (theory and practice) that attempts to consider multiple viewpoints, perspectives, positions, and standpoints (always including the standpoints of qualitative and quantitative research)".* The constituent methods in a mixed methods approach can be configured in various ways, with methods concurrent, sequential, or in a nested relationship to each other. These different typologies are further detailed in Appendix 5A and Figure 5-1.

In conclusion, bringing together different modes of doing research through a mixed method approach can deliver a number of theoretical and practical advantages, such as:

- Complementarity of results, where findings from one method assists in seeking elaboration, enhancement, illustration, clarification with the results of the other (Greene, Caracelli & Graham 1989; Molina-Azorín et al. 2012);
- Identifying sample/typical or deviant cases (Sieber 1973);
- Process tracing (Rohlfing & Starke 2013) and examining experiences along with the outcomes of a study (Clark 2010; Plano-Clark et al. 2014);
- To gain rich information (Rossman & Wilson 1985) and access new ways of thinking which emerge from two different sources (Rossman & Wilson 1985);
- *Critical multiplism* where multiple sources of collected evidence help in decreasing the bias of different methods (Collier & Elman 2008; Cook 1985);
- Participant enrichment (Collier & Elman 2008);
- To study complexity of various issues (Creswell et al. 2011).

Some of the listed practical advantages were applicable to this study. The complementarity here came in the form of case studies to provide elaboration and illustration of survey results, in addition to further focus on providing clarity of any results which were not similar. These multiple sources also helped in decreasing a bias in either method, and because the study is about interaction of factors, it was aiming to address the complexity related to them and how this interaction affects innovation outcome.

5.2.1 Applying mixed methods

Having outlined the mixed method approach, this section makes the case for its adoption in the present work. The purpose of this study was not solely to examine the factors that affect innovation outcomes or to explore the phenomena; it was to obtain a comprehensive consideration of the question of *which* and *how* internal factors mediate the effect of external factors on innovative activities, thereby following the approach of (Schulenberg 2007; Silverman 2011).

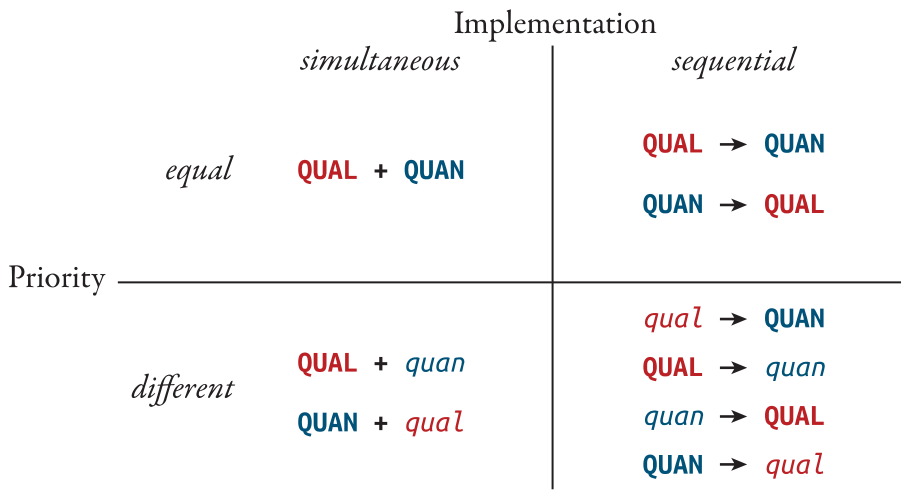

Figure 5-1: Type of mixed methods designs by Molina-Azorin (2012, p. 10).

The main or dominant method appears in capital letters (QUAN, QUAL); the complementary method is in lowercase letters (quan, qual); A + indicates a simultaneous design; → denotes a sequential design.

The best fit methodology for this research was a sequential method where different priorities were accorded to quantitative (quan) and qualitative (QUAL) methods (see also Figure 5-1) (Creswell 2011; Molina-Azorin 2012, p. 10). The quantitative method assisted in *determining* the factors that were important for the Australian context and the relationship between internal and external, while the later qualitative method assisted in *exploring the relationship* between internal and external factors in the process of innovation. The variation in the data helps to answer the questions from different perspectives and to overcome any gaps where one methodology did not provide all the information required. This sequential approach also provided the opportunity to identify and select businesses from the survey responses that were suitable as case studies.

For the quantitative study, the concept of technological change was not well conceptualised in the management literature. However, it was considered that measuring technological change within a sufficient sample would give an indication of how Australian SMEs adapted aspects of innovation within their businesses – the intention of the quantitative study. The quantitative analysis needed data from a number of firms, and this could be provided effectively and economically, and in sufficient quantities, by conducting a survey targeted at a sample of fitting SMEs.

The second aspect of this research is the relationship between internal and external factors as seen through the interpretations of those involved in SME decision making processes and the undertaking of innovative activities. This interest argued for a qualitative approach in which various individual perspectives and beliefs are examined, along with other pieces of information on specific cases. The case studies are not used to verify the preconceived associations and causations gathered through survey analysis, but are used to explore the process of *why* and *how* new products and processes were introduced. Organisational process tracking was a second step for which the qualitative case studies were used in order to explore the phenomena of innovation in the selected businesses (Flyvbjerg 2006).

Mixed methods can provide an opportunity "*to combine case studies and regression in both sequences*" (Rohlfing & Starke 2013, p. 494) thus helping to answer questions from a number of perspectives. Unlike quantitative research approaches, qualitative studies are dependent on the rich information collected through the analytic abilities and decisions of the researcher, rather than the statistical information that represents a population. Decreasing bias was fundamental in the interviews; hence critical multiplism played an important role for this study. Critical multiplism here refers to the idea that differences, and potential downsides, of methods are not ignored or hidden but rather accepted so a complementary whole is delivered (Patry 2013). In particular, qualitative case studies may inherit a bias if, for instance, the CEOs of the studied SMEs chose the interview participants from their employees. Rather than ignoring such potential issues, the inclusion of multiple sources of information within a company (e.g., various interviewees, documents) can alleviate such issues as multiple perspectives may be explored. In this thesis, this multiplism was deemed necessary in each case to study the complexity of innovation processes. In fact, the combination of a quantitative and qualitative method could also be regarded as multiplism, where the strengths of each method supplements and alleviates potential issues in the other. The combination of these methods required a sequential approach, contributing to the research design, as further detailed in the next section.

5.3 Research design

The previous section demonstrated why the present study employed a mixed methods approach. It argued that quantitative data was needed to determine the relative importance of the various internal and external innovation drivers, as identified in the SME literature in the Australian manufacturing context. The previous section also showed why qualitative case study data would be used to identify effective management strategies and government policies to enhance innovation in this sector. This section explains how each aspect of this research was designed.

The quantitative aspect required data on firm level innovations, as well as many of the external and internal drivers of innovation identified in Chapter 3, and developed in the model outlined in Chapter 4. Some of this data was available from the Australian Bureau of Statistics (ABS) but much was not available. Thus, the present work demanded the acquisition of specific data to answer the questions of interest. In fact, most of the relevant studies discussed in Chapter 3 collected firm level data via specifically designed surveys.

Laforet (2008, p. 343) defines survey research as succinct sampling with a purpose to describe the covariation between different variables or to describe patterns amongst the sample (Sapsford 2007, p. 3). Conclusions are aimed to be applicable for the entire population (Babbie 1990, p. 36). The importance of using survey research is explored through various descriptions as summarised in Appendix 5B Table 1, with (dis)advantages covered in Appendix 5B Table 2.

Among prior studies looking into factors affecting innovation, survey research is the most common analytical technique as evidenced from studies by Mohannak (2007); O'Regan, Ghobadian and Gallear (2006); Romero and Martínez-Román (2012); Romijn and Albaladejo (2002). Previous research suggests that a range of internal factors such as personal characteristics which includes education, previous experience, motivation (Romero & Martínez-Román 2012) and organisational characteristics such as knowledge (Beaver & Prince 2002; Cassiman & Veugelers 2006), learning (O'Regan, Ghobadian & Gallear 2006), and culture (Laforet & Tann 2006) affects innovation in manufacturing SMEs. External factors include improved technology, knowledge spillovers from improved technology, and tougher competitive environments. For evidence for the importance of these kinds of factors see studies such as Beaver and Prince (2002), Bougrain and Haudeville (2002), OECD (2005), Leichtenthaler (2008) and Romero and Martínez-Román (2012). Various methodologies were used by Cassiman and Veugelers (2006), Romero and Martínez-Román (2012), Romijn and Albaladejo (2002) who looked at identifying the factors which impacted on innovation. Most used a positivist approach, where every study cited was highly dependent on quantitative surveys. An exception was research by Romijn and Albaladejo (2002), who used both a quantitative survey and interviews to study the impact of various factors on innovation.

For this study, an online survey was chosen to allow participants to complete the survey in their own time. Dillman, Smyth and Christian (2009) argue that surveys are the best medium for answering sensitive information because people tend to provide socially desirable answers when answering a telephone survey or an interview, compared to a self-administered survey. Here, sensitive information relates to the reputation of the business (e.g., to what extend businesses follow competitors, and the success rate of innovations).

In exploring validating factors, and their interactions, that contribute to produce innovation, a deductive approach was employed. Brea et al. (2013, p. 42) argue that survey data helps to validate a variety of explanatory models using readily available software. As it was likely that all the factors known in the literature were not necessarily significant for Australian manufacturing SMEs, this deductive approach could indicate the important factors. Using quantitative survey data is commonly seen as a form of a deductive analysis (Veal & Burton 2014).

The surveys thus assisted in determining whether there existed any association amongst different variables. The data generated from surveys for this research study pointed towards a potential relationship between internal and external factors, and thus helped in the appropriate selection of case studies (Pavitt 1991, p. 882).

The businesses for the case studies were chosen using a range of criteria. These criteria were the number of innovative activities undertaken in the past three years, the number of employees, and attitude towards undertaking innovation captured through a company's vision statement and information on its website. Different cases were explored so that patterns could be identified within a selected case, as well as across different cases. The interpretations of people who represented the chosen cases, and the documents collected such as company accounts, newsletters, and any website information, assisted in qualitative data analysis based on an inductive logic (Veal & Burton 2014). Therefore, the cases helped in producing explanations, rather than previously identified findings from quantitative data analysis, showing the path of process of innovation (Veal & Burton 2014, p. 39). In addition to surveys, qualitative cases helped in exploring the complexity of the processes of innovation in their respective businesses. To explore this complexity, the researcher followed a critical realist paradigm though the analysis. Additionally, as stories of people were captured through interviews, narrative analysis was used for the qualitative interviews. Thus a mixed method methodology similar to Romijn and Albaladejo (2002) was used to identify and explore the relationship between internal and external factors of innovation. The section below encapsulates the major choices made whilst conducting this study. This includes discussion of the unit of analysis, selection of participants for the survey, and selection of SME manufacturing case studies and documents collected during this research.

5.3.1 Unit of analysis and industry selection

Firms as a whole were designated as the unit of analysis. Specifically, the firms chosen were manufacturing small and medium enterprises (SMEs) that were registered with Enterprise Connect, a subsidiary of the *Department of Industry and Science*. As such, many SME employees participated in this study, helping to explore the factors that affect innovation in Australian manufacturing SMEs. This study, as previously discussed, first focused on identifying the interactions between various factors that affect innovation through a survey completed by the owner(s) of the manufacturing SMEs. Subsequently, case studies were selected from the surveyed organisations where owners, managers and some of its employees were interviewed. These people were sought as participants for their involvement and the ability to make decisions in a particular unit.

5.3.2 Contacting firms through *Enterprise Connect*

To answer the main research question, data was sought from firms in the Australian manufacturing sector. First, existing databases were searched and it was found that the *Australian Bureau of Statistics* (ABS) had Business Longitudinal Data which measured innovation indicators at a firm level. This could not be used because it did not cover data on the newly developed construct, *technological change,* which was required to be measured in this study. Therefore, other alternatives were sought.

At the time this study was performed, *Enterprise Connect*, a now defunct subdivision of the *Department of Industry and Science*, operated to connect Australian businesses. Their database of firms in the manufacturing sector covered relevant industries. Some of the relevant criteria for SMEs to be part of *Enterprise Connect* were solvency, possession of adequate resources to undertake innovative activities, and capacity to implement new technologies. The chances of obtaining a good response rate from data collected through

Enterprise Connect database registered firms was thought to be high as these firms were likely to be interested in carrying out innovative activities, and understood its importance.

Participating companies were drawn from the *Department of Industry and Science* database on the condition that a report outlining the findings of this study was provided and the confidentiality of their clients maintained. An agreement was signed with Enterprise Connect and a survey instrument was later sent to companies along with the letter of consent available in *Appendix 5C*. Responding companies were kept anonymous.

An overview of the data collection for this research is presented in Table 5-2. The remainder of this chapter will elucidate the particulars for each method.

Table 5-2: Overview of data sources in this thesis.

		Methods description	Collected data
	Survey	An invitation to participate in a self-administered survey comprising closed and open questions was sent to the owners of Australian manufacturing SMEs.	74 respondents (10.6% of the sample). Responses were gathered over a period of 4 months.
CASE STUDIES	Interviews	Semi-structured interviews (duration 40 min-1.5 hours) of respective case studies. 4 case studies were selected based on the purposeful sampling technique. Company 1, 2 and 3 were personally visited and company 4 interviews were conducted face to face through Skype.	12 interviews (duration 40 min-1.5 hours) of owners or managing directors, managers and employees (10 males and 2 females) who are involved in the development or execution of innovative activities in their respective businesses.
	Documents	Product information, company information and account reports provided by the respective businesses both through hard copies and web based-information.	Web information was available for all the companies. Other documents provided were: **Company 1** – 2 business plans, product information, newsletters, company information and two-year consecutive account statements **Company 2** – Account statements **Company 3** – Company information, product information **Company 4** – Account statements.

5.4 Quantitative method

The quantitative method within this research study was chosen to explore *which* factors are important for the innovation of Australian and if there are any interactions between internal and external factors that affect innovation within these enterprises. For the quantitative method, data were obtained through ABS economics data, and a survey questionnaire designed based on the literature and personal correspondence with three different authors who shared a similar methodology. This section lays out the measures, questions used, and other considerations that went into the quantitative study and design of the survey.

5.4.1 Technological change from statistical data

The previous chapters made the case that technological change within SMEs not only contributes towards innovation outcomes, but also assists in knowledge acquisition. By focusing on technological opportunities or advancements, the *perception* of individuals of technological change within their industry is captured. It is assumed that the difficulty of measuring the external change 'not adapted to' is a reason this has not been addressed previously. To overcome this measurement issue, technological change was measured in two ways. First, through numbers derived from Australian Bureau of Statistics (ABS) data following an economics-based calculation, and second, technological change was captured from a management perspective in survey questions on perceived technological change. The latter is detailed further below under survey measures.

As explained in Chapter 3, technological change has been measured in economics using accounting framework. His model emphasises the importance of technological change for economic growth as this change drives improvements in productivity. Therefore, this thesis adopts Solow's model to measure technological change through a growth accounting measure based on ABS data. The Australian Bureau of Statistics publishes data for industrial sub-sectors that relate to each of the variables, such as labour and capital, and these were used to construct a specific measure of total factor productivity for each Australian manufacturing sub-sector (and this was used as a proxy for external technological change). Thus, this data was acquired separately from the survey data but both were used within the quantitative analysis to evaluate the conceptual model of innovation in SMEs.

5.4.2 Survey sampling

The participants for this survey were CEOs/owners or senior managers of Australian manufacturing SMEs because they are the decision makers with the prime responsibility for setting and controlling the strategic plan or direction for their organisation according to their company's vision (Gioia & Chittipeddi 1991, p. 434). Similarly, Frost, Birkinshaw and Ensign (2002) and O'Regan, Ghobadian and Gallear (2006, p. 35) state that CEOs or chief executives are the ones who have the "*wide breadth of knowledge of all the organisation's functions, activities and operating environments*" and are, therefore, aware of the main drivers of growth in the manufacturing SMEs. Thus owners' perceptions helped to study innovative behaviour practised by their respective businesses in the Australian manufacturing context.

Two structured samples were recruited through convenience sampling. Both of the samples consisted of businesses registered with Enterprise Connect, a subsidiary of the Department of Industry, Innovation and Science. To register with Enterprise Connect, every business had to satisfy the conditions given below.

> 1) possess an Australian Company Number (ACN);
>
> 2) have revenue or expenditure between $1.5 million to $100 million in the current financial year, or one of the two preceding financial years;
>
> 3) have operated in Australia and filed Business Activity Statements showing ongoing trading in at least three full consecutive years;
>
> 4) be in manufacturing and/or a manufacturing-related service business. (An enterprise is also defined as manufacturing or manufacturing-related service enterprise where its predominant business activity is not manufacturing or manufacturing-related service, provided it has an eligible manufacturing or manufacturing-related services division or unit), and;
>
> 5) comply with their obligations under the Workplace Gender Equality Act 2012. Note: This act currently applies to organisations with 100 or more employees only (Enterprise Connect 2013, p. 9).

Participants responded to a request sent by Enterprise Connect to manufacturing businesses in their database for volunteers to participate in a study examining '*innovation in manufacturing companies*.' Contact details of businesses that volunteered to be part of this study were given to the author on two different occasions because the first round resulted in a sample that fell short of the anticipated response rate. However, the survey design was kept the same for both of the received samples.

5.4.3 Survey design

Constructing a questionnaire for this study required careful design strategies with a *litany of cautions* so respondents understood the questions and the terminology used (following Caprara, Barbaranelli & Guido 2001, p. 7). Floyd and Fowler (1998) argue that, although survey design is the least expensive component of the survey process as compared to significantly increasing the sample size or putting effort into improving the response rate (p.343), it is the most significant component within a survey process. Thus the sources of potential errors in previous surveys were examined to reduce the error rate (Sudman & Bradburn 1974). A basic survey design required five main characteristics, as listed below:

- Questions need to be understood consistently
- Questions need to be communicated to respondents consistently
- Unless measuring knowledge is the goal of the question, all respondents should have access to the information needed to answer the question accurately
- Respondents must be willing to provide the answers called for in the question (Floyd & Fowler 1998, p. 344)
- Open-ended questions and any difficult-to-be-answered questions should be avoided to decrease drop-out (Manfreda & Vehovar 2002).

The questionnaire was designed based on the above characteristics and intended to be completed on an individual basis by the CEOs, or owners of the participating Australian manufacturing SMEs. The structure of the final questionnaire is provided in Figure 5.2 (also see Appendix 5D). The questionnaire was influenced by the deductive approach, and was designed based on the literature. A list of variables is provided in Appendix 5E.

5.4.4 Survey measures

After extracting the factors from the literature and the model designed in Chapter 3, the next step was measuring them effectively through a survey questionnaire. The items used by other authors were explored to develop the survey questionnaire, as provided underneath.

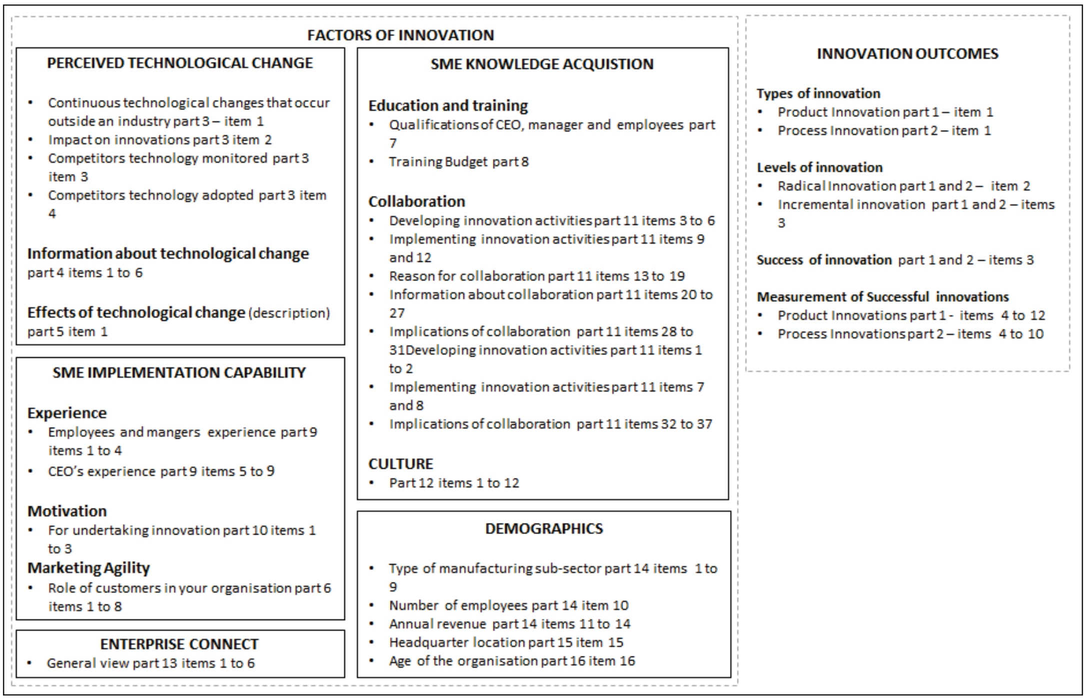

Figure 5-2: Final structure of the questionnaire.

5.4.4.1 Perceived technological change

Separately from calculating technological change from ABS data (section 5.4.1 above), the survey adapted Rogers and Shoemaker's (1971) concept of *perceived* change of the members of a social system of the rate of adaption. Technological change was measured from the perception of the social group of a firm – owners and senior managers – and a Likert scale was used to gauge their perceptions (see Appendix 5F). Thus, perceived technological change was captured via the awareness of SME owners through a series of questions under Part 2 *Technological changes in your organisation* of the survey. The questions were designed to establish whether owners are continuously involved in checking outside technology, especially that adapted by their competitors, their response to competitors technology and where they get their sources of information about technological change. These questions were posed in the questionnaire, questions 7-11. Question 12 was an open-ended question *how does external technological change affect your organisation?*

5.4.4.2 SME knowledge acquisition capabilities

Knowledge acquisition capabilities consists of three sub-constructs – education, training and collaboration –and includes internal linkages within the organisation itself and external linkages with research institutions and universities. The constructs are explored underneath and its operationalisation is shown in Appendix 5G.

a) Education

The skills of employees, managers, and owners, were captured through a proxy measure, namely their level of education. This is in line with prior literature. Leiponen (2005) found that technical skills can be measured through higher technical or natural scientific degrees, while business management educational professional courses, including any management degrees, assist in measuring management skills (Romero & Martínez-Román 2012).

Options were categorised based on the highest level of education attained: high school, TAFE or trade certificate, technical or natural science degree, management degree, degree or diploma related to R&D or other education. For a CEO, the education was categorical while for employees and owners finding an approximate percentage for each category was chosen. The education measure was adapted from Leiponen (2005) and Romero and Martínez-Román (2012) who consider education plays an essential role in undertaking innovations in an organisation. Survey questions 21-23 concerned education.

b) Training

Galende and de la Fuente (2003) note that training can be measured through expenditure on gaining skills. The questionnaire checked the approximate proportion of money spent on technical, marketing, people skills to deal with customers, team work, or on any other training (Survey question 25).

c) Collaboration – internal departments, external links, and mechanisms

To examine the cooperative networks that exist within and outside the SME manufacturing firms, the operationalisation of the collaboration construct was adapted from Bougrain and Haudeville (2002), and Mohannak (2007). The types of networks include: inter-firm networks, suppliers, clients, other firms, professional and technical centres, education institutions (university, technical schools and colleges including business schools), research institutions (such as Commonwealth Scientific and Industrial Research Organisation (CSIRO), other individual partners (such as inventors and designers) and foreign partners. Next, the source of information for collaboration was tested: whether from clients or customers, computer-based information networks, conferences, meetings, journals, fairs and exhibitions, consultancy firms, government/government subsidiary institutions, other non-profit institutions, or patent disclosures. An understanding of whether the source of partnership or collaboration was due to family or personal ties, spatial proximity of the businesses, professional meetings or any other reasons, was investigated. The reasons for undertaking collaborative practices were also sought: whether from the need for technical assistance, marketing/organisational assistance, resource assistance, government assistance, or due to a decision made by the parent company or other reasons (Questions 37-45).

Other collaboration-related questions were adapted from Agarwal and Selen (2009) where the benefits of partnership for the implementation of knowledge for innovation outcomes was queried (Questions 53-58). Following Agarwal and Selen (2009, p. 470), sub-items relating to partnering with suppliers, customers and distributors were also included. These partnering sub-items were: assistance with new governance structures; increased efficiency as measured through new business processes that combine, recombine, and create new business; creating new ways of managing organisational structures and partnerships; and online, rapid and up-to-date communication across partnerships which reduce information discrepancies. In-house partnering was a new dimension added within this survey, with questions on internal collaboration between workers or different departments and its role in the organisation undertaking innovative activities, and in the rapid communication of innovative ideas and strategies to undertake new projects (Questions 46-51).

5.4.4.3 SME general implementation capabilities

The SME implementation capabilities consist of further sub-constructs – business experience, motivation, marketing agility and culture – all of which are further discussed below (also see Appendix 5H).

d) Experience

Experience was measured with a two-scale item – business experience and other experience for owners, employees and managers – based on the work of Romijn and Albaladejo (2002), Harada (2003); (Harada 2004), Caprara et al. (2001) and Marcati, Guido and Peluso (2008). Adapting Romijn and Albaladejo (2002), the previous experience of owners/employees and managers in the same or other sectors was examined (Questions 26-29). The personality traits of owners are affected by their experience in the same or a different sector (Capara et al. 2002; Marcati et al. 2008). Thus an item was developed to capture an owner's experience through his/her personality traits of innovativeness, risk-taking behaviour, and emotional intelligence, to assess his/her involvement in promoting innovative projects (Questions 30-35).

e) Motivation

The construct of the measurement of motivation is something newly captured as a factor that helps in the growth and development of innovative projects in SMEs. Following Reijonen and Komppula (2007), Di Zhang and Bruning (2011), and Romero and Martínez-Román (2012), items were designed to capture the intrinsic and extrinsic motivation that drives owners, managers and employees to conduct innovative activities in a SME (Question 36). Intrinsic motivation includes the need to be considered as the best in the industry or the company, to produce productive resources, improve business performance, or to achieve customer satisfaction or customer relationships (Di Zhang & Bruning 2011). Extrinsic motivation includes economic rewards.

f) Marketing agility

Marketing agility is supported by the ability to respond to the market. Marketing agility is adapted from Morgan (2004) who used this instrument to measure the quality of services. Adapting Morgan's metrics to the manufacturing sector, the dimensions included are: reliability, responsiveness, assurance, and empathy. Reliability is the extent to which the SME performs its services and its customers can depend upon it. Responsiveness includes the SME's willingness to help customers and provide a prompt service. Assurance includes the knowledge and courtesy of individuals (employees and managers) and their ability to be trustworthy and inspire confidence. Empathy is the extent to which the organisation *cares* about its customers (Morgan 2004, p. 469). This is captured in the survey through the questions 13-20. Customer feedback is important for businesses (Prahalad & Ramaswamy 2004) as it can enhance the innovativeness of a business. However, using customer feedback to create products is dependent upon the culture of a SME.

g) Culture

Following Laforet and Tann (2006), the culture construct of beliefs, values, and support by the CEO/owners, was used to measure innovative culture. The support of the CEO/owners was measured through commitment towards innovation, and commitment towards risk-taking behaviour. In addition, the SME's involvement with customer feedback, and any market change, was also included in the culture of the organisation (Questions from 52-63).

5.4.4.4 Innovation outcomes and performance

Innovation outcomes were measured through types of innovation (Appendix 5I) – product, process, and levels of innovation – and radical change or incremental change. Following Romero and Martínez-Román (2012) yes/no questions were asked, such as: *approximately how many product innovations did your organisation introduce in the last three years?* etc. (Question 1 and 4).

To measure performance (see Appendix 5J), questions such as the innovation's success rate were asked, along with the radical nature of the innovation (Questions 2 and 5). These yes/no question were adapted from Soule (1999) and, if a firm's performance was rated as successful, they were asked how they measured their performance. The options included: sales increase, profit increase, turnover increase, innovation speed (Chandy & Tellis 2000), increase in productivity (Alegre et al. 2006), product uniqueness and superiority (Cooper 1979), and newness to the firm (Cooper 1979) (Questions 3 and 6).

5.4.4.5 Demographic questions

Numerous organisational factors can help to differentiate firms. These factors were based on size, number of employees, location of headquarters, revenue earned in either the last or preceding year, and age of the company (Questions 70-76).

5.4.4.6 Enterprise Connect

As the Department of Industry and Science supported this research, and their clients were surveyed, questions queried the use of the support offered by the Department of Industry and Science. By exploring the Australian-manufacturing SMEs who have received the support of government intervention programs, and charting these against those who did not, the effectiveness of such initiatives, investments, and policy decisions made by the Australian government for the economic growth of SMEs can be measured. These questions include: connections to researchers, or industry associations, training, and other sources of funding and advice (Questions 64-69).

5.4.5 First pilot survey

To check whether participants understood the survey design and clarity of the questionnaire, a pilot study was conducted. Fifteen Australian manufacturing SMEs were first approached to participate in the pilot study. In addition, two research methodologists from the University of Technology Sydney were approached to review the design, structure and feasibility of the instrument. Their requests for modification were accommodated without undermining the integrity of the instrument. In the course of accommodating the feedback from the pilot study and survey designers, the outlook of some of the questions was revised so that respondents could select multiple options. Options such as *don't know* or *not applicable* were included. Common feedback concerned the length of the questionnaire, as a result of the number of important innovation factors which needed to be included in this study. A compromise was made on the inclusion of questions, and the time to finish the survey was estimated to be 25-30 minutes. A new survey was submitted to the UTS Human Research Ethics. As there was little difference between the pilot survey and the final survey, no separate copy is provided in the Appendices section.

5.4.5.1 Questionnaire response rate

The intension of having a first pilot survey questionnaire was to get more data, analyse the data response rate and results and then further develop a new survey questionnaire. Although this process was undertaken, but the second and final survey was unable to be launched as the database of these companies were exhausted.

Table 5-3 provides details of the distribution of the questionnaire and the response rate. The response rate was 46% for the pilot and 25.8% for the final. Of these, 74 (41%) were useable responses. A reason for the relatively low response may be the number of questions in the survey instrument, but this could not be avoided due to the high number of factors that needed to be tested in this empirical study.

Table 5-3: Questionnaire distribution and response statistics.

Type	Number Distributed	Response	Reminders	Number Used	Notes/Conditions Imposed
1 Pilot	1	1	0	1	
2 Pilot	14	6	2	6	
Final 1	498	158	5	66	First sample provided by EC.
Final 2	1	1	0	1	Problem in the email address of a participant which was rectified and sent.
Final 3	198	21	0	7	EC gave another sample of manufacturing firms upon request as the previous response rate was low. **Condition imposed by EC:** No reminders would be sent.
Total	697	180		74	Only final numbers included.

5.4.6 Quantitative data analysis

As the second survey questionnaire was unable to be used, so to overcome any endogeneity from the survey questionnaire, some variables were deleted which had any signs of it. The remaining questions were used for the indices. For instance, for *PERC*, questions 7, 9 and 10 were used. For *MAG*, questions 13, 14 and 16 to 20 while *COL* had 38, 39 40, 42, 43, 44 and 46. *CULT* index was formed with the questions 52, 54 to 63.

After the quantitative data were collected, a preliminary analysis was conducted during which the major assumptions and limitations of the various statistical procedures were examined to test the relationship between internal and external factors. *Microsoft Excel 2010* and *SPSS 22* were initially used for the quantitative analysis. First the data was inspected using Microsoft Excel 2010 and eyeballing techniques were used to simply check the respondent rate for each variable. Then the data was imported in SPSS 22.

SPSS was used for the descriptive analysis, where the profile of the respondents was studied by depicting all the variables in a chart, or tabular format or cross tabs, to study their distribution, check for outliers and for correlation with other variables. This was undertaken to gain familiarity with the data while also examining the outliers. An important part of the analysis involved presentation and representation of the descriptive statistics, which further led to other analysis.

The next step was to select variables that would help to improve the predictive accuracy of the models, with product and process innovation as outcome variables. Exploratory factor analysis (EFA) was intended to be used to recognise the main dimensions for constructs (Costello & Osborne 2011).

The exploratory factor analysis technique (EFA), which combines similar variables together into one factor, could not be used due to the relatively low number of observations, (Comrey and Lee (1973)[6]) and most importantly due to high sample (observations) to variable ratio (*N:p* ratio) was not achieved. Hair et al. (1995) argue that this ratio of 20:1 is important while Cattell (1978) cited in Hogarty et al. (2005, p. 203) argued that a minimum of 3:1 ratio is needed for a valid factor analysis (here, the ratio is < 1). This means an alternative technique was required to combine and/or select variables that could be used to evaluate a model with regression analysis. To this end, the concept of indexes was adapted from Acs, Desai and Klapper (2008). Acs et al. (2008) calculated five indexes in their variable measures. They took averages of subindices and then normalised the data.

Indices were formed based on variables that best represented a relation with innovation. Specifically, variables that dealt with an impact on innovation were selected, as were variables that the literature suggested should strongly relate and influence innovation. For example, three indices were formed for marketing agility, culture, and collaboration, based on two variables for each index. To confirm this approach, a significant non-parametric correlation was observed between these variables. When forming an index variable, rather than taking an average of the underlying variables and then normalising the data as used by Acs et al. (2008), here a total of the indices was used to reflect the index value as close as possible to its original values. A description of all selected variables is provided in Table 5-4 (on the next page).

5.4.6.1 Quantitative result validity and reliability

The item scales selected were based on questions and theoretical constructs that have been derived from the literature. As the analysis was conducted with the use of multiple item scales, it is important to assess the validity and the reliability of the scales developed (Gerbing & Anderson 1988).

For reliability of the data, a Cronbach alpha for each construct was calculated (Cronbach 1951). A value of 0.70 alpha is considered as adequate for reliability (Nunnally 1978).

[6] A rough guide as proposed by Comrey and Lee to have an adequate sample size for conducting factor analysis; *100=poor, 200=fair, 300=good, 500=very good, and 1000 or more=excellent.*

Table 5-4: Variable definitions.

Variables	Units Measured	Description
Technological Change Index (PERC)	Likert Scale combined 0-10 Index, where 6 (not applicable) was taken as 0	A composite index, measured through the perception of the owner for any changes observed in the external and direct competitors' technology, with possible likelihood to adopt those changes.
Marketing Agility Index	Likert Scale combined 0-10 Index, where 6 (not applicable) was taken as 0	A composite index, measured through items related to a firm's response to the customer needs and mechanisms used by the firm to meet those needs.
Collaboration Index	Likert Scale combined 0-10 Index, where 6 (not applicable) was taken as 0	A composite index, measured through questions which aim to measure the degree of how often companies collaborated to develop and implement innovations, the reasons why a firm collaborated, and how both internal and external collaborations affected the company.
Culture Index	Likert Scale combined 0-10 Index, where 6 (not applicable) was taken as 0	A composite index, based on items related to how a firm's culture is aligned with their own goals, and the degree of support provided by upper management to its employees (both intrinsically and extrinsically) to participate in getting new ideas and opinions, such that learning experiences are shared amongst the company members.
Training Expenditure	Dollars	The total expenditure for each observation was calculated in the dollar value, where the highest value of the every category chosen by the participant was taken and then summed together as total expenditure for each observation. Therefore, new categories were now divided as 5,000, 15,000, 50,000, 100,000 and 150,000.
CEO's Education	Categories: HS, TAFE, Tech, Management, R&D, Other	The variable was chosen from the survey itself where CEO's education was indicated.
Managers' General Education	Per cent of managers with degree or better	The percentage of managers who had degree level or better were taken together as one value.
Managers' Management Education	Per cent	Per cent of managers' management education
Employees' General Education	Per cent of employees with degree or better	The percentage of employees who had degree level or better were taken together as one value.
Employees' Management Education	Per cent	Per cent of employees with management education.
Value of experience of employees in another sector	Likert Scale (0-6)	This variable had variability as seen in the descriptive statistics uncorrelated with any other variable representing previous experience, hence this variable was chosen.
Motivation for CEO to innovate	3 options (Intrinsic, Extrinsic or Necessity)	As the CEOs were the people who did the survey, only their motivation to innovate variable was chosen.
Number of Innovations (Product)	Number of Innovations	The number of product innovations undertaken by each organisation.
Number of Innovations (Process)	Number of Innovations	The number of process innovations undertaken by each organisation.
Innovations (Product)	Dichotomous, 0 or 1	If an organisation had any product innovations then a number of 1 was given, else 0 was allocated to them.
Innovations (Process)	Dichotomous, 0 or 1	If an organisation had any process innovations then a number of 1 was given, else 0 was allocated to them.
Number of Employees	Number	The number of employees in the participant organisation.
Revenue	Discrete	The four categories as provided by the Enterprise Connect classification were chosen (please refer to the survey attachment).
Sector	Options (1-9)	The industry sector to which a participant's organisation belongs.
Headquarter situated in which state	Options (1-8)	Location of a participant's company headquarter at state level.
Age	Number	The number of years the participant organisation has been operating.

However as some scales that were designed are new and some from the extant literature, alpha values of 0.6 are considered acceptable, as argued by Nunnally (1978) and Peterson (1994b). While Jenkinson, Wright and Coulter (1994, p. 9) argue that alpha above 0.5 should be acceptable for a sample which has high items in a variable. Further to check both the validity and reliability of the indices used, robustness check was conducted where the indices values were altered based on the importance of questions determined within the literature.

5.4.6.2 Regressions

Regressions were then run on the selected variables to identify those factors that contributed most towards innovation within Australian SMEs. Regressions were used to test the influences of independent variables on the innovation variables. The models were tested with different variables added through various techniques to see the impact of each variable on the model and its significance. Various techniques and many algorithms have been used in the literature (Bradley, Mangasarian & Street 1998) to test a model's significance. The three most common approaches are *forward selection* where variables are added in an empty model to improve the overall model's performance (Soroush, Bahreininejad & van den Berg 2012); *backward elimination* where variables are removed from a full model (Soroush et al. 2012) and *stepwise regression* where both variables can be added and removed. For this study, first stepwise regression and then backward elimination methods were used through E-views. Further details regarding the econometric methodology are provided in Chapter 6.

5.5 Qualitative method: case studies

To answer the main research question of exploring the impact of the relationship of internal and external factors in Australian businesses, in-depth case studies were chosen. First, case studies assist in exploring empirically *contemporary phenomena* within their real context (Yin 2009, p. 12). Second, case studies provide an opportunity to use multiple sources of evidence apart from just interviews. Third, the benefit of already having existing theoretical propositions through the quantitative analysis assisted in guiding what themes can emerge, and provided a research direction to identify the impact of the relationship between internal and external factors (Seawright 2005, p. 18).

The case study method provided a fertile source of managerial implications, where patterns were discerned in cases of continuous involvement in the generation of innovations. The case studies used within this thesis were chosen to uncover information that cannot be gained from statistical findings. The selection of the cases was a critical component of the study and is discussed on the next pages.

5.5.1.1 Case selection

As this study focused on exploring the process of innovation, whilst looking at the impact of any relationships between internal and external factors, companies were needed that claimed to be involved with generating innovations. Thus a purposive, and not random, sampling technique was used (Denzin & Lincoln 2009). It was difficult to select a complete set of cases from a wider population while meeting every requirement, although having a specific purpose did assist in finding the relationship between internal and external factors. Mason (1990, p. 94) reflects on this difficulty in choosing case studies, stating:

> *"…you do not simply pick those sampling units which will support your argument and disregard those inconvenient ones which do not. You can and should make sure that you sample in a way which will help you not only to develop your theory or explanation, but also to test it, and you need to build in a mechanism for doing this."*

Table 5-5: Case selection in mixed-methods research.

Typical cases	Either to generate or test the hypotheses on the mechanisms that account for the causal effects discerned in the regression analysis.	Do not know why a cross-case pattern exist and refrains from formulation of hypothesis prior to empirical analysis. Risk of overgeneralisation. Possibility of a mis-selection.	Process tracing is exploratory – therefore the generations of propositions can be tested in the follow-up study. Test of a hypothesis on mechanisms – several rival theories predict the same causal effect, but stipulate distinct causal mechanisms.
Deviant cases	Studies of those cases which are known to deviate from the established generalisations. Test omitted variable analysis through exploratory process tracing; improving the overall model fit in a theoretically intelligent way.	Subjective assessments of a case's substantive importance is only looked into. No generalisation can be done based on just one case	Analysis is centred on a sample or population of cases expected to be causally homogenous. Within process tracing – search for variables which are theoretically considered to be irrelevant assists in selecting the deviant case.
Alternative cases provided	a) Intentional case: comparison of a case's actual outcome with the score predicted by regression model. b) Random selection case: avoid the investigator bias by selecting through stratified relevant factors.		Selection based on the scores on the observed and the predicted outcomes for the best and worse predicted case. A plot of residuals against fitted values – to determine assessment of systematic patterns in the distribution of the residuals.

Source: Summarised by researcher based on the descriptions by Rohlfing and Starke (2013)

Rohlfing and Starke (2013) discussed various methods of selecting cases when using a mixed-method approach, as outlined in Table 5-5. Based on their argument, typical cases were needed to identify process tracing for this study, while for case selection, specifically, Mason's (1990) strategy was used. A group of companies that were different in size and revenue, but most importantly where the number of innovation success rates differed, were selected.

The organisations which gave consent to be interviewed were narrowed down based on different sectors. The next step was to choose a particular sector for study. As seen in Chapter 2, the metal and machinery sectors had grown since 2005-06 and were performing well in GDP contribution (Australian Bureau of Statistics 2012), therefore these sectors contained potential case study companies. Further selection of cases was made under advice from experienced case study researchers. A list was generated with the respondents' names, business name, size of the business and number of years of operation.

5.5.1.2 How large should the sample be?

Once the sector was selected, the next step required selection of the case study companies to understand how the relationship between internal and external factors affected innovation. There were two alternatives, to have a single case analysis or multiple cases. While a single case analysis may assist in developing hypotheses for the areas which are under-researched (Wooldridge 2012), multisite or multiple case studies can test the theory on a larger scale (Rohlfing & Starke 2013).

Although, for this study, it is recognised that manufacturing SMEs and factors affecting their innovation is widely researched, the interactions between internal and external factors is less well understood. The research question aims to explore how complex innovation phenomena operate in Australian manufacturing SMEs, and to do this it was necessary "*to overcome the problem of generalizing from a single case study and at the same point provide more in-depth analysis*" (Rohlfing 2008, p. 1516). Thus, this work used multiple case studies.

Companies[7] were approached through an email invitation (Appendix 5K) to participate in further studies. Companies across different states with a range of employees were contacted. Before interviews could be conducted, based on the UTS Human Research Ethics

[7] The UTS Human Research Ethics Committee approval required anonymity of the companies in this research. Therefore no company names or specific locations are disclosed in this thesis.

Committee policies, all participants were asked to sign consent forms (Appendix 5L) and a copy of an information sheet (Appendix 5M) was shared with each participant.

5.5.2 Data collection

5.5.2.1 Interviews

Within this research setting, the objective is to explore the process of innovation, whilst focusing on how the interaction between the different factors affects innovation outcomes. Interviews were the best choice to learn about the stories of the owners or managers of how they introduced, or worked together to achieve, innovation (Secor 2010).

The interviews are influenced by social encounters to explore social reality (Dingwall 1997, p. 56). While it is difficult to capture this social reality in the interview situation, as the interview goes beyond aspects of local interaction and is dependent upon the actions of the interviewer, Alvesson (2011) argues that an interviewer uses interviews as his/her instrument to judge a situation. This means that interviews do not judge a local event which occurred, but are meant to *report* events based on an interviewer's interpretations and judgement (p.19). Therefore, the position of the interviewer is an important aspect, which is discussed within this sub-section.

Different approaches from the literature were extracted (a more detailed view is included in Appendix 5N). A mixed position was adopted where the interview was used as a form of conversation (Collier & Elman 2008, p. 138) done with a purpose (Yin 2006, p. 126) to know about the practices, experiences, and knowledge of the people interviewed with regard to innovative practices (Elliott 2004). Open questions (Appendix 5O) were framed to explore the phenomenon of innovation within these SMEs through the mode of conversation (Alvesson 2011). As the information shared with the interviewer was not very sensitive, apart from business (competitor) strategies, there was a low probability of an interviewee providing distorted or misleading information.

The first interview was a pilot interview conducted through Skype and was challenging as the owner of the business looked at his emails and responded to phone calls during the interview. Further he was unwilling for anyone else in the business to be interviewed. Following Sedorkin (2011) who emphasised that *preparation* is key to a good interview (p. ix), the interview techniques were changed where better information for a stronger story became the aim of the researcher.

Follow up calls and emails were made to almost all the SME participants. A trend to analyse interviews through a narrative approach emerged as interviewees explained their experiences as stories. *Verbatim* transcription was used where every line, pause, tone, voice pitch provided by the interviewee was transcribed by the researcher and then analysed, rather than focusing only on the repetition of words or statements (Hollway & Jefferson 2012, p. 34). Further, emotions that were easily identifiable by the positioning of words and body language were noted just after the interview, and included in the research notes.

a) Narrative research technique

Narrative research was used to gain a rich insight into a participant's experiences and how they explained the process of innovations within their businesses (Pepper & Wildy 2009). The importance of narrative technique was emphasised by Pepper and Wildy (2009) who conducted semi-structured interviews in various educational institutions to study leadership within Western Australia. They argue that narrative research requires careful attention to four aspects: data collection, constructing narratives, confirming the quality of the narratives and conducting analysis.

Following their approach, data were collected in an informal and relaxed setting at the premises of the participants. Participants were encouraged to talk about their experiences within the company and address how innovation was important to them, including any issues related to implementing innovations. Some prompts were used, such as a participant's background, personal highlights within the company, and their role in developing, implementing, or leading others in the innovation process. Aiming to validate the case study, interview information was captured from different members within the same organisation.

b) Participants

> *"Participants contribute to making public their understandings and experiences in ways that can lead to powerful changes in their worlds – through both greater public or professional understanding of their lives and even, perhaps, through their own greater interpersonal understandings"* (Niesz, Koch & Rumrill 2008, p. 120).

The CEO/owner for their respective company chose the interviewees. These interviewees were involved in the process of conducting, implementing or commercialising innovations in their respective organisations. Although some bias is inherent in this approach, participants were forthright in explaining their experiences and did not necessarily have similar views as other participants within the same organisation.

Exploring reality from the perspective of different people in organisations was necessary to provide some internal validity of the cases chosen. Further, the owners/CEOs and senior managers were considered to be decision makers while employees were crucial to a SME in creating opportunities understandings, experiences and opinions of a company in the minds of customers, hence they were also included.

5.5.2.2 Documents

While adapting other studies (Bernstein & Singh 2006; Tarafdar & Gordon 2007), the interviews were analysed based on the industry reports and policies which affected their respective sectors. The documents of the respective organisations were obtained from the companies and others were available online.

The importance of documents within this research study was crucial in exploring, not only the company or product information, but also the motivation behind introducing innovations. A number of tangible items captured outside the interview information were regarded as documents. Documents, whether in a paper format or electronic, were treated as a useful source of information as *historical evidence* (O'Hara et al. 1998, p. 390). This captures those transactions that are officially authoritative (Hodder 2000). Documents are also "*a type of formal communication that shows the competence, and often the specialised knowledge, of their producers… and action in documentary form is fundamental to the development of complex and enduring social arrangements*" (Miller & Alvarado 2005, p. 349).

Not all the information collected from the documents, however, was useful for the purposes of this research, and not all desired documents were made available. Some documents assisted in providing relevant factual information, while others were less applicable as they lacked information that could supplement information that was gained through the semi-structured interviews.

5.5.3 Qualitative data analysis

Interviews recorded were transcribed and coded to conduct the final analysis. Coding was done in a systematic manner. The interviews were viewed as a narrative. Although research questions were designed as a guide, most interviews were narratives where an interviewee provided an account of their experiences within the business, and what impacted innovation practices for them and their business. This means the transcriptions were studied thoroughly for understanding the positioning of words rather than simply coding through particular software (Silverman 2011). Verbal transcription, that is, word-to-word reproduction of verbal data helped to understand the dynamics of how each factor contributed towards innovation and discerning if there was any relationship between these factors.

Thematic analysis assisted to identify emerging themes of what impacts innovation in a manufacturing business. Thus, the objective was to identify repeated *patterns of meaning* across the interviews (Braun & Clarke 2006, 2014). A semantic approach was used where a more detailed and nuanced account of themes surrounding internal and external factors assisted in developing a coding scheme. This means that although a theoretical perspective based on the literature was existing, the coding of data tried to identify any new emerging themes which were not part of the model developed in Chapter 4. The coding process was thorough and comprehensive for all the conducted interviews and interview excerpts were coded based on both individual and multiple themes for every interview. All the extracts were collated for a particular case study to enable the identification of patterns. Thereafter, similar themes from all around the cases were collated, themes were checked against each other and related back to the original data set before data could be analysed.

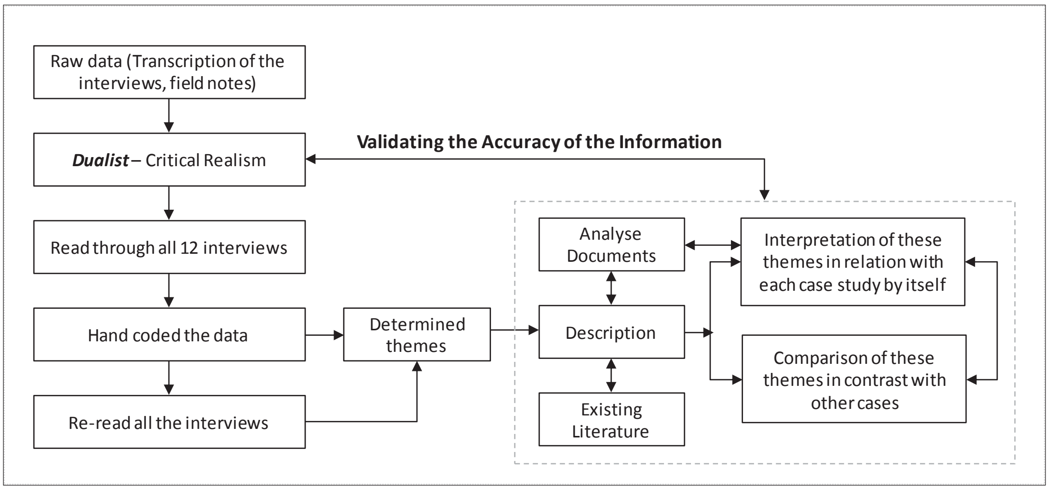

Figure 5-3: Process of data analysis of the qualitative research in this study.

The data analysis technique for this research study is illustrated in Figure 5-3. Transcriptions were read carefully three to four times on different occasions and data were hand coded. As themes started to emerge, they were clustered thereafter and if different phrases were used whilst describing the situation they were clustered separately. To check the coding technique used was consistent, interviews of one case study company were hand coded simultaneously by two different researchers. Later the researchers discussed the codes, any discrepancies between their codes were discussed, and a consensus was reached. This strategy was used to minimise the bias error of coding the interviews. The focus was more towards the meaning and interpretation of the events, rather than the repetition of the words. Moreover, descriptions of the shared experiences were made to validate the findings (Creswell 2014, p. 202). Descriptive information of the research is provided in tabular form in the analysis chapter. Interpretations of a case study that included various participants were determined separately and then validated against the historical information collected through the documents, as outlined in Table 5-2. The next stage was to compare case studies and draw interpretations based on this comparison. This validation, and scrutinising each interview with others in a case study, was driven through a critical realist framework while at times an interpretivist view was used to analyse the interviews through narrative analysis.

5.5.4 Qualitative data validity and credibility

The next step was to check whether the data collected for this study was appropriate and valid. Following Creswell (2014, pp. 201-02), the validity of the qualitative research findings was ensured as below:

- Different sources of data were used to critically analyse and examine the justification of themes that originated from the 12 interviews along with the documents obtained from the case study companies. Further, metal and manufacturing updates and reports were compared to check how various businesses, chosen as cases, performed in comparison with the overall industry.
- Follow up calls and follow up emails were made to the participants of this study during the analysis phase to validate any specific doubts which the researcher had.
- Rich descriptions from interviews, as well as other sources, were provided as evidence to support findings.
- Extended time was spent with nine participants as part of the company visits, and follow up calls and emails made.
- Self-reflection was used in the cases to explain the background of the people and companies interviewed. Photos of the three sites visited, and field notes, were taken to aid recollection.

Establishing credibility means demonstrating that bias was minimised within the collection of the data. Using established and tested methods and rich descriptions of the phenomenon (Lincoln 1985) assists with this. As the CEO/owner of the businesses chose participants for the interviews, it was particularly important to test the trustworthiness of this research. Different results gained in the study through interpretations of reality from different people in the same organisation, were found to tally with the documents of the company, and other sectoral reports. To facilitate consistent coding across transcripts and to limit issues of personal interpretation, a coding scheme was developed to interpret the data. This scheme assisted in increasing the reliability and thereby the trustworthiness of this study (Hsieh & Shannon 2005, p. 1286). For the reliability of interviews, different interview results were compared, as undertaken by Welk et al. (2007, p. 616). For instance, for this study data collected from the upper management was compared with their employees of the same organisation. Personal observations, such as a change in the tone of the interviewee while discussing their previous experiences within the same or other businesses, assisted in establishing the data's credibility.

5.6 Limitations of mixed methods

The quantitative survey had too many variables to be tested, which might impact factors such response rate, or issues regarding the richness of data in a quantitative sense, or the reliability and validity of the instrument itself. Therefore a mixed method approach was used. However a mixed methods approach is not completely sanitised from the problems of bias and validity (Fielding & Fielding 1986). A few limitations can be noted in the study.

There were limitations found whilst interviewing. For instance, people perceived reality from different perspectives and thus their interpretations were analysed in a narrative manner as they mostly discussed their experiences in the form of stories. However an overlap was seen in their interpretations of perceived reality. A common issue was that interviewees knew some details, such as competitor information, which they did not discuss or which they conveyed in a distorted manner (Alvesson 2011; Silverman 2011). Silverman (2011) suggests using interpretative data at that point. This means that a position of the interviewer needs to be known first so that a careful analysis is made to know the *reality* of interview data (Silverman 2011, p. 144).

5.7 Conclusion

The *first* section of this chapter explained the mixed methods approach and why it was preferred over a single quantitative or qualitative methodology. Based on previous empirical literature, the interactions between external and internal factors towards innovation were underexplored. Testing these interactions at a larger scale was needed and this was feasible only through a survey method. Some of the other advantages of using a survey include its cost-effectiveness and therefore suitability for a PhD project to collect data on a larger scale. While the survey helped in finding important factors for innovation in Australian SMEs, the research thereafter turned to the process of how such interactions apply in practice. Qualitative analysis was used to assist in explanations of this process.

The dualist theoretical approach, governed by mainly positivistic ideology, was chosen to explore the first research question through a quantitative survey. Exploring reality through interpretations of the interviewees within four different case studies helped in exploring the process of innovation through the introduction of new products and processes.

The *second* section discussed the research design, which focused on following both deductive and inductive approaches to answer the research questions in the best possible manner. The unit of analysis was discussed as an *organisation* which was chosen from the database of Enterprise Connect, a now defunct subdivision of the Department of Industry and Science.

The *third* section included a discussion of the quantitative analysis, where the survey meaning was explored, followed by advantages and disadvantages of using a survey. The design of a survey is the least expensive component, but is pivotal to the success of the research, as emphasised in this section. Various constructs of measurement that included technological change, both knowledge and non-knowledge-related internal factors and innovation outcomes were discussed. The data analysis techniques used were outlined including descriptive analysis, exploratory factor analysis and regressions. The survey data also helped in choosing case studies as the next stage of the data collection process.

The *fourth* section outlines how the contemporary phenomenon of innovation in Australian SMEs was investigated in depth. The cases were purposively chosen from the survey respondents from the metal and machinery manufacturing sector. The reason for choosing these organisations was due to their capacity to innovate, as well as the sectors' economic position. A post-positivist approach was chosen, but as stories of these enterprises emerged, an orientation towards narrative was deemed to be the most appropriate technique for analysis. Maintaining the validity, reliability and credibility of both types of data assisted in ensuring the quality of the research was not compromised. The next chapter concerns the quantitative data collected, while the subsequent chapter explores the case study companies studied.

The following chapter provides a detailed description of the data collected from the survey of Australian manufacturing SMEs and results from econometric estimation of equation (4.1) using this data.

Chapter 6: Quantitative Analysis

6.1 Introduction

Chapter 3 which reviewed the literature on innovation in a range of firm types, highlighted the importance of two sets of factors that shape innovation including in SMEs: factors *external* to the firm, including technological change developed in other parts of the economy but with possible application to the firm's operations, the firm's competitive environment, and the shape of government innovation policy; and factors *internal* to the firm, including the firm's ability to manage technical knowledge, the level and type of education possessed by the firm's owners and employees, the management style used in the firm, the work culture created by that style, and how the firm engages with external stakeholders. We saw that while the literature identifies the relevance of these factors as drivers of innovation in SMEs, it treats these factors as largely *separate* from one another. The one important exception to this rule is the *absorptive capacity* literature which considers how the firm's internal knowledge management capabilities mitigate the effect of externally generated technological change to bring about innovation outcomes. But the literature has largely ignored the investigation of interactions between *other* factors identified as important for innovation, especially interactions between external innovation drivers and a firm's *managerial* characteristics. Addressing this issue within Australian manufacturing SMEs is the central objective of this thesis. To this end Chapter 4 drew upon the literature considered in Chapter 3 to develop a model of innovation in SMEs. Chapter 5 then outlined a mixed methodology capable of effectively employing the model developed in Chapter 4 to explore internal-external innovation factor interaction.

This chapter reports the results from stage one of the methodology outlined in Chapter 5. This involves a quantitative examination of internal-external factor interactions for firms responding to a survey of Australian manufacturing SMEs sponsored by Enterprise Connect. Section 6.2 describes the data obtained from this survey after which Section 6.3 documents a series of regressions used to explore internal-external factor interactions for firms responding to the survey. It also reports results from these regressions. Section 6.4 provides a discussion of these results before Section 6.5 summarises and concludes.

6.2 Descriptive statistics of survey data

As outlined in the introduction, the model developed in Chapter 4 provides a framework for thinking about the interaction between innovation drivers generated externally to the firm (such as technological change) and internal characteristics of the firm relevant to innovation processes. Chapter 5 then specified a number of variables thought to be relevant to innovation and applicable to Australian manufacturing SMEs that could be understood using the framework of Chapter 4. It also detailed a survey used to collect this data. The present section describes the data collected from that survey.

An invitation to complete the survey along with a hyperlink to the online version of the survey was sent to 697 firms on the Enterprise Connect database in November 2014. As explained in Chapter 5, the survey[8] asked respondents a series questions about their firm's recent innovation experience and practice, a series of questions about their perception of external innovation drivers, a series of questions related to internal innovation divers and firm characteristics, and set of questions about background demographics.[9] The data is outlined for each of these categories although we begin with the demographic variables to provide a picture of the nature of firms responding to the survey.

6.2.1 Demographic characteristics of responding firms

The range of manufacturing sub-sectors in which respondent firms were operating is shown in Figure 6-1. Of the 74 respondents, the largest proportion were operating in the metal products sub-sector (27.03 %) by a considerable margin. The next biggest proportion (16.2 %) were firms operating in the food, beverage, and tobacco products sub-sector, with smaller proportions of firms in the machinery and equipment (10.8%), textile and clothing (6.76%) and wood and paper products (6.67%) subsectors. While firms from other sub-sectors represented relatively small proportions of survey respondents, there were at least some firms from each of the other five manufacturing sub-sectors.

The mean age of firms responding to the survey was about 27 years. The oldest firm had been operating for 173 years while the youngest firm had been in business for only 2 years.

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[8] The survey was designed as a discrete choice experiment where respondents were asked to select their most preferred scenario from a set of hypothetical options. These scenarios included a range of items under a number of construct levels (see Bech & Gyrd-Hansen 2005, p. 1079).

[9] This generated data for 119 items. Their classification according to the categories outlined above is shown in Appendix 4E. The first step in preparing this data for quantitative analysis was to check whether the items were coded properly. For instance, the choice of analysis for categorical variables can be problematic as SPSS and R both assume that there is ranking involved. To manage this assumption, some variables were transformed into dummies (Field 2013). For dummy coding, a single reference category was used, where the number of dummies created was one less than the number of variables. Thus for a question with five possible options for the respondent, four dummies were created. For each dummy, one option was assigned a value of 1 and the remaining options were registered as 0.

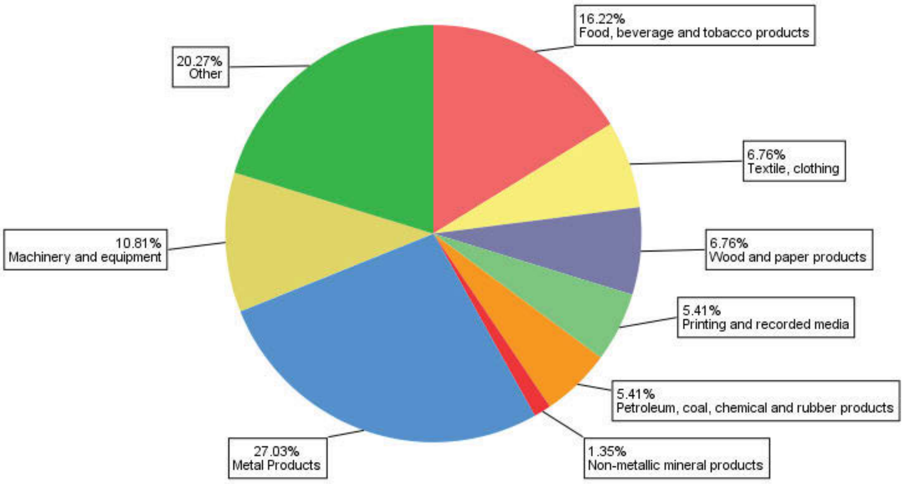

Figure 6-1: Distribution of Respondents by Manufacturing Sub-sector.

The survey also asked about the revenue earned by responding firms. The distribution of revenue flows sizes is shown in Figure 6-2. This suggests that most respondent firms generated revenue between 1.5 million and 10 million dollars in either the previous or the previous but one year at the time the survey was completed in November 2014. A small proportion of respondents had revenue between 50 and 100 million dollars across this time frame. These were firms in the food, beverage and tobacco, and the metal products sub-sectors.

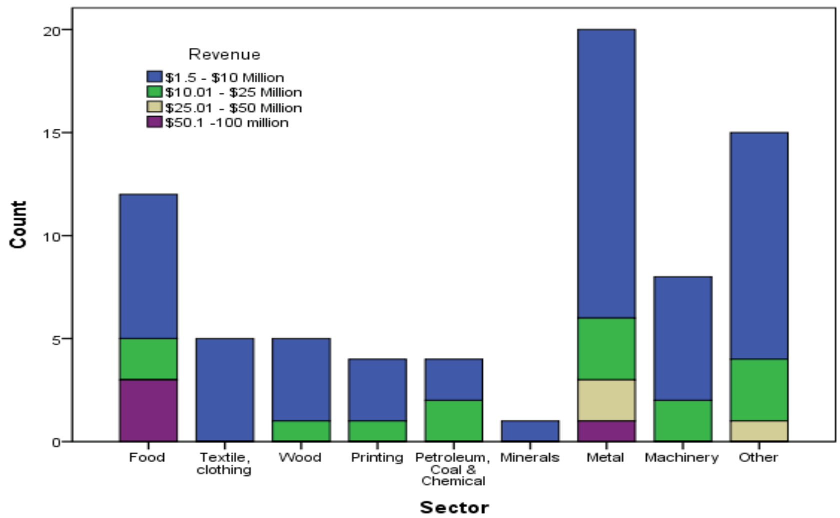

Figure 6-2: Distribution of Respondents by Revenue.

6.2.2 The innovation experience of respondents

As outlined in Chapter 5, the survey asked respondents for information about the number of innovations they had undertaken across the three years prior to their completion of the survey. These innovations were classified in the survey under two headings: *product* innovations (defined as the introduction of a product that had not previously been supplied to customers) and *process* innovations (defined as the introduction of a new technique used in the firm's production or distribution methods). Figure 6-3 shows the proportion of firms in the survey that reported particular levels of *product* innovation in the previous three years. The mean number of product innovations reported was 5.68 with a standard deviation of 7.16. The median number of product innovations was 3.00. Figure 6-3 indicates that this was also the most frequently reported number of this kind of innovation although the second most frequently reported number was between 6 and 10 such innovations over the previous three years followed by a level of 2 innovations. Nearly 10% of firms reported implementing more than 10 product innovations over this period.

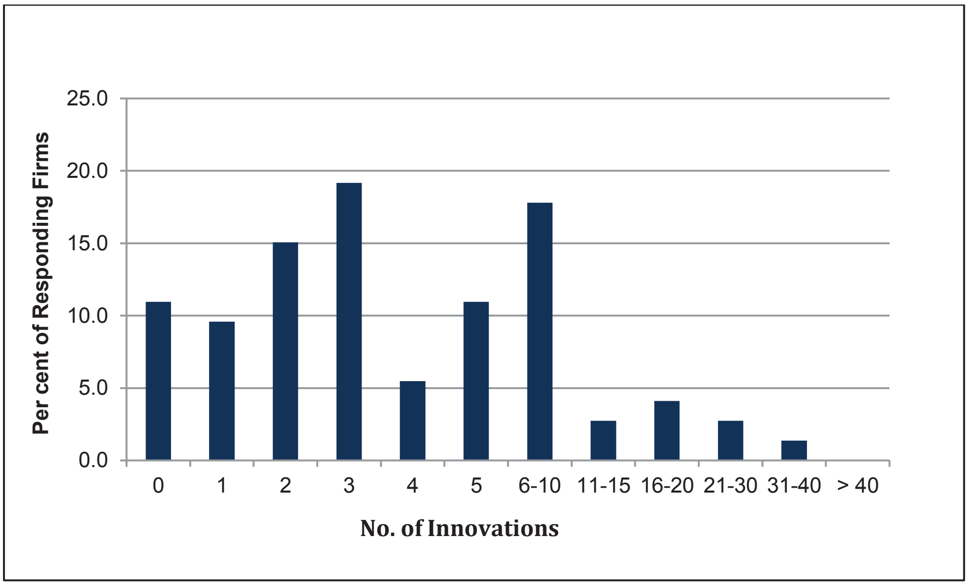

Figure 6-3: Product Innovations Reported by Responding Firms.

Table 6-1 reports the distribution of these product innovations by manufacturing sub-sector. Of the 415 product innovations reported by all firms in the survey, the majority of these innovations were undertaken by firms in the *metal products* sub-sector (28.19% or 117 innovations shown in the third and fourth columns of Figure 6-1) with firms in the *machinery and equipment* sub-sector accounting for the second largest proportion (23.37% or 97 innovations) and firms in the *food, beverage and tobacco products* sub-sector accounting for the third largest proportion (the third largest 21.20% or 88 innovations).

Interestingly, the first two of these sub-sectors were shown in Chapter 2 to have experienced strong growth in labour productivity across the 1990-2014 period. The least innovative subsector represented in the survey were firms in *non-metallic mineral products* (1.69 % or 7 innovations) with those in *printing and recording media* not far behind (2.17% or 9 innovations). These statistics are, however, driven by the number of responding firms in sector which are shown in the second column of Table 6-1. When we correct for the number of firms generating the innovations reported in the survey, the picture changes slightly. Column 5 indicates this by looking at the number of innovations per firm in each sector. The highest number of innovations per firm is now occurring in the *textile and clothing* sub-sector, followed by *machinery & equipment*, *food, beverage & tobacco*, and *metal products* and *wood & paper products*.

Table 6-1: Distribution of *Product* Innovations by Manufacturing Sub-sector.

Manufacturing Sub-sector	No. Firms	No. of Innovations	% Total Innovations	No. of Innovations per Firm	% Total Innovations per Firm
Food, Beverage & Tobacco	14	88	21.20	6.29	15.14
Textile and Clothing	5	52	12.53	10.40	25.05
Wood and Paper Products	7	35	8.43	5.00	12.04
Printing & Recorded Media	5	9	2.17	1.80	4.33
Petroleum, Coal, Chemical, Rubber	4	10	2.41	2.50	6.02
Non-Metallic Mineral Products	2	7	1.69	3.50	8.43
Metal Products	21	117	28.19	5.57	13.42
Machinery and Equipment	15	97	23.37	6.47	15.57
Total	**73**	**415**	**100.00**	**41.52**	**100.00**

Interestingly, the first two of these sub-sectors were shown in Chapter 2 to have experienced strong growth in labour productivity across the 1990-2014 period. The least innovative subsector represented in the survey were firms in *non-metallic mineral products* (1.69 % or 7 innovations) with those in *printing and recording media* not far behind (2.17% or 9 innovations). These statistics are, however, driven by the number of responding firms in sector which are shown in the second column of Table 6-1. When we correct for the number of firms generating the innovations reported in the survey, the picture changes slightly. Column 5 indicates this by looking at the number of innovations per firm in each sector. The highest number of innovations per firm is now occurring in the *textile and clothing* sub-sector, followed by *machinery & equipment*, *food, beverage & tobacco*, and *metal products* and *wood & paper products*.

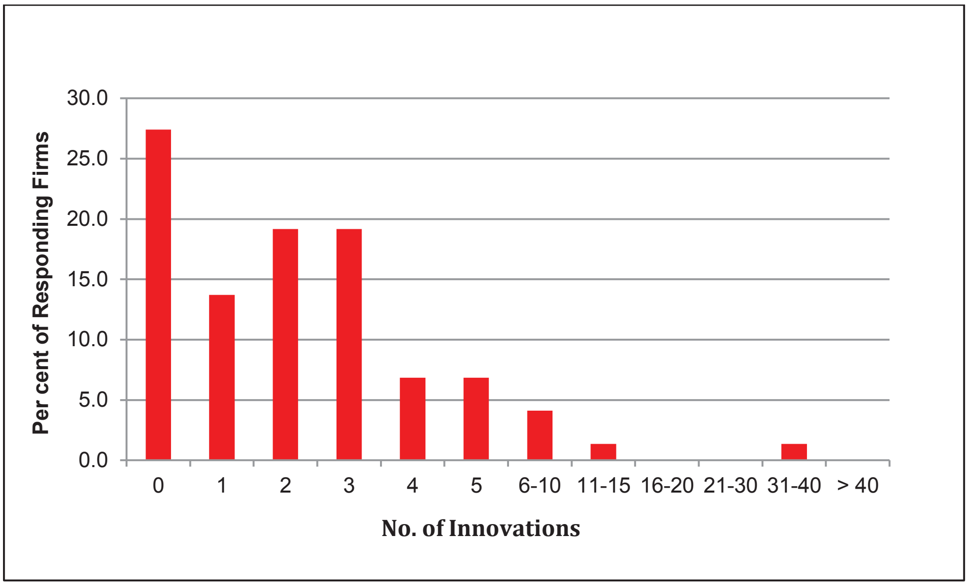

Figure 6-4: *Process* Innovations Reported by Responding Firms.

Figure 6-4 shows the proportion of firms reporting particular levels of *process* innovation in the previous three years. The mean number of process innovations reported was 2.60 with a standard deviation of 4.18. The median number of process innovations was only 2.00. Figure 6-4 indicates that over 255 of responding firms report no process innovations at all with the next most frequently reported number of these innovations being 2 and 3 innovations each of which was reported by 19.2% of firms in the survey. Nowhere near the same proportion of firms reported high levels of innovation in the process category as compared with the product category discussed above.

Table 6-2: Distribution of Process Innovations by Manufacturing Sub-sector.

Manufacturing Sub-sector	No. Firms	No. of Innovations	% Total Innovations	No. of Innovations per Firm	% Total Innovations per Firm
Food, Beverage and Tobacco	14	43	22.63	3.07	18.08
Textile and Clothing	5	8	4.21	1.60	9.42
Wood and Paper Products	7	15	7.89	2.14	12.62
Printing & Recorded Media	5	14	7.37	2.80	16.48
Petroleum, Coal, Chemical, Rubber	4	8	4.21	2.00	11.77
Non-Metallic Mineral Products	2	0	0.00	0.00	0.00
Metal Products	21	75	39.47	3.57	21.03
Machinery and Equipment	15	27	14.21	1.80	10.60
Total	**73**	**190**	**100.00**	**16.99**	**100.00**

Table 6-2 reports the distribution of process innovations across the manufacturing sub-sectors. Of the 190 process innovations reported by all firms in the survey, the majority were also undertaken by firms in the metal products sub-sector (39.47% or 75 innovations in columns three and four) with firms in the food, beverage and tobacco products sub-sector accounting for the second largest proportion (22.63% or 43 innovations) and firms in the machinery and equipment, sub-sector accounting for the third largest proportion (the third largest 14.21% or 27 innovations). All of these sub-sectors were shown to have experience improvements in labour productivity over the 1990-2014 period in Chapter 2. The least innovative subsector represented in the survey was made up of firms in non-metallic mineral products which reported no innovations at all in this category. The picture for innovation leaders is not significantly altered when we correct for performance on a per firm basis. Column five indicates that firms in the metal products sub-sector are the most innovative in the sample implementing 3.57 innovations per firm over the previous three years, with firms in food, beverage & tobacco demonstrating the second most innovative performance with 3.07 process innovations per firm over this period. The performance of the machinery and equipment sub-sector, however, falls significantly in importance, and the least innovative sub-sector remains non-metallic mineral products.

Table 6-3: Number of Firms Innovating by Innovation Category and Manufacturing Sub-sector.

	Number of Innovations by Category				
Manufacturing Sub-sector	**None**	**Product**	**Process**	**Both**	**Total**
Food, Beverage and Tobacco Products	0	2	0	10	12
Textile and Clothing	0	0	0	5	5
Wood and Paper Products	0	2	0	3	5
Printing and Recorded Media	0	0	1	3	4
Petroleum, Coal, Chemical and Rubber	1	0	0	3	4
Non-Metallic Mineral Products	0	0	0	1	1
Metal Products	2	4	2	12	20
Machinery and Equipment	1	1	0	6	8
Other	0	4	0	11	15
Total	**4**	**13**	**3**	**54**	**74**

An overall picture of innovation is provided in Table 6-3 which uses the above data to characterise the innovation experience of each firm responding to the survey in terms of one of four categories: no innovation undertaken over the three years prior to the survey; only product innovation conducted over this period; only process innovation conducted over this period; or both types of innovation carried out over the previous three years. Table 6-3 also categorises this innovation experience by the manufacturing sub-sector in which the firm was operating.

This table reinforces the perception from Tables 6-1 and 6-2 above that firms in the metal products sub-sector are the most innovative manufacturing firms within the survey. According to this table, this sub-sector has the highest number of firms (20) reporting some kind of innovative activity, and the highest number of firms reporting both types of innovation (product and process). Firms in the *food, beverage and tobacco products* sub-sector were also relatively highly innovative with 12 firms undertaking both types of innovation over the previous three years while the least innovative sub-sector was *non-metallic mineral products* with only a single firm reporting any innovative activity over this period.

Table 6-4: Distribution of *ALL* Innovations by Manufacturing Sub-sector.

Manufacturing Sub-sector	No. of Innovations per Firm	% Total Innovations per Firm
Food, Beverage and Tobacco Products	9.36	15.99
Textile and Clothing	12.00	20.51
Wood and Paper Products	7.14	12.21
Printing and Recorded Media	4.60	7.86
Petroleum, Coal, Chemical and Rubber	4.50	7.69
Non-Metallic Mineral Products	3.50	5.98
Metal Products	9.14	15.63
Machinery and Equipment	8.27	14.13
Total	**58.51**	**100.00**

This overall picture is further enhanced by Table 6-4 which reports the distribution of *all* innovations on a per firm basis across the various manufacturing sub-sectors in a manner similar to Tables 6-1 and 6-2 for product and process innovation separately. This table indicates that the strongest innovation performance on a per firm basis was demonstrated by firms in the *textiles and clothing* sub-sector with 12 overall innovations per firm over the three years prior to the survey. This accounted for 20.51% of the total level of innovations on a per firm basis in the survey, a performance well above other sub-sectors. A second tier of performance came from a group of sub-sectors comprising *food, beverage and tobacco*, *metal products*, machinery and equipment, and wood and paper products with innovations per firm of 9.36, 9.14, 8.27 and 7.14 respectively over the previous three years. Most of these sub-sector experienced increases in labour productivity according to the analysis in Chapter 2 with the exception of the *food, beverage and tobacco* sub-sector.

6.2.3 External innovation factors

The survey asked respondents about their perceptions of innovation factors *external* to the firm in terms of how changes in technology were perceived to affect the firm and its operations, and how the firm learned about such technological changes. The precise questions are depicted in Appendix 5D from Question 7 to 10, to which participants could respond on a Likert scale from *Strongly Disagree* (coded as 1) to *Strongly Agree* (coded as 5). The first question aimed at understanding whether technological change in general was carefully observed by respondents while the second question attempted to ascertain the importance of technological change in the *perceptions* of respondents. Clearly firms that regarded external technological change as irrelevant to the day to day operations of their firms would be less likely to observe such change, and one might expect this to have a significantly negative impact of the degree of innovation undertaken in that firm. The third question examined the degree to which the practices of competitors were a focus for observation of external technological change by respondent firms. Firms concerned about the behaviour of their competitors and the degree to which competitors are adopting technological changes in their operations are more likely to engage in innovative behaviour themselves, all else equal, according to the literature considered in Chapter 3. The fourth question essentially asked about the same thing with different wording.

Figure 6-5 reports the responses to these questions in the form of a box plot. Median responses are indicated by a dark line, purple bands indicate a significant frequency of responses in this range, *whiskers*, or thin lines, indicate a low but continuous frequency of responses in this range, and circles represent outliers. Figure 6-5 thus indicates that the median response for the first three questions outlined above was 4, most respondents *agreed* with the proposition expressed in the question (but not *strongly*). For the first question, a significant proportion of respondents also *strongly agreed* with the proposition (i.e. they were diligent in their monitoring of technological change in relevant industries), with the median value resulting from a thinner distribution of respondents neither agreeing nor disagreeing, and an outlier that did disagree with the proposition and hence did not undertake such monitoring.

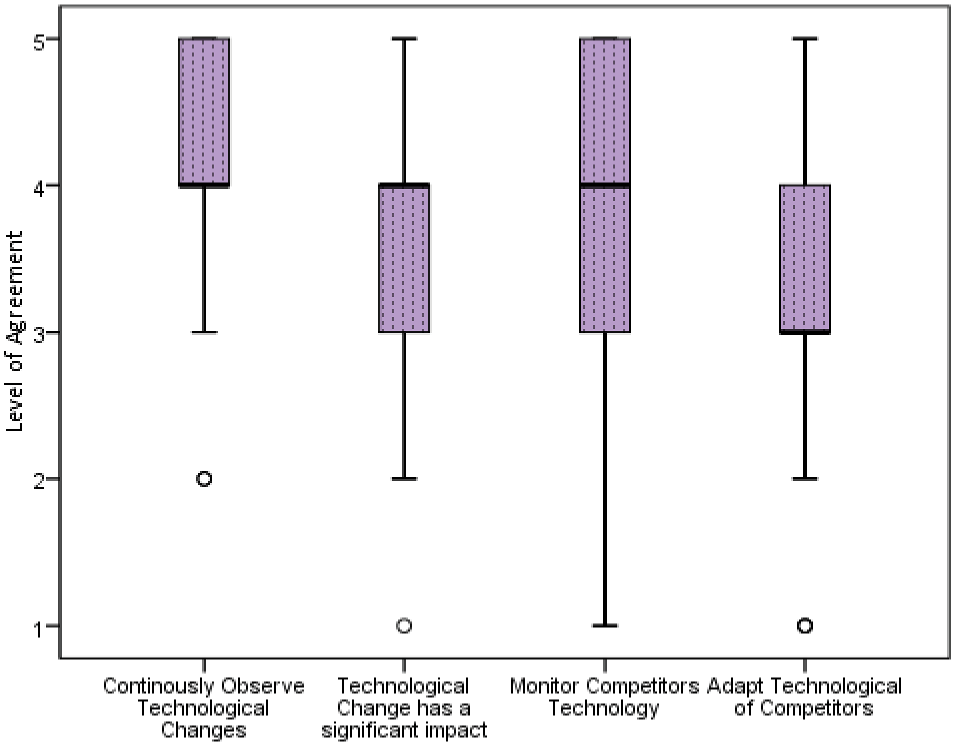

Figure 6-5: Perceptions of Technological change and its Impact on the Firm.

Note: The Likert scale employed in the survey used 1 to represent the *strongly disagree* response and 5 to represent the *strongly agree* response, with 6 indicating that the proposition in the question was *not applicable*. Median responses are indicated by a dark line, purple bands indicate a significant frequency of responses in this range, "whiskers", or thin lines, indicate a low but continuous frequency of responses in this range, and circles represent outliers.

For the second question above, a significant proportion of respondents were ambivalent about the importance of technological change for their business, responding with a 3 (neither agreeing nor disagreeing) and an outlier at end of the scale that strongly disagreed with the proposition that technological change had a significant impact. For the third question, regarding the role of competitors in the monitoring of technology, there was a thicker distribution around both sides of the median response of 4 but with a long, thin tail on the *disagree* side, indicating that for these respondents, competitors were *not* important. For the fourth question about whether respondents would adopt technology simply because competitors had done so, the median response was lower than for the other questions considered so far, with a general ambivalence regarding this proposition. There were, however, a number of responses that indicated this was important and a thinner distribution of respondents who strongly asserted that they would *not* adopt technology simply because a competitor had done so.

The question that asked respondents *how* they learned about external technological change is depicted in Appendix 5D, question 11. Once again, responses were defined over a Likert scale with *Strongly Disagree* coded as 1 to *Strongly Agree* coded as 5. This question aimed simply to discover the means by which external technological change came to the attention of respondents. The responses to this question are shown in Figure 6-6. The median value for each of employees, customers, competitors, conferences and research/industry as sources of knowledge about technological change was again 4 but with very different spreads around this median response. For customers, conferences and research/industry connections there were thicker distributions of responses that more *strongly* agreed, thus indicating the importance of these sources of information on average. For employees and competitors, the distribution of responses was slanted towards ambivalence, thus indicating that these sources were *less* important on average. The least important source of learning about technological change was the government with a median response of 3 (neither agree nor disagree) and a fairly symmetric, normal distribution around that value.

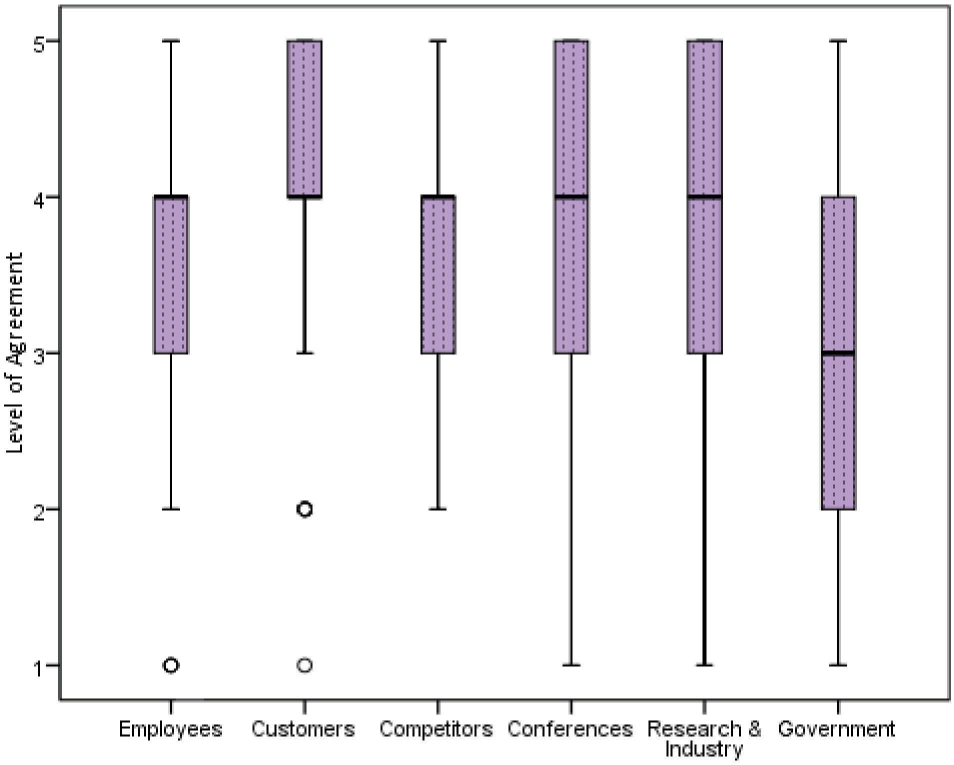

Figure 6-6: Means by which Firms Learned about External Technological change.

Note: The Likert scale used employed 1 to represent *strongly disagree* and 5 to represent *strongly agree*, with 6 indicating that the proposition in the question was not applicable. See caption under Figure 6-5 for key to box plot.

These were the survey questions that asked about key external drivers of innovation. Of particular significance were responses to the statement: *external technological change has a significant impact on the innovations implemented in my organisation*. Responses to this statement can be taken as an indication of the degree to which respondents perceived there to be technological change in their industry significant enough that it facilitated or even demanded an innovative response from their firm. Reponses to this question will thus be used as a proxy for the amount of external technological change relevant to the firms in our sample. It is, however, possible that these perceptions of technological change may be inaccurate, so it was decided to derive a second proxy for technological change for each of the Australian manufacturing sub-sectors from *outside* the survey.

This was done using the standard growth accounting framework from macroeconomics (see, for example, Jones 1998, pp.41-42). This framework starts from a simple aggregate production equation for a macro-economy according to which the volume of goods and services produced (Y) is some function of capital (K) and labour (L) inputs, and the state of technology (A):

$$Y = A \cdot F(K, L) \tag{6.1}$$

Taking differences, dividing through by Y, and performing some mathematical rearranging gives the following expression for the rate of *growth* of Y (g_Y) over time:

$$g_Y = \theta \cdot g_L + (1 - \theta) \cdot g_K + g_{TP} \tag{6.2}$$

where g_L if the rate of growth of the labour supply, g_K is the rate of growth of the capital stock, g_{TP} is the rate of growth in technological know-how, or what is sometimes call *total factor productivity*, and θ is the share of labour in national product (by implication $1 - \theta$ is the share of capital). As suggested in Chapter 3 above, g_{TP} is frequently taken as a measure of technological change which can, therefore, be expressed as:

$$g_{TP} = g_Y - \theta \cdot g_L - (1 - \theta) \cdot g_K \tag{6.3}$$

Since the Australian Bureau of Statistics publishes data for industrial sub-sectors that relate to each of the variables on the right hand side of equation (6.3), it is possible to construct a specific measure of total factor productivity for each Australian manufacturing sub-sector that can be used as a proxy for external technological change. The relevant data is shown in Table 6-5.

The final two rows of Table 6-5 provide alternative measures of total factor productivity growth for each of the eight Australian manufacturing sub-sectors using equation (6.3): one uses data on *total* employment in each sub-sector to construct a measure of labour supply growth; while the other uses only *full time* employment to construct this measure. The first probably *overstates* labour supply since part-time workers are counted as a single employment unit despite their labour supply contribution being a fraction of one unit, while the second *understates* labour supply because it excludes part time workers. Both measures were thus calculated but only the total employment measure was used in the regressions reported below since this seemed to approximate overall labour supply more closely.

The various rates of growth shown in Table 6-5 were calculated as the average rates of growth for the 5 years immediately prior to November 2010. Since the conceptual model of Australian SME innovation developed in Chapter 4 of this thesis takes external technological change as a given to which firms *react* in deciding whether or not to innovate, the measure of technological change used in this study needed to reflect the state of technological change *at* or *prior to* the point in time when innovations reported in the survey were being undertaken. Since the survey which opened in November 2013 asked about innovations over the *previous three years*, the external technological change measure needed to capture progress prior to the end of 2010. It was decided to calculate this

Table 6-5: Components of Australian Manufacturing Sector Growth, 2008-2013.

Growth Component	**Manufacturing Sub-sector**							
	Tobacco	**Textiles & Clothing**	**Wood/ Paper Products**	**Print/Rec Media**	**Petrol**	**Non-Metal Minerals**	**Metal Products**	**Mach & Equip**
	%	%	%	%	%	%	%	%
Output	-0.04	-5.55	-2.51	-4.68	-1.42	3.19	4.23	1.75
Labour Force (Tot)	1.05	-1.62	-2.94	-0.77	-0.96	1.17	1.79	-0.27
Labour Force (F/T)	0.42	-2.36	-3.83	-0.92	-1.00	0.79	0.48	-0.68
Capital Stock	-12.08	-24.61	4.16	6.84	-7.64	-12.02	-23.49	-11.58
Capital Share	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
Labour Share	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
$TPG_{,Total\ L}$	4.62	5.74	-2.88	-7.23	2.30	7.76	13.41	6.82
$TPG_{F/T\ L}$	5.12	4.96	-4.29	-7.60	1.84	8.33	14.27	6.70

Sources: Australian Bureau of Statistics, Cat No.5206, *Industrial Production*, Table 41; Cat No.6291.0.55.003 *Labour Force, Australia*, *Detailed, Quarterly*, Table 06, Employed Persons by Industry Subdivision and Sex; Cat No. 5625.0, *Private New Capital Expenditure and Expected Expenditure*, *Australia*, Table 2E: Actual Expenditure, Detailed Industries, s.a., Current Prices; Cat No. 5204, 5204.0 *Australian System of National Accounts*, Table 6: Income from Gross Domestic Product (GDP), Current Prices; and Cat No.6427.0, *Producer Price Indexes*, *Australia*, Table 14: Input to Manufacturing Industries, Subdivision Index Numbers.

measure as an *average* over the five year period to the end of November 2010 to reflect the fact that there can be periodic variations in the data and since technological change has a medium to long term nature about it. Alternative measures were calculated over 2 and 10 year time horizons with same end date but the five year horizon was judged to be reflect the best combination of the medium to long term nature of technological change but also its dynamic nature. The 2 and 10 year calculations are thus not reported. Data on the growth of capital stock is provided by the ABS in dollar values and so real growth was calculated by deflating dollar values by inflation in sub-sector specific producer price indices.

It is clear from the second last row of Table 6-5 that the measure of technological change, $TPG_{Total\ L}$, is highest in the *metal products* sub-sector and lowest in the *wood and paper products* and *printing & recorded media* sub-sectors, where growth in total factor productivity was substantially negative. Most other manufacturing sub-sectors experienced growth between about 5 and 8 per cent per annum on average over the five year period between 2006 and 2010. These outcomes are broadly similar to the measures of growth in labour productivity for the manufacturing sector discussed in Chapter 2.

6.2.2 Internal innovation factors

The survey also asked respondents a series of questions about characteristics of the firm that the literature considered in Chapter 3 indicates are important *internal* drivers of innovation. A number of these drivers, were, therefore, included in the model of SME innovation developed in Chapter 4 and, as a result, data needed to be collected on these variables to enable the quantitative consideration of SME innovation in the Australian manufacturing sector for which the model was to be used. These drivers included CEO and employee educational background, expenditure on training and professional development, network links, connections and collaborations, the previous experience of CEOs and employees, the CEO's motivation for engaging in innovation, the firm's marketing agility and ability to respond to new opportunities, and the firm's culture.

Table 6-6: Highest Educational Qualification of CEO.

Education Qualification of the CEO/Owner	Valid Per cent
High School	17.6
TAFE or Trade Certificate	24.3
Technical Degree or Diploma	10.8
Management Degree or Diploma	37.8
Degree or diplomas related to R&D	0.0
Other	8.1
None	1.4

a) Educational background

The first set of questions relating to these internal drivers of innovation, therefore, focused on CEO and employee educational background. This background not only determines the ability of a firm to adapt and apply externally generated technological change but this thesis suggests that it may also affect the ability of a firm to develop appropriate business responses that enable a firm to take advantage of external innovation drivers. The survey thus collected information about both the *management* educational backgrounds of the CEO, firm managers and other employees, as well as about the *general* education of these stakeholders. The relevant questions Q21, Q22 and Q23 were listed under Appendix 5D.

Table 6-6 reports responses to the Q21. It shows the percentage of firms responding to the survey for whom the CEO had each level of qualification. This table indicates that the top three highest qualification levels were a *management degree or diploma* (37.8% of respondents), a *TAFE or trade certificate* (24.3%) and a *high school completion certificate* (17.6%). No firms reported CEOs with degree or diplomas related to research and development (R&D). Four CEOs were reported to possess a Ph.D. degree under the *other qualifications* option. Very few CEOs were reported to possess no formal education at all.

The second question about educational background listed above asked for the percentage of mangers that possessed particular qualifications as their highest educational achievement. A sizeable majority of 91% of respondents reported that *none* of their managers possessed a relevant research and development degree or diploma while 76% reported that *none* of their managers possessed a degree of any kind related to the relevant innovation processes. With respect to management education, a *TAFE/Trade Certificate* was one of the most commonly reported qualifications, followed by a management diploma. Few managers possessed technical degrees as their highest qualification, which was somewhat unexpected.

An identical question to that asking about the proportion of managers with particular levels of highest educational qualification was also asked about other employees in the respondent organisations. The most common response here was *a high school completion certificate* followed by a *TAFE/trade certificate*. While very few respondents indicated that their employees had management or technical degrees, a very small group (approximately 3%) reported that their employees possessed a tertiary qualification related to innovation learning and development.

b) Training and development

Two questions in the survey related to the ongoing training and development of firm employees. The first was a simply yes/no question asking whether any budget was allocated for this purpose (Q24). The second question asked about the level of expenditure allocated to various types of training (Q25).

The proportion of firms reporting the allocation of some expenditure on training and development for staff (an affirmative answer to the first question above) was 67.2%. Figure 6-7 reports the responses to the second question above concerning the allocation of expenditure on specific training activities. None of the respondents chose the *other* or *don't know* response options, so these are not reported in Figure 6-7. The remainder of responses were structured over five different categories from *less than $5* (coded as 1) *between $5001*

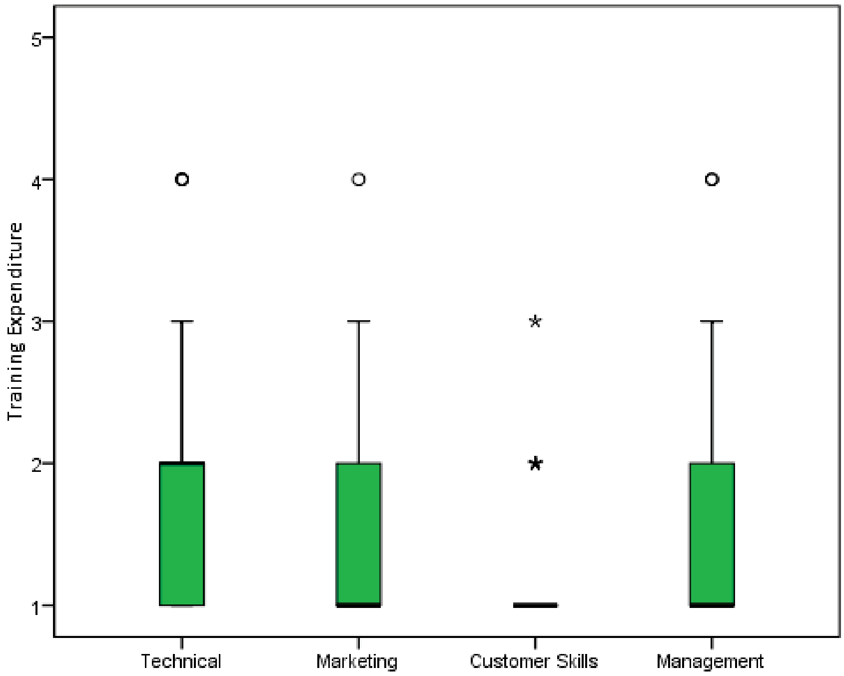

Figure 6-7: Training Expenditure.

Note: The Likert scale used employed 1 to represent *strongly disagree* and 5 to represent *strongly agree*. See caption under Figure 6-5 for key to box plot.

and $15K, *between $15001 and $50K*, *between $50,001 and $100K*, and *more than 100K* (coded as 5). The median value for each type of training expenditure except for *technical skills* was 1. The spreads for *marketing* and *management training skills* were similar around this median response. This indicates that most respondents spent less than $5000 on marketing, customer and management skills per year. There existed some outliers (represented by circles) for the *gaining marketing and management skills* spending category. The stars in Figure 6-7 represent extreme points and suggest that few respondents spent between $5001 and $50,000 a year on *gaining customer skills*. The median response for expenditure on *technical skills* was 2, indicating that most respondents spent between $5001 and $15,000 per year on *technical skills*. The two outliers spent between $50,000 and $100,000 on both *technical* and *management* skills.

c) Network links, connections, and collaborations

A third set of questions in the survey asked about skills and knowledge made available to the firm via networks and alliances both within and outside the organisation. Two questions focused on how often respondents made use of partnerships with various potential parties firstly to *develop* (Q38) and then to *implement* (Q39) innovations within the firm.

Responses were structured on a five point Likert scale from *never* (coded as 1) to *always* (coded as 5). An identical question simply replaced the word *development* with *implementing*.

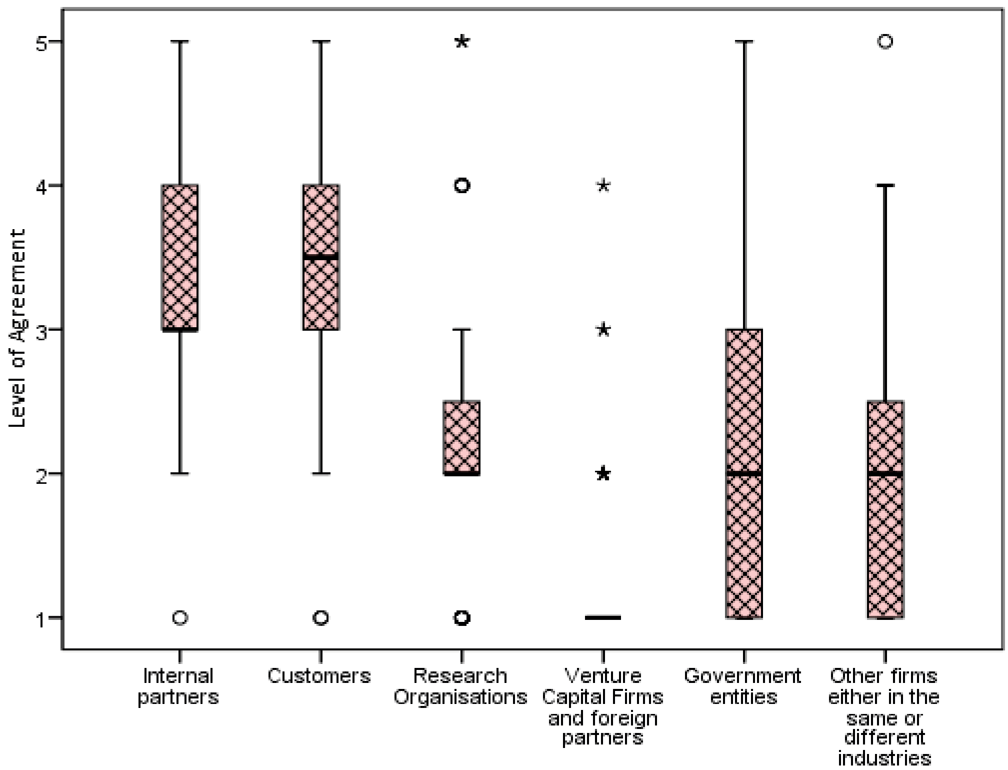

Figure 6-8: Partners involved in *Developing* Innovative Activities.

Note: Responses were made on a five point Likert scale with 1 = Never, 2 = Seldom, 3 = About half of the time, 4 = Usually and 5 = Always. See caption under Figure 6-5 for key to box plot.

Responses to the first question on *developing* innovative activities are shown in Figure 6-8. This indicates that respondents made relatively frequent use of *customers* as collaborators in innovative activities with a median of 3.5 for these parties and a thick distribution around this median. Little use was made of other possible parties listed in the question especially *venture capital firms*, *research organisations*, *other firms in the same or different industries* and *government entities*. Although the distribution of responses for *government entities* has a long tail indicating that few respondents developed innovative activities in collaboration with government. Extreme points and outliers in the same figure suggest that some respondents found collaborative partners in *research organisations including consultants*, *venture capitalists* or *other firms in the same or different industries*.

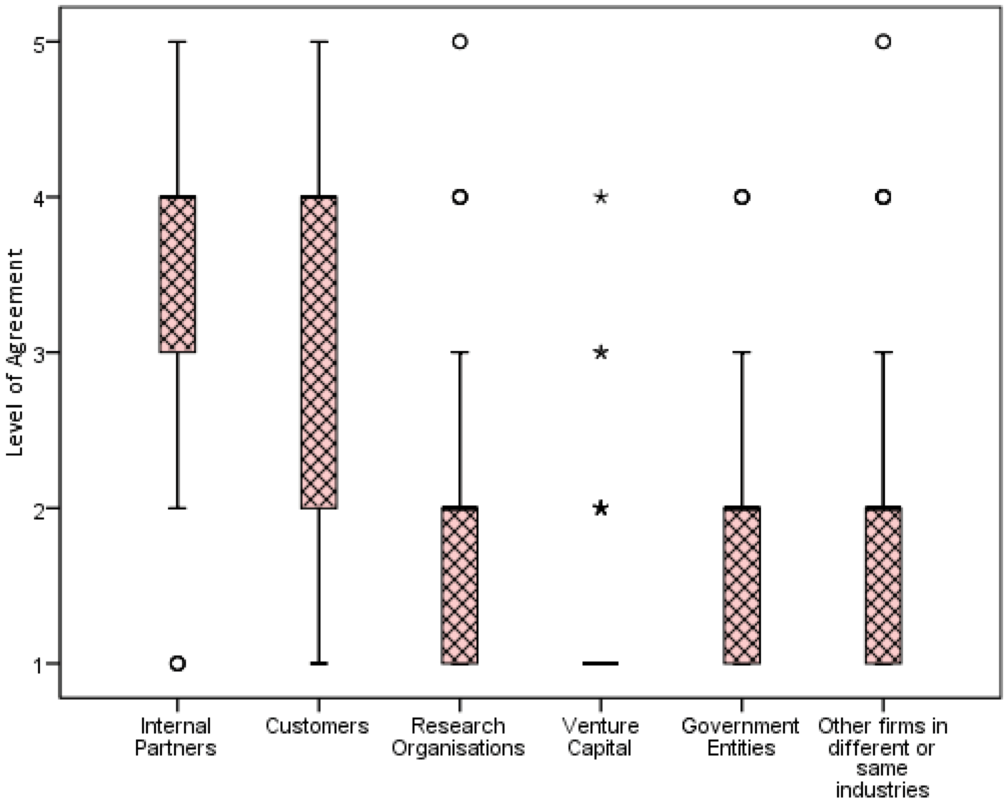

Figure 6-9: Partners involved in *Implementing* Innovation Activities.

Note: *Note*: Responses were made on a five point Likert scale with 1 = Never, 2 = Seldom, 3 = About half of the time, 4 = Usually, and 5 = Always. See caption under Figure 6-5 for key to box plot.

The responses for collaborations related to the *implementation* of innovations are shown in Figure 6-9. These responses suggest that the most important innovation partners were *customers* (with a median response of 3.5) followed by *internal partners* (with a media response of 3). Collaborations with *research organisations*, *government entities* and *other firms* were seldom used and there were very few collaborations with *venture capital firms* at the implementation stage of innovation.

A separate question asked whether respondents actively collaborated with external organisations in response to which 75.7% indicated that they did. This is consistent with the data in Figures 6-8 and 6-9.

The survey also asked about the reasons for collaboration. Potential reasons listed in the question were: *a need for technical assistance*; *a need for marketing/organisational development assistance*; *a need for resource assistance*; *a need for government assistance (either monetary or advisory assistance) when conducting innovations*; *a need for knowledge and learning*; *the firm's parent company acquired another company and/or wanted a project to include collaboration*; or *some other reason* which the respondent was asked to specify. Against each of these possible reasons for collaboration respondents were invited to express their level of agreement (with a Likert value of 1 indicating *strong disagreement* and a value of 5 indicating *strong agreement*). Responses are shown in Figure 6-10. This indicates that respondents largely collaborated with external organisations for *technical* reasons (with a median response of 4). *Marketing*, accessing *additional resources*, obtaining *government* support and *obtaining additional knowledge* were also important reasons for external collaborations. Forced collaborations arising from the directions issues by parent companies were not very important.

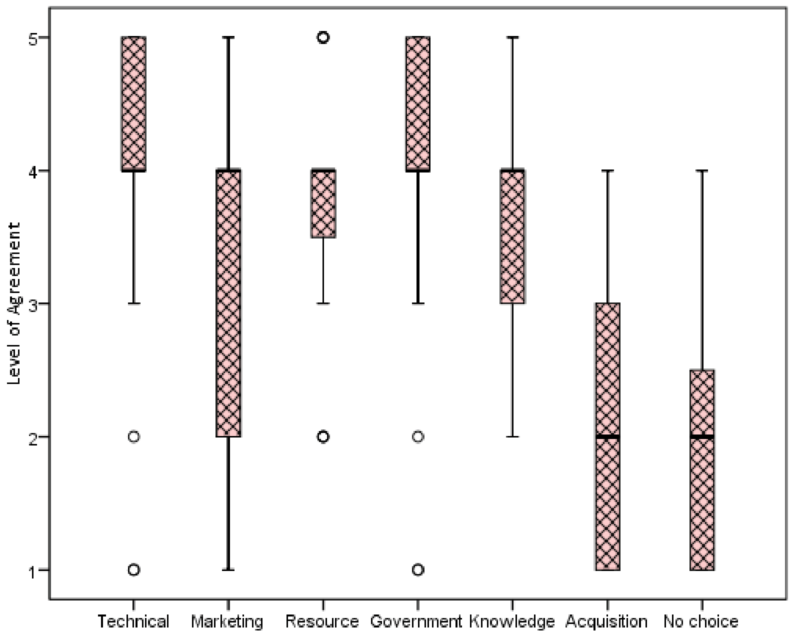

Figure 6-10: Reasons for Collaborating with External Organisations.

Note: The Likert scale used employed 1 to represent *strongly disagree* and 5 to represent *strongly agree*. See caption under Figure 6-5 for key to box plot.

The survey asked respondents about their understanding of the benefits of collaboration by posing a series of propositions about these benefits as listed under Q42-Q51 in Appendix 5D.

Out of the above 10 statements, 3 were reverse coded. These reverse coded statements were *collaboration with outside organisations did not affect knowledge and learning*, *collaboration with outside organisations had little effect on their innovations*, *collaboration with internal partners did not affect efficiency*. These statements were recoded. Figure 6-11 reports the responses to these propositions. This figure indicates that the median response for all statements was 4, most respondents *agreed* with them but not *strongly*. The responses for the last two propositions, *open communication* and *assists innovation* displayed thicker distributions around the *strongly agreed* sentiment indicating the importance of these implications of collaboration for respondents on average. For all other implications in this question, the distribution of responses was slanted towards ambivalence.

d) Experience

Three questions in the survey related to previous experience of employees and managers. The first asked whether respondents thought that the previous experience of employees and managers in the same or another sector was useful for a firm's growth and innovation from Q26 to Q29.

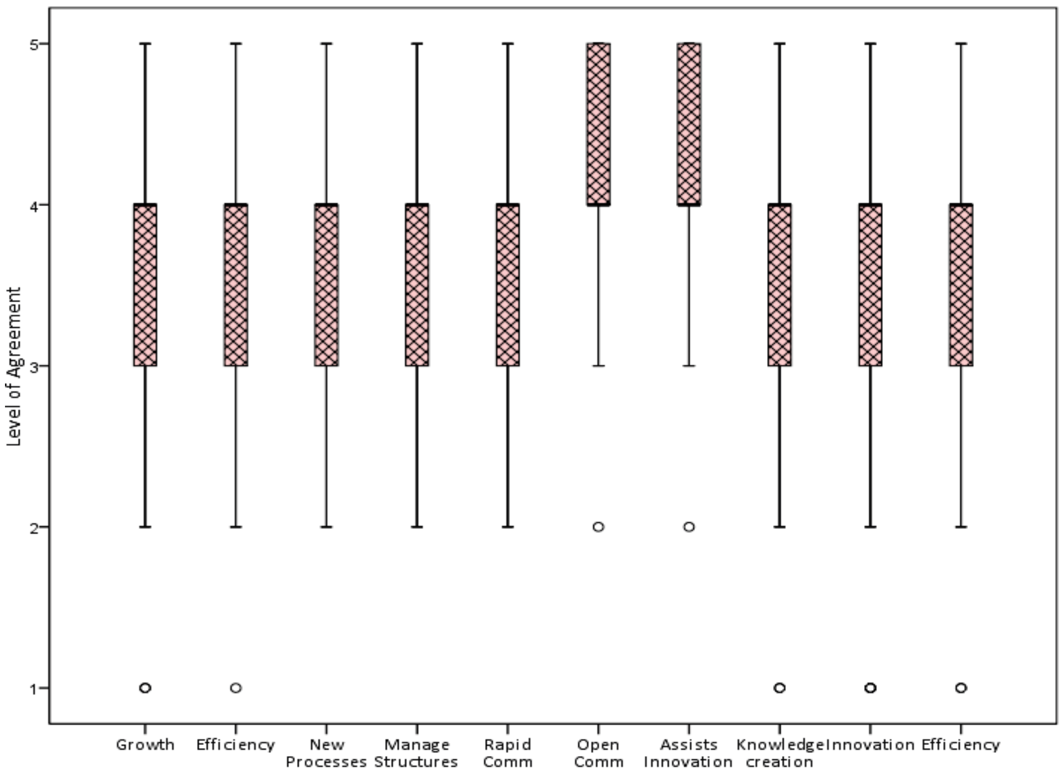

Figure 6-11: Benefits of Collaboration.

Note: The Likert scale used employed 1 to represent *strongly disagree* and 5 to represent *strongly agree*, with 6 indicating that the proposition in the question was not applicable. See caption under Figure 6-5 for key to box plot.

The responses to this question are shown in Figure 6-12. This indicates little variation in responses about the usefulness of previous experience of employees and managers with almost all responses returning a Likert value of 4 apart from a sprinkling of outliers. The one exception relates to the value of *previous experience of employees in another sector* where the distribution of responses was a little thicker on the less-valued side of this median response.

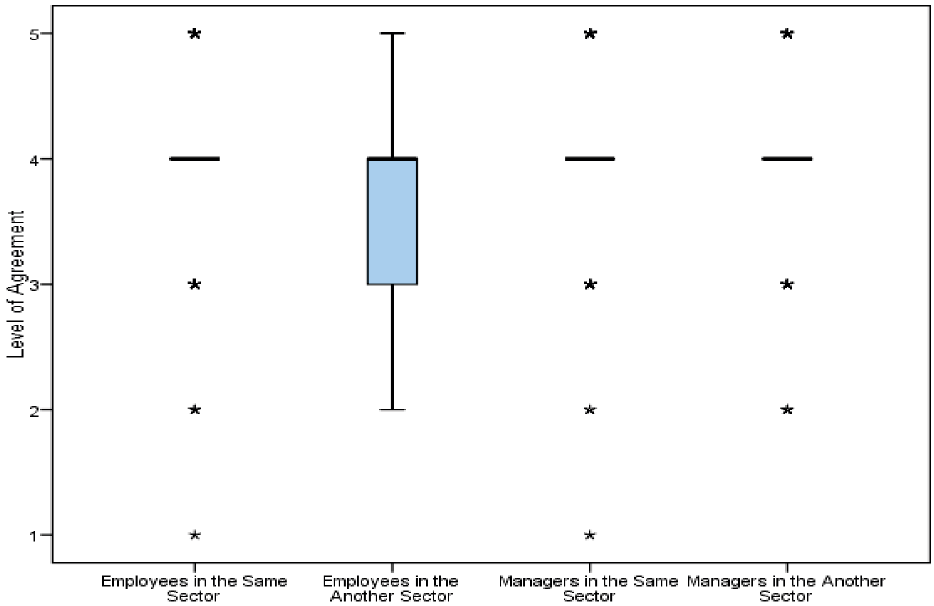

Figure 6-12: Previous Experience of Managers and Employees.

Note: The Likert scale used employed 1 to represent *strongly disagree* and 5 to represent *strongly agree*, with 6 indicating that the proposition in the question was not applicable. See caption under Figure 6-5 for key to box plot.

e) Motivation

The survey asked about the motivation of CEOs/owners, employees and managers to innovate using the question *why do the following* [stakeholders in the firm] *undertake innovative activities in your organisation*. Table 6.7 indicates that approximately 58% of respondents agree that the motivation for CEOs/owners to innovate was to stay in the market, while most managers (41%) were motivated by the fact that their organisation earns more money if they innovate. Most employees (43%) were motivated, however, by the potential to obtain both personal and professional development. Thirty three per cent of employees were motivated by company profit, and there are almost equal proportions of managers who think that innovating is best for their professional and personal development on the one hand and the key for them to stay in the market on the other.

f) Marketing agility

One section of the survey related to marketing agility. This focused on the role of the customer by identifying how well customer feedback was used to develop innovative ideas, to understand whether online media was used to communicate with customers and to broadly understand the behaviour of employees towards customers. The questions were listed from Q13 to Q20 in Appendix 5D.

Figure 6-13 reports responses to the statements within this question. The median value for each of *aim to promote prompt service to customers*, *the main goal was to retain customers*

Table 6-7: Motivation of CEO, Managers and Employees Cross-tabulated with the Innovation Types.

Type of innovation	Best option for personal and professional development	Company earns more money than if they do not innovate	They have to innovate to stay in the market	Not applicable	Total
			Motivation of the CEO		
No innovation	1	0	2	1	4
Product innovation	3	2	8	0	13
Process innovation	0	1	2	0	3
Both product and process innovation	7	15	31	1	54
Subtotal	11	18	43	2	74
			Motivation of Managers		
No innovation	3	0	0	1	4
Product innovation	3	5	5	0	13
Process innovation	1	2	0	0	3
Both product and process innovation	15	23	16	0	54
Subtotal	22	30	21	1	74
			Motivation of Employees		
No innovation	2	0	0	2	4
Product innovation	5	4	3	1	13
Process innovation	0	3	0	0	3
Both product and process innovation	25	18	10	1	54
Subtotal	32	25	13	4	74

and *employees and managers are courteous*, was 5 indicating the importance of customers on average. Some extreme points were visible in two questions – *aiming to provide prompt service to customers* and *main goal was to retain customers*. These extreme points indicate a disagreement in comparison to other answers with which few respondents *strongly disagreed*. This suggest that customers were not a high priority for these respondents. The median value of other statements such as *regularly studying customer wants* and *seeking customer feedback* were slanted towards *agreement*, indicating that customer feedback was quite important to these firms. The propositions that *employee knowledge helps to retain and attract new customers* had a median response of 5 but there was an ambivalence towards *agree* with the whisker for this proposition in Figure 6-13 indicating that few respondents *agreed* or *disagreed* with this proposition. The use of *online communication* had a median response of 4 with a slant towards ambivalence, indicating that this was not very important on average.

There were some outliers (represented with circles) that suggest some respondents believed that customer wants were not regularly studied, customer feedback was not continuously sought, employee courtesy and knowledge did not aim to retain customers, and some employees or managers were not courteous towards customers.

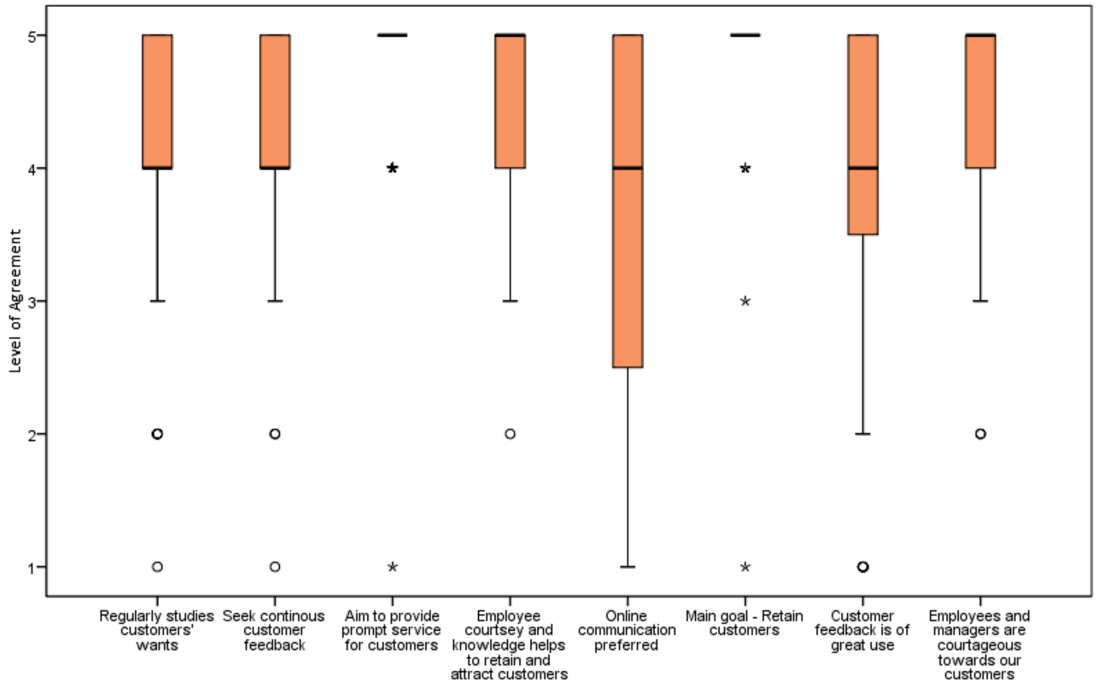

Figure 6-13: Marketing Agility.

Note: The Likert scale used employed 1 to represent *strongly disagree* and 5 to represent *strongly agree*, with 6 indicating that the proposition in the question was not applicable. See caption under Figure 6-5 for key to box plot.

g) Culture

A series of survey questions asked about the day-to-day practices of respondents, including the encouragement and role of employees within innovative activities, learning exercises practiced at the workplace, CEO support towards technology and the like. These questions were designed to see whether management culture within respondent firms was geared towards encouraging innovation listed under Appendix 5D from 52 to Q63.

Once again, responses were defined over a Likert scale with *Strongly Disagree* coded as 1 and *Strongly Agree* coded as 5. The agility, experience and education of the individuals would be unable to help in practicing innovative activities if its culture was not supportive of innovative activities, hence culture and strategy were explored as represented in Figure 6-14.

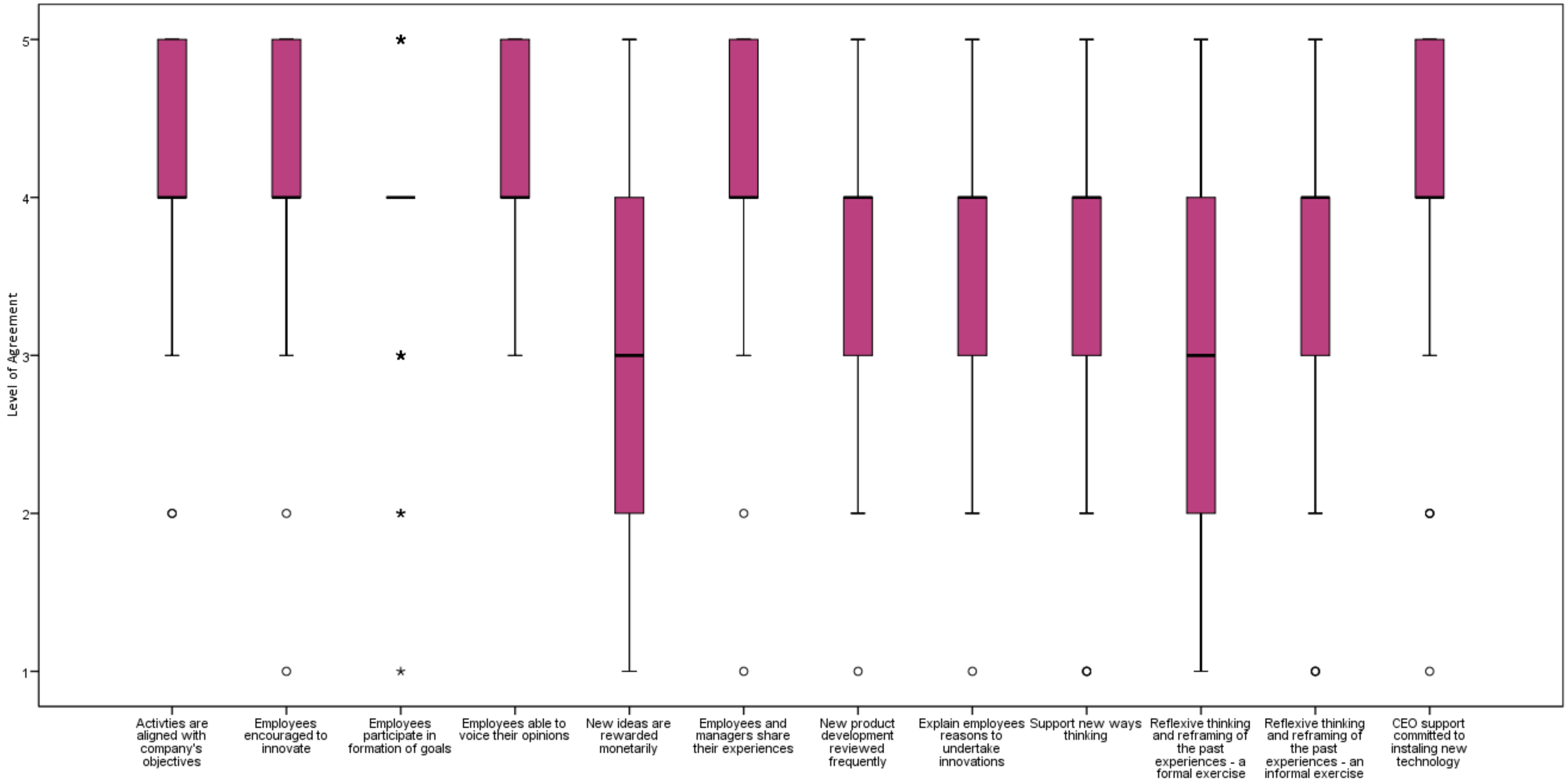

Figure 6-14: Culture and Strategy

Note: The Likert scale used employed 1 to represent *strongly disagree* and 5 to represent *strongly agree*, with 6 indicating that the proposition in the question was not applicable. See caption under Figure 6-5 for key to box plot.

Specifically, this figure outlines responses to twelve questions on employee participation, encouragement of innovative activities and the generation of ideas, and open discussion of company processes and developments. Notably, responses to *new ideas are rewarded monetarily* and *reflexive thinking and reframing of the past as a formal exercise* were broadly distributed along the 5-point scale, indicating views on these matters are far from universal. Questions pertaining to employee participation were met with *agreement* to *strong agreement*, whereas those questions pertaining to *company development* and *reflection processes* showed responses that were slightly lower and more variable although still in *agreement*.

h) Enterprise Connect

The survey also asked questions about the involvement and assistance of *Enterprise Connect,* listed under Appendix 5D from Q64 to Q69.

The responses to above questions were captured by Figure 6-15. The median value describing the role of *Enterprise Connect* towards support, finding funding, overall strategies for design and connection with researchers/industry associations was 4 which is a fairly symmetric, normal distribution around that value. Similarly, the median response for role of Enterprise Connect in advising marketing strategies and IT solutions was 3 and a fairly symmetric distribution around that value.

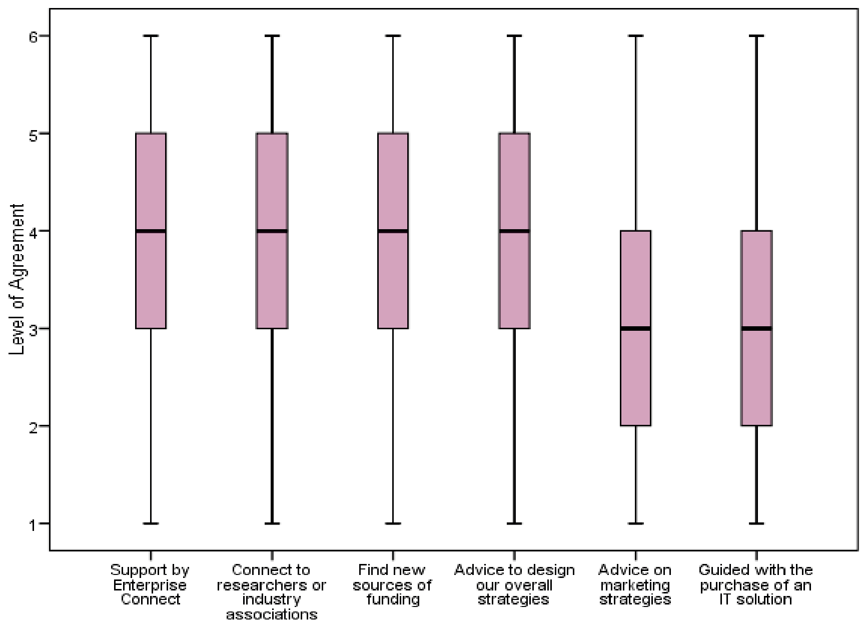

Figure 6-15: Engagement with *Enterprise Connect*.

Note: The Likert scale used employed 1 to represent *strongly disagree* and 5 to represent *strongly agree*, with 6 indicating that the proposition in the question was not applicable. See caption under Figure 6-5 for key to box plot.

The survey data reported above thus provides a detailed snapshot of the degree of innovation practiced by a sample of 78 Australian manufacturing SMEs spread across the full range of sub-sectors within this industry. It also provides data for these firms on key innovation drivers. The following section reports on a series of regressions using this data which were designed to examine the quantitative relationship between various innovation drivers for this sample of firms.

6.3 Statistical analysis

As explained in the introduction to this chapter, the structure of the survey and the data it generated were determined by the model of innovation in Australian manufacturing SMEs developed in Chapter 4. It was originally thought that this survey would act as the pilot for a larger survey that would generate a substantial amount of data so that *Exploratory Factor Analysis* (EFA) could be used to complement the kind of regressions which are reported below. This would have meant a two pronged approach to statistical analysis of firm innovation behaviour. Use of EFA would have allowed the data collected to identify the factors driving the determinants of SME innovation. Use of regression analysis would have allowed hypotheses shaped in response to the existing SME innovation literature to be tested against the data. The EFA approach involves collecting as much data as is feasible with constructs informed by the literature and by previously used surveys. The regression approach involves framing appropriate hypotheses and then collecting data which best reflect the variables included in regression models suggested by those hypotheses. To some extent the two types of data may overlap since for the regression approach only data which adequately reflects variables in the model is required and other data can be discarded.

This two pronged approach, however, proved not to be possible since for logistical reasons, a second survey was not possible and the only data available for analysis was that collected from the pilot. Since the methodology of EFA requires that the number of observations be greater than the number of items included in the survey,[10] and this condition was not met with respect to the pilot, it proved not to be feasible to use EFA. While a larger data set would also have been desirable for regression analysis, the sample was judged to be large

[10] Cattell (1978) argues that the ratio of the number of variables to the number of observations (N/p) should be between 3 and 6 for EFA to be determinate. For the pilot study, this ratio was 74:90 (where 90 represents 97 in total minus 7 highly correlated variables). When there are more variables than observations, this may lead to mathematically indeterminate results which was confirmed when we ran EFA on the survey data using SPSS. No unique solution was found.

enough to identify issues that could be explored in the qualitative side of the research. It would also have been desirable to modify some of the questions used in the pilot survey to enhance the quality of data collected but it was also judged that sufficient usable data was available from the pilot to frame regressions that were capable of testing the hypotheses posed earlier in the thesis about the role of firm management characteristics in moderating the impact of external technological change on innovation in SMEs.

The regression model developed earlier in the thesis is replicated in equation (6.4):

$$Y_i = \alpha + \beta X_i + \boldsymbol{\gamma} \boldsymbol{Z}_{\mathbf{i}} + \boldsymbol{\mu} \boldsymbol{M}_i + \boldsymbol{\nu} \boldsymbol{C}_i + \boldsymbol{\vartheta}(X_{\mathrm{i}} * \boldsymbol{Z}_{\mathbf{i}}) + \boldsymbol{\varphi}(X_{\mathrm{i}} * \boldsymbol{M}_{\mathbf{i}}) + \varepsilon_i \quad (6.4)$$

where Y_i represents the innovation outcomes for each firm i, X_i represents the external technological change experienced by each firm, $\boldsymbol{Z_i}$ is a vector of knowledge-related characteristics for each firm, $\boldsymbol{M_i}$ is a vector of other management-related characteristics for each firm, $\boldsymbol{C_i}$ is a vector of control variables such as firm size and age, ε_i is a random error term, and α, $\beta, \boldsymbol{\gamma}, \boldsymbol{\mu}, \boldsymbol{\nu}, \boldsymbol{\vartheta}$ and $\boldsymbol{\varphi}$ are parameters or vectors of parameters to be estimated.

A unique dimension of this model that has not been discussed in the previous literature are the terms $\boldsymbol{\varphi}(X_{\mathrm{i}} * \boldsymbol{M}_{\mathbf{i}})$ which capture any influence on a firm’s innovation performance that is due to the interaction of internal management-related innovation drivers and external innovation drivers. It may be the case, for instance, that firms with particular management styles or the ability to respond to customers quickly and effectively are better able to take advantage of externally generated technical change in a way that is over and above the *direct* contribution that such internal factors make to innovation performance. The interaction terms in equation (6.1) are designed to capture such effects.

As suggested above, it had originally been expected that data for around 500 firms would be available to estimate the model in equation (6.4) but a series of unexpected developments meant that this did not eventuate, and that only data from the pilot survey was available for estimation. This greatly restricted the available number of degrees of freedom and thus the range of data management and estimation techniques that could be used. It was nevertheless decided to go ahead with model estimation using data from the pilot survey because quantifying the model had the potential to identify relationships between variables that could be used to inform the design of the qualitative dimension of the study. In other words, with appropriate qualifications about the limitations of the analysis, an estimated model might provide hints about aspects of innovation practice that could be probed at the case study stage of the analysis. The sub-sections below thus explain the econometric methodology employed and outline the main quantitative results.

6.3.1 Regression methodology

As outlined at the end of section 4.5 above, equation (6.4) was used to frame the collection of data via the survey so that the research questions outlined in chapter 4 could be answered. The relationship between the variables identified by equation (6.4) and the survey questions

Table 6-8: Summary Statistics

Variable	Short Name	Mean	Std. Error	Median	Mode	Std Dev	Variance	Skew	Kurt
No. Product Innovations	PROD1	5.62	0.82	3.00	3	7.13	50.81	2.70	8.53
No. Process Innovations	PROC1	2.54	0.49	2.00	0	4.17	17.38	5.31	35.24
Product Innovations 0-1	PROD2	0.91	0.03	1.00	1	0.30	0.09	-2.83	6.17
Process Innovations 0-1	PROC2	0.77	0.05	1.00	1	0.42	0.18	-1.31	-0.29
Technological Change Index	PERC	7.62	1.41	7.33	7	3.19	1.99	-1.98	4.46
Marketing Agility Index	MAG	6.33	1.22	6.50	9	1.22	1.49	-1.93	8.46
Collaboration Index	COL	4.08	2.52	5.13	6	2.52	6.37	-0.73	2.08
Culture Agility Index	CULT	7.38	1.53	7.45	8	1.53	2.34	-1.71	9.43
Training Expenditure	TRAIN	43,243	5,916	30,000	0	50,892	$2.59 \bullet 10^9$	2.19	5.71
CEO’s Education	ED1	2.99	0.16	3.00	4	1.34	1.794	-0.08	-1.14
Manager Ed (General)	ED2	46.03	4.12	38.85	100	35.49	1260.24	0.30	-1.34
Manager Ed (Management)	ED3	19.19	2.97	10.00	0.00	25.41	646.15	1.77	2.87
Employee Ed (General)	ED4	17.61	3.12	3.50	0.00	26.85	721.01	1.70	1.80
Employee Ed (Management)	ED5	5.60	1.58	0.00	0.00	13.55	183.72	4.16	21.50
Employee Experience	EXPER	3.70	0.09	4.00	4	0.74	0.54	-0.53	0.27
CEO Motivation	MOTV	2.54	0.11	3.00	3	0.94	0.88	0.75	3.60
No. Employees	EMP	1.87	0.12	2.00	1	1.04	1.08	1.79	4.00
Revenue	REV	1.43	0.09	1.00	1	0.81	0.66	2.04	3.54
Sector	SECT	5.65	0.34	7.00	7	2.92	8.53	-0.48	-1.30
Base Location	BASE	3.34	0.22	3.00	5	1.90	3.60	0.45	-0.48
Age	AGE	26.80	2.93	20.50	8	25.21	635.32	3.36	15.97

used to generate that data is outlined in Table 5.4 and the data from individual survey questions was described in section 6.2 above. Table 5.4 indicates that four variables were measured using indices which incorporate information from a number of questions in the survey. This was done to provide a more comprehensive measure of the relevant firm characteristic than data from the answer to a single question might have provided. The four characteristics measured in this way were external technological change perceived by the firm, marketing agility, collaboration and culture (explained below). Table 6.8 provides summary statistics for all of the variables identified in Table 5.4 and constructed from the survey data for use in estimating equation (6.4). Noteworthy is the mean spread of the number of product and process innovations at 5.62 and 2.54 respectively, which suggests that product innovations were almost double that of innovations in processes. However, the standard deviation for the number of product innovations was found to be higher than for process innovations (SD of 7.1 against 4.1).

The indices used to measure the four firm characteristics mentioned above were constructed by choosing questions from the survey that represented important aspects of the relevant variable and taking their average value. This was aimed at providing a richer measure of the firm characteristic in question than taking the response to a single question (see Acs et al. 2008). Consideration was given to the relative significance of the aspects about which questions were asked in the survey in light of the literature discussed in chapter 3 to insure that excessive weight was not given to aspects of the particular characteristic that were not warranted from a theoretical perspective. Questions, for example, originally designed to cross check responses by repeating a question in reverse-coded form were excluded unless the additional weight that would have been attached to that aspect of the firm characteristic by inclusion of this question was warranted on theoretical grounds. In addition, some of the questions used in the pilot survey were taken from surveys in various published studies and were to be modified in the revised survey after our experience with them in the pilot. As discussed above, however the revised survey was not able to be conducted. Where questions relating to exogenous variables were to be modified because of the possibility that they may have introduced endogeneity, for example by referring explicitly to innovation, these questions were excluded from availability to calculate a particular index.

These four indices were calculated using the following expression:

$$INDEX = \frac{10}{(J+K)\cdot 5}\cdot\left[\sum_{j=1}^{J} LK_j + \sum_{k=1}^{K}(6 - LK_k)\right]$$

where LK_j represents a firm's Likert response to question *j*, *J* represents the number of responses to directly coded questions included in the index, LK_k represents the Likert response to question *k*, and *K* represents the number of *reverse* coded responses included in the index (since the expression $[6 - LK_k]$ effectively reverse codes the response to question k. Since all relevant Likert scales used in the survey were coded over 5 responses, the fraction $10/(J + K) \cdot 5$ scales the sum of J+K individual responses to a number out of 10.

Table 6-9: Reduction of Variables to Enhance Model Tractability.

Variables	No. Survey Questions	Reduced to
Technological Change	10	3
Marketing Agility Index	8	6
Collaboration Index	37	23
Culture Agility Index	12	11
Training Expenditure	5	1
CEOS Education	6	1

As explained above, four indices were created in this way. The first of these indices measured the owner's perception of the external technological change. This was called the perceived technological change index, *PERC*. As Table 6-9 indicates, 10 survey questions asked about some aspect of the perception of external change. It was, however decided, to exclude Q8 on the grounds that it would introduce endogeneity (given its inherent relation to the dependent variable). Q11 had 8 sub-questions which focused on how a firm learnt about external technological change. On careful consideration, it could be argued that these questions did not relate to the perception of change as much as to inquire into the source of that perception. This might not contribute to technological changes to same extent as other questions and hence these questions were excluded. This left three usable questions for the index for this firm characteristic with J =3 and K = 0.

The second of the indices measured the overall ability of a firm to respond to customer needs. This was called the *marketing agility index*, *MAG*. As Table 6-9 indicates, 8 original survey questions asked about some aspect of this firm characteristic. It was, however, decided to exclude Q15 on the grounds that it would introduce endogeneity, while Q17 and 18 were sufficiently closely related that it was judged that the literature justified the inclusion of only one of them (18). This left 6 usable questions for the index for this firm characteristic with J =6 and K = 0.

The third index provided a measure of the extent to which firms encouraged collaboration both internally and externally to generate innovation. This was called the *collaboration index*, *COL*. A meta-analysis conducted by Rosenbusch et al. (2011) of the relationship between innovation and the performance of SMEs covering 42 empirical studies and 21,270 firms found that internal and external collaborations both help to reduce complexity, create technological expertise and speed up the innovation process. These partners could be a range of partners to develop and implement new and improved ideas thus having a positive impact on innovation and SME performance. The original survey had 37 questions relating to this firm characteristic. Q41, however, related to *learning* about collaboration rather than the extent of some collaborative behaviour or feature of the firm, and was seen as unlikely to account for the fundamental idea above. It was, therefore, not used to calculate the index. Further, Questions 42, 45, 47, 48, 50 and 51 included reference to innovation that might introduce endogeneity into the regression. Q49, which was taken from an existing survey (Agarwal & Selen 2009, p. 470) was found to contain jargon which could have been misunderstood by respondents and was also excluded. This left 23 usable questions for construction of the *COL* index.

The fourth index was designed to reflect the overall management culture of the firm and to assess such things as the extent to which employees felt that they could take risks that might lead to profitable innovations for the firm. This was labelled the *management culture index*, *CULT*. The original survey had 12 questions relating to this firm characteristic. Q53 was removed because it introduced endogeneity leaving 11 usable questions.

A further econometric challenge arose from specification of the functional form in which the regression model (equation 6.4) should be estimated. The model was initially estimated in levels but this specification performed extremely poorly and is not reported. Alternative specifications such as an exponential or semi-log form could not be used due to the presence of nil values for several observations in both the explanatory variable (innovation performance) and dummy independent variables. A common estimation strategy used in the innovation literature is to make the dependent innovation variable dichotomous and then to use a *logistic* or *logit* estimated by the maximum likelihood method (see, for example, Vega-Jurado *et al.* 2008).

What this approach would entail in the present study is to posit that the probability of a firm undertaking some innovation is a function of the external innovation factors, the internal innovation factors, the interaction between those two sets of factors, and a number of control variables. This is shown in (6.5):

$$P_i = F(\alpha + \beta X_i + \boldsymbol{\gamma Z_{\mathrm{i}}} + \boldsymbol{\mu M_i} + \boldsymbol{\nu C_i} + \boldsymbol{\vartheta}(X_{\mathrm{i}} * \boldsymbol{Z_{\mathrm{i}}}) + \boldsymbol{\varphi}(X_{\mathrm{i}} * \boldsymbol{M_{\mathrm{i}}}) + \varepsilon_i) \qquad (6.5)$$

where P_i is the probability that a firm undertakes some form of innovation and all of the other terms have the same meaning as in equation (6.4). The *logit* model assumes that the function $F(^{\cdot})$ is the cumulative logistic function so that (6.5) can be re-written as:

$$P_i = \frac{1}{1+e^{-(\alpha+\beta X_i+\boldsymbol{\gamma Z_\mathrm{i}}+\boldsymbol{\mu M_i}+\boldsymbol{\nu C_i}+\boldsymbol{\vartheta}(X_\mathrm{i}*\boldsymbol{Z_\mathrm{i}})+\boldsymbol{\varphi}(X_\mathrm{i}*\boldsymbol{M_\mathrm{i}})+\varepsilon_i)}} \tag{6.6}$$

Some straightforward manipulation transforms (6.6) into the following expression:

$$ln\ \frac{P_i}{1-P_i} = \alpha + \beta X_i + \boldsymbol{\gamma Z_\mathrm{i}} + \boldsymbol{\mu M_i} + \boldsymbol{\nu C_i} + \boldsymbol{\vartheta}(X_\mathrm{i} * \boldsymbol{Z_\mathrm{i}}) + \boldsymbol{\varphi}(X_\mathrm{i} * \boldsymbol{M_\mathrm{i}}) + \varepsilon_i \tag{6.7}$$

which can be estimated using the maximum likelihood method (see Gujarati & Porter 2009, p. 562).[11]

Three different algorithms were considered for model selection once equation (6.7) was initially estimated: *forward selection* where variables are progressively added to improve overall model performance (Soroush, Bahreininejad & van den Berg 2012); *backward elimination* where variables are removed from the largest model dictated by the theoretical rationale developed from the literature (Soroush et al. 2012); and *stepwise regression* where variables can be both added and removed to improve statistical fit (Bradley et al. 1998).

This fit can be determined using the McFaddens R^2, a specification of the standard goodness of fit measures for binary models (Gujarati & Porter 2009, p. 563) with *Akaike Information Criterion* and evaluating the deviation of innovation probabilities predicted by the model with actual probabilities. A lower AIC value indicates a better fit. The AIC takes into account the fact that as parameters are added in a model the sum of squares should fall thus apparently improving the model's fit. It therefore adds a *penalty* by including a term that increases with the number of explanatory variables (Posada & Buckley 2004). With respect to ability to predict innovation probabilities, comparison between models was made based on the percentage of firms for whom the model correctly predicted whether they would innovate. Gujarati and Porter (2009, p. 563) argue, however, that goodness of fit is of secondary importance in interpreting binary models. What is important is the sign and statistical significance of the regression coefficients. This approach is consistent with the methodology of this thesis where the quantitative results from these regressions are designed to identify issues for further exploration in qualitative analysis.

[11] These regressions were estimated using Eviews. Diagnostics were conducted with a full data matrix where the outcome variables were resp. product and process innovation. As each factor constituted of different variables aiming to measure a particular construct, the next step was to select important variables representing internal and external factors. The variable selection is a "*process of choosing a subset of the original predictive variables by eliminating variables with little predictive information*" (Kim 2006, p. 544), in order to determine the accuracy of the model such that generalised conclusions could be made.

The procedure followed was thus to run a *baseline* model that included only the direct effects of internal and external factors and then to use a process of stepwise backward elimination to decide on a final model *without* interaction effects. This model was then used as a secondary baseline to which were added interaction effects, and a similar process of backward elimination was used to refine this model. This was done separately for product and process innovation using the perception (of the importance of external technological change) variable, *PERC*, and again for both product and process innovation using the growth accounting index for external technological change, *TP*. The following section reports the results from these regressions.

6.3.2 Results

Table 6-10 reports results from the first set of logit regressions in which *product* innovation (or more precisely in which the log of the odds ratio that a firm in the sample would undertake product innovation) was the dependent variable. The measure of external technological change used in these regressions was *PERC*, the first index constructed using survey responses to the *three* most relevant items about perceived technological change. Other explanatory variables are listed in the table including three control variables, the age of the enterprise, *AGE*, firm revenue, *REV*, and the number of staff employed, *STAFF*.

Model 1 reported in Table 6-10 included *all* firm characteristics but no interaction effects between these characteristics and external technological change due to the small number of degrees of freedom. Two variables were statistically significant for this model.[12] The first was *ED2*, the general education of managers, which was significant at the 10% level and the sign of which was positive, indicating that firms with managers possessing a higher level of general education were more likely to engage in product innovation than firms with less educated managers. The second variable was *COL*, the degree of collaboration in the firm, which was significant at the 5% level and which also had a positive sign, indicating that firms which engaged in more collaborative behaviour were more likely to generate product innovations than firms with which collaborated to a smaller degree. It is interesting to note that external technological change itself appears to have no impact on the likelihood a firm will innovate. *McFadden* R^2 indicates that this model accounts for about 29% of the variation in the log of the odds ratio. The *Likelihood Ratio (LR)* statistic is relatively low and

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[12] See Gujarati and Porter (2009, p. 563) who argue for this focus on coefficient sign and statistical significance in judging the useful of binary regression models.

statistically insignificant at the 10% level. *Model 1*, therefore, does not provide a particularly satisfactory account of product innovation for firms in the survey.

Model 2 was generated by a process of backwards elimination taking *Model 1* as the starting point. The least statistically significant variable was removed and the model re-run in a step-wise fashion until it was judged that the resulting model provided a sufficiently better account of the variation than Model 1. Table 6-10 indicates that the same two variables, *ED2* and *COL*, were statistically significant in this model with the same signs as in *Model 1*.

Interaction effects between the explanatory variables retained in *Model 2* and *PERC* were then included to generate *Model 3* but this model performed on slightly better than *Model 2*. Adding interaction effects improved *McFadden's* R^2 and reduced the *Akaike Information Criterion* only slightly compared to *Model 2*, only *MOTV*, the nature of CEO motivation, was statistically significant and none of the interaction terms at all were significant at the 10% level. The interaction of external technological change with *MOTV* was, however, only just outside this level of significance (with a *p*-value of 0.12) and a negative sign. This might be taken as weak evidence of an effect of motivation in moderating the impact of external technological change on product innovation where firms whose CEOs are *intrinsically* motivated are more likely to engage in product innovation than firms whose CEOs are motivated by profit. The same backwards elimination process that had been applied to *Model 1* was also then applied to *Model 3* but *only* to the interaction terms to ensure that the *direct* effect of any endogenous variable whose interaction with external technical progress was statistically significant in the final model was not removed. In this case the coefficient of interaction terms indicates the marginal effect on innovation of the two terms working together over and above the direct effects from separate terms in the interaction. This procedure produced *Model 4* in Table 6-10. The results for *Model 4*, indicate that the direct effects of *ED2* and *MOTV* on product innovation were statistically significant at the 10% level or better, both with positive effects, but *none* of the interaction terms were significant at the 10% level. This suggests that firms with managers whose general education level was higher and with CEOs motivated by profit were more likely to engage in product innovation than other firms. A similar result was, however, obtained in this model for the interaction term between *PERC* and *MOTV* as was obtained for *Model 3*, suggesting weak evidence for an effect of CEO motivation in mediating the effect of external technical change on product innovation.

Table 6-10: Results of Multinominal Logistic Regressions for *Product* Innovation using the *Perceived* Measure Index for Technological change (PERC) and other indices.

Variable	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)
Intercept	-3.8248	0.2802	-3.7181	0.1387	-11.5518	0.4501	-11.5411	0.4204	-2.6065	0.3799	-16.1965	0.0996*
PERC	0.1855	0.5190	0.1085	0.6704	1.2006	0.5511	1.2214	0.5103	-0.0749	0.8326	1.8231	0.1650
ED1	0.0113	0.9709										
ED2	0.0302	0.0935*	0.0303	0.0370**	-0.0076	0.9281	0.0284	0.0594*	-0.0033	0.9616	0.0287	0.0462**
ED3	0.0021	0.9297										
ED4	-0.0239	0.2971	-0.0230	0.2042	-0.0728	0.6077	-0.0235	0.1920	-0.0628	0.6225	-0.0233	0.1843
ED5	-0.0139	0.7040										
TRAIN	0.0000	0.8683										
COL	0.3070	0.0444**	0.3402	0.0126**	0.8242	0.3986	0.6921	0.4522	0.3456	0.0153**	0.3208	0.0216**
EXPER	0.3058	0.5314	0.2529	0.5814	-1.4094	0.7295	-1.8436	0.6187	0.2987	0.5427	0.2990	0.5432
MOTV	0.5777	0.1718	0.5944	0.1303	6.0479	0.0891*	6.1573	0.0935*	0.6034	0.1290	5.5162	0.1110
MAG	0.1138	0.7278										
CULT	-0.0043	0.9880										
AGE	-0.0231	0.2586										
REV	-0.6695	0.3893										
STAFF	0.0132	0.4636										
PERC * ED1												
PERC * ED2					0.0047	0.6598			0.0046	0.6169		
PERC * ED3					0.0067	0.7187			0.0052	0.7553		
PERC * ED4												
PERC * ED5												
PERC * TRAIN												
PERC * COL					-0.0681	0.5956	-0.0520	0.6672				
PERC * EXPER					0.2368	0.6636	0.2888	0.5553				
PERC * MOTV					-0.7569	0.1191	-0.7690	0.1235			-0.6768	0.1490
PERC * MAG												
PERC * CULT												
PERC * AGE												
PERC * REV												
PERC * STAFF												
McFadden R-squared		0.2846		0.2521		0.3100		0.3027		0.2605		0.2969
Akaike Info Citerion		1.1538		0.9433		1.0200		0.9734		0.9888		0.9251
Predicted Probabilities (%)		85.14		83.78		85.14		85.14		82.43		85.14
LR statistic (df)		21.23		18.81		23.13		22.58		19.44		22.15
p-value		0.1296		0.0045		0.0169		0.0072		0.0127		0.0024

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

Two strategies were then employed to test the robustness of these results. Firstly, *individual* interaction terms were added to *Model 2* one at a time to see whether the addition of any individual effects could improve the performance of that model. None of these additions, however, was dramatically successful in improving that performance and the results of this approach are not reported. Secondly, interaction effects for all *knowledge-related* variables (*ED1 to ED5* and *TRAIN*) were added to *Model 2* and a process of backwards elimination was applied just to *these* interaction effects to see whether the performance of *Model 2* could be enhanced. The results of this procedure are reported as *Model 5* in Table 6-10. This procedure was repeated but adding instead all *implementation capability* variables (*COL*, *EXPER*, *MOTV*, *MAG*, and *CULT*) to *Model 2*. The results of this procedure are reported as *Model 6* in Table 6-10.

In *Model 5*, only *COL*, the degree to which firms collaborate with a variety of partners was significant at the 5% (in fact at the 2%) level with none of the interactions terms significant. In *Model 6*, the direct effects of both *ED2* and *COL* were both significant at the 5% level with none of the interaction terms significant. Similar weak evidence for the interaction effect of *MOTV* with external technical progress as in *Model 3* and *4* was, however, present in *Model 6*.

The overall implication of the results reported in Table 6-10 thus suggest that collaboration and the general education of managers were important factors in *directly* affecting product innovation. These variables were statistically significant in four models of the models reported in Table 6-10. The more educated were managers, the more likely were the firms they oversee to innovate. There is also weak evidence for a negative interaction effect between motivation and external technological change on product innovation suggesting the possibility that firms with CEOs motivated by intrinsic goals such as taking pride in the service of the firm are more likely to use external technological change to engage in product innovation than firms with CEOs motivated by profit.

Table 6-11 reports results from a second set of regressions obtained using the same methodology as the first set but taking the log of the odds ratio for *process* innovation as the dependent variable rather than that for product innovation. Once again, the model was initially estimated without interaction effects due to the available degrees of freedom. This is reported as *Model 1* in Table 6-11. For this model, *PERC*, *ED2*, *TRAIN* and *MAG* all possessed statistically significant, positive coefficients, while *ED1*, *ED4, EXPER* and *STAFF* possessed statistically significant but negative coefficients. Thus, firms experiencing *greater* external technological change, with *better* generally educated managers, spending *more* on training, and having a *greater* index for marketing agility were *more* likely to introduce process innovations than firms with the opposite characteristics. However, firms with *less* educated CEOs and shopfloor workers, with a *less* experienced and *smaller* staff were also more likely to engage in process innovation.

These results warrant some reflection. The various effects of education outlined above suggest that the key person is the firm manager. This makes sense if the manager is the key planner and day to day decision maker so that their ability to handle information affects the operation of the firm in an important way. It may well be than having better educated CEOs and workers leads to conflict with the manager so that when these parties are less educated they bring other skills to the running of the firm that avoid this conflict. The positive effect of *TRAIN*, however, suggests that *targeted* education for workers probably associated with specific firm processes is very important for process innovation. On the other hand, causality may run the other way since firms engaging in more process innovation are more likely to need to train workers in these new processes. The positive effect of *MAG* suggests that firms who listen and are responsive to customers and able to exploit market opportunities are more likely to generate internal processes that can be used to facilitate this responsiveness than other firms. The negative effect of *EXPER* and *STAFF* may suggest that smaller and younger firms are more open to change than larger and older firms which may have established patterns of operation they are less willing to alter.

The process of backwards elimination, applied to *Model 1* produced *Model 2* which did not differ greatly from the initial model in terms of *McFadden's* R^2, the *Akaike Information Criterion* or the proportion of predicted probabilities. *Model 3* was obtained by adding interaction effects between the variables included in *Model 2* and external technological change but few variables were individually significant at the 10% level although the overall diagnostic statistics were superior than those for *Model 2*. Backwards elimination applied to the interaction terms in *Model 3* produced *Model 4*. Most of the coefficients statistically significant in *Models 1* and *2* were also significant in *Model 4* and in addition, the interaction effects between external technological change and the education of the CEO and the general education of the workforce were significant although positive indicating effects for these education variables working in the opposite direction to their direct effects. This suggests that the education of the CEO and workers plays a positive role in modifying the impact of external technological change on innovation outcomes. The interaction effects of *MAG* and *CULT* were insignificant at the 10% level but only just outside this level with *MAG* exerting a negative effect and *CULT* exerting a positive effect.

The two strategies discussed above to test the robustness of these results for the first set of regressions was used again on this second set. Firstly, *individual* interaction terms were added to *Model 2* one at a time to see whether the addition of any individual effects could improve the performance of that model. As above, none of these additions was effective in improving the performance of *Model 2* and the results are not reported. Secondly, interaction effects for all *knowledge-related* variables (*ED1 to ED5* and *TRAIN*) were added to *Model 2* and a process of backwards elimination was applied just to *these* interaction effects to see whether the performance of *Model 2* could be enhanced. The results of this procedure are reported as *Model 5* in Table 6-11. This procedure was repeated but adding instead all *implementation capability* variables (*EXPER*, *MOTV*, *MAG*, and *CULT*) to *Model 2*. The results of this procedure are reported as *Model 6* in Table 6-11.

The results for *Model 5* indicate broadly the same results for direct effects as do those of *Model 4* with the exception of external technical change *PERC* which has a statistically significant, negative effect on innovation and *CULT* which has a statistically significant, positive effect. The effect of education variables is very similar to those of *Model 4*. The results for *Model 6* reinforce the general results from *Model 4* including the possibility that *MAG* has a negative interaction effect with external technical change which is here statistically significant at the 5% level. Given that the direct effect of *MAG* on innovation is positive, this may suggest that firms with strong marketing agility characteristics focus the attention of these characteristics on applying the technologies already available to the firm in meeting the demands of customers, thus generating process innovations, but are not so good at adapting new technological developments in meeting these demands. This result is counter to expectation but may well reflect a limit to the complexity that firms can cope with in managing innovation. Those responsible for focusing on customer needs may thus be unable to simultaneously monitor and adapt new technological developments to this end because their capacities are already fully absorbed adapting the technology *they already know* to meeting these needs.

Overall, the results reported in Table 6-11 highlight the importance of the direct impact on innovation of four firm characteristics: *MAG*, whether the customers input and a firm's ability to respond to their needs; *TRAIN*, the level of expenditure on training which may be a consequence of innovation rather than a cause; *ED1*, the level of education of the firm's owner which tends not to be high for firms that innovate; and *ED2*, the level of general education of firm managers, which tends to be better for firms that innovate. These four effects are statistically significant in almost all of the models reported in Table 6-11. In addition, these results suggest that the impact of external technological change on process innovation depends on internal firm characteristics such as the education of firm owners and/or of the average employee in the firm. Although the direct effect of firm owners'

Table 6-11: Results of the Multinominal Logistic Regressions for *Process* Innovation using the *Perceived* Index Measure for Technological change (PERC).

Variable	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)
Intercept	-16.1350	0.0087***	-15.2688	0.0057***	-343.6140	0.2634	-69.7886	0.3823	6.2750	0.5908	-48.9187	0.0662*
PERC	1.1640	0.0086***	1.0985	0.0093***	41.6322	0.2926	5.6994	0.5913	-3.4887	0.0633*	4.7747	0.1449
ED1	-0.8640	0.0388**	-0.8171	0.0341**	-32.5942	0.1264	-20.4916	0.0316**	-13.5168	0.0316**	-1.0678	0.0271**
ED2	0.0603	0.0133**	0.0536	0.0084***	0.8383	0.1798	0.5471	0.1437	0.2855	0.2295	0.0685	0.0085***
ED3	-0.0086	0.7006										
ED4	-0.0385	0.0539*	-0.0352	0.0542*	-2.2927	0.4946	-1.9538	0.0692*	-1.2528	0.0935*	-0.0534	0.0329**
ED5	0.0106	0.7143										
TRAIN	0.0001	0.0046***	0.0001	0.0041***	0.0007	0.7701	0.0001	0.0078***	0.0001	0.0071***	0.0001	0.0026***
COL	-0.1028	0.6076										
EXPER	-1.5812	0.0354	-1.5254	0.0333**	5.1502	0.8525	-2.1385	0.0643*	-1.5258	0.1058	-1.3982	0.0828*
MOTV	0.6685	0.1918	0.6546	0.1929	74.4921	0.6037	1.1511	0.1433	0.8724	0.1721	0.9228	0.1028
MAG	1.2005	0.0098***	1.0876	0.0078***	40.4049	0.1215	21.7486	0.0972*	2.0082	0.0036***	9.7610	0.0173**
CULT	0.5966	0.1651	0.5843	0.1406	-16.5692	0.4848	-4.7630	0.1910	1.4870	0.0613*	-2.3514	0.2548
AGE	0.0088	0.6693										
REV	1.2100	0.2587	1.1953	0.2528	6.5255	0.1891	1.6482	0.3736	1.0754	0.5066	1.0640	0.3526
STAFF	-0.0523	0.0753*	-0.0468	0.0843*	-0.1441	0.2086	-0.0592	0.1406	-0.0366	0.2586	-0.0545	0.0735*
PERC * ED1					3.9163	0.1422	2.5094	0.0385**	1.6413	0.0404**		
PERC * ED2					-0.0943	0.2244	-0.0605	0.1967	-0.0291	0.3281		
PERC * ED3												
PERC * ED4					0.2944	0.5183	0.2564	0.0759*	0.1639	0.1024		
PERC * ED5												
PERC * TRAIN					-0.0001	0.8283						
PERC * COL												
PERC * EXPER					-1.1053	0.7737						
PERC * MOTV					-10.0719	0.6068						
PERC * MAG					-4.9363	0.1343	-2.5838	0.1283			-1.1246	0.0308**
PERC * CULT					2.6670	0.4343	0.9476	0.1045			0.4625	0.1236
PERC * AGE												
PERC * REV												
PERC * STAFF												
McFadden R-squared		0.4706		0.4638		0.7716		0.7140		0.6494		0.5446
Akaike Info Citerion		1.0502		0.9501		0.8071		0.7932		0.8146		0.9099
Predicted Probabilities (%)		86.49		83.78		95.95		93.24		93.24		86.49
LR statistic (df)		40.64		40.06		66.64		61.67		56.08		47.03
p-value		0.0004		0.0000		0.0000		0.0000		0.0000		0.0000

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

education levels does not seem to be important, firm owner's education and that of general employees seems to be important for how external technological change is harnessed to generate process innovation. In addition there does seem to be evidence that marketing agility also plays a role in modifying the impact of technological change on innovation with agile firms making less use of this technological change than less agile firms possibly because these capacities are fully focused on meeting customers' needs using technologies with which the firm is already familiar. This may suggest a limit to the complexity a firm can cope with in innovation. There is also weak evidence that a firm with a culture more tolerant of employees taking chances and making mistakes is able to make better use of technological change in generating process innovation.

As suggested earlier in this chapter, a potential limitation of the *PERC* measure of external technological progress is that since it is perceptions-based it may not reflect the true nature of that change but may involve some kind of perception error. Its use can certainly be defended since the firm's innovative reaction to external change must in the end depend on how external developments are perceived within the firm but it would nonetheless be useful to employ a more independent measure of external technological change. To this end an alternative measure for external technological progress was constructed from ABS data as described earlier in this chapter. The *PERC* measure of external technological change used in the regressions reported in Tables 6-10 and 6-11 was thus replaced with the *TPG Total L* measure from Table 6-5 and the same procedures as described above repeated to test the robustness of the results obtained in Tables 6-10 and 6-11. This variable was simply called *TP* and results for product and process innovation regressions using this measure for technological change are reported in Tables 6-12 and 6-13 respectively.

The results for *product* innovation without the inclusion of any interaction terms are reported as *Model 1* in Table 6-12. In this model only the coefficients of *ED2* and *COL* were statistically significant with both being positive. The application of backwards elimination to this first model produced *Model 2* in which *TP* and *MOTV* were statistically significant in addition to *COL* and *ED2* each with a positive effect on product innovation. This was broadly in line with the results obtained above using the *PERC* measure for external technological change and reported in Table 6-10 except that *PERC* was not statistically significant in *Model 2*. The addition of interaction effects between *TP* and each of the firm characteristics included in *Model 2* produced *Model 3* which did not perform very favourably compared to *Model 2* on the basis of *McFadden's* R^2 and the *Akaike Information Criterion*. The application of backwards elimination to this model produced *Model 4* in which again the direct effects of *ED2* and *COL* were statistically significant. Again,

Table 6-12: Results of Multinominal Logistic Regressions for *Product* Innovation using *Externally* Measured Technological change (TP).

Variable	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)
Intercept	-3.7964	0.2806	-3.7583	0.0850*	-3.3608	0.1364	-3.3913	0.1281	-3.2351	0.1539	-3.2117	0.1524
TP	0.1586	0.1949	0.1825	0.0922*	-0.4578	0.4487	-0.4369	0.4321	-0.3776	0.5067	-0.2718	0.6085
ED1	-0.0154	0.9612										
ED2	0.0360	0.0650*	0.0335	0.0287**	0.0321	0.0855*	0.0322	0.0866*	0.0351	0.0275**	0.0335	0.0319**
ED3	-0.0039	0.8720										
ED4	-0.0228	0.3326	-0.0251	0.1837	-0.0384	0.1892	-0.0380	0.1912	-0.0395	0.1340	-0.0229	0.2436
ED5	-0.0100	0.7843										
TRAIN	0.0000	0.9581										
COL	0.3207	0.0410**	0.3445	0.0151**	0.2838	0.0944*	0.2804	0.0910*	0.3009	0.0417**	0.3442	0.0161**
EXPER	0.3219	0.4986	0.3252	0.4827	0.3347	0.5247	0.3253	0.5282	0.2810	0.5925	0.1717	0.7351
MOTV	0.6497	0.1412	0.6828	0.0934*	0.7194	0.1856	0.7473	0.0921*	0.6874	0.1034	0.7151	0.0854*
MAG	0.1572	0.6552										
CULT	-0.0013	0.9963										
AGE	-0.0085	0.6906										
REV	-0.5590	0.4857										
STAFF	0.0102	0.5846										
TP * ED1												
TP * ED2					0.0021	0.7151	0.0021	0.7210				
TP * ED3												
TP * ED4					0.0055	0.5231	0.0054	0.5292	0.0066	0.3433		
TP * ED5												
TP * TRAIN												
TP * COL					0.0160	0.7638	0.0167	0.7533				
TP * EXPER					0.1121	0.4300	0.1150	0.4056	0.1229	0.3861	0.1169	0.3868
TP * MOTV					0.0129	0.9290						
TP * MAG												
TP * CULT												
TP * AGE												
TP * REV												
TP * STAFF												
McFadden R-squared		0.3034		0.2900		0.3168		0.3167		0.3130		0.3001
Akaike Info Citerion		1.1348		0.9050		1.0131		0.9862		0.9359		0.9219
Predicted Probabilities (%)		85.14		82.43		85.14		85.14		83.78		83.78
LR statistic (df)		22.64		21.64		23.64		23.63		23.35		22.39
p-value		0.0922		0.0014		0.0143		0.0086		0.0029		0.0022

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

Table 6-13: Results of Multinominal Logistic Regressions for *Process* Innovation using *Externally* Measured Technological change (TP).

Variable	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)
Intercept	-7.0013	0.0622*	-6.7934	0.0446**	-4.9178	0.2784	-4.2477	0.2992	-5.6713	0.0811*	-9.0054	0.0634*
TP	-0.0692	0.5247	-0.0626	0.5259	-0.2706	0.8434	-0.5644	0.6205	0.0209	0.9414	1.0198	0.4010
ED1	-0.5888	0.0778*	-0.5206	0.0812*	-0.6567	0.1221	-0.6486	0.1162	-0.5885	0.1336	-0.5841	0.0689*
ED2	0.0360	0.0486**	0.0368	0.0116*	0.0253	0.1854	0.0230	0.2106	0.0220	0.2364	0.0396	0.0088***
ED3	0.0081	0.7058										
ED4	-0.0201	0.2557	-0.0202	0.1984	-0.0267	0.1426	-0.0267	0.1412	-0.0269	0.1386	-0.0209	0.1820
ED5	0.0093	0.7565										
TRAIN	0.0000	0.0263**	0.0000	0.0340**	0.0000	0.0945*	0.0000	0.0264**	0.0000	0.0256**	0.0000	0.0323**
COL	0.0834	0.6209										
EXPER	-0.9954	0.0978*	-0.8048	0.1293	-1.1615	0.0936*	-1.2083	0.0773	-1.1541	0.0825*	-0.7966	0.1379
MOTV	0.5073	0.2678	0.4601	0.2573	0.1824	0.7000	0.1677	0.7193	0.1759	0.7037	0.4349	0.2876
MAG	0.7488	0.0342**	0.6941	0.0292**	0.6992	0.0730*	0.6217	0.0670*	0.6263	0.0651*	0.9113	0.0137**
CULT	0.6491	0.0593*	0.6731	0.0429**	0.8131	0.1319	0.8301	0.0948*	0.9820	0.0190**	0.8111	0.1358
AGE	0.0038	0.8556										
REV	0.4642	0.6336										
STAFF	-0.0181	0.3985										
TP * ED1					-0.1775	0.1071	-0.1816	0.0979*	-0.1682	0.1129		
TP * ED2					0.0113	0.0563*	0.0122	0.0311**	0.0114	0.0322**		
TP * ED3												
TP * ED4												
TP * ED5												
TP * TRAIN					0.0000	0.9314						
TP * COL												
TP * EXPER												
TP * MOTV												
TP * MAG					-0.0594	0.6708					-0.1459	0.2175
TP * CULT					0.1023	0.5718	0.0860	0.5964			-0.0231	0.8778
TP * AGE												
TP * REV												
TP * STAFF												
McFadden R-squared		0.3676		0.3523		0.4457		0.4436		0.4402		0.3716
Akaike Info Citerion		1.1705		1.0262		1.0523		1.0008		0.9776		1.0577
Predicted Probabilities (%)		78.38		78.38		85.14		83.78		82.43		77.03
LR statistic (df)		31.75		30.43		38.49		38.31		38.02		32.09
p-value		0.0070		0.0004		0.0004		0.0001		0.0001		0.0007

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

interaction terms between *TP* and specific internal firm characteristics were individually added to *Model 2* to see whether these outperformed *Model 3*. The two best of these models are reported as *Models 5* and *6* in Table 6-12. In each case the previous results obtained concerning *COL* and *ED2* were confirmed but no interaction terms were statistically significant.

Table 6-13 reports the results of regressions for *process* innovation using the *TP* measure for external technological change. In the base model, *Model 1*, the general education of firm managers, expenditure on training, market agility and cultures that facilitate risk-taking without recrimination for failure, all exert positive influences on the likelihood of innovation and are statistically significant, while the CEO's education and firm experience had negative coefficients which were significant at the 10% level. Backwards elimination essentially confirms the sign and significance of these variables.

The addition of interaction effects for the variables in *Model 2* again produces *Model 3* and backwards elimination applied just to the interaction terms in *Model 3* produces *Model 4*. The only statistically significant direct effects in *Model 3* are for *TRAIN* (positive), *EXPER* (negative) and *MAG* (positive), and the only statistically significant interaction effect is for the general education of managers, *ED2*, which has a positive effect. The education of the CEO is just outside the rejection region at 10.71%. Backwards elimination applied to just the interaction terms produces similar results except that *CULT* now has a statistically significant and positive effect on innovation and both education of the CEO is now statistically significant. None of the robustness regressions using individual effects produced interaction effects that were statistically significant at anything close to the 10% level (these have not been reported). Adding *knowledge-related* variables to *Model 2* and then eliminating variables with insignificant coefficients produced *Model 5* which is broadly in line with *Model 4* except that the education of CEOs lies just outside the region of significance. Following the same procedure with the addition of *implementation capability* variables to *Model 2* produced no statistically significant interaction effects at anything close to the 10% level. In general, the models in Table 6-13 using the *TP* measure for technical progress had significantly lower values for *McFadden's* R^2 than the models in Table 6-11 that used *PERC* as well as poorer values for the *Likelihood Ratio* statistic. Their performance was thus generally poorer than the models using *PERC* instead of *TP*.

Overall, Table 6-13 reinforces the importance of the manager's level of education, firm expenditure on training (with the same qualifications made above), and a firm's marketing agility for directly increasing the likelihood of process innovation. There is also evidence for knowledge-related interaction effects with external technical change. There is weaker evidence for the importance of the direct effect of firm culture but no evidence of interaction between external technological change and non-knowledge related internal firm characteristics. The difference between results in Tale 6-11 and 6-13 suggests that firm perceptions of external technological change are very important in affecting innovation performance.

The robustness of the results reported above to the specification of the indices for *PERC*, *MAG*, *COL* and *CULT* were tested using two techniques. First Cronbach's alpha, as discussed in Chapter 5, was used. The reliability of the scale is reflected in the relatively high *PERC* (0.68), *MAG* (0.62), *COL* (0.54) and *CULT* (0.92) measure of internal consistency. The Cronbach's alpha for the *COL* index was quite near to the cut off limit, that is 0.5, probably because of the limited number of observations in comparison to the scale items as argued by Peterson (1994a).

The second approach to checking the robustness of the above results was to vary the precise construction of the four indices used to measure technological change, collaboration, marketing agility and culture and re-run the regressions using these revised indices. Firstly the construction of *PERC*, the measure of perceived technological change, was modified. Three items were included in the original index from Qs 7, 9 and 10 in the survey. It was decided that two Qs could legitimately be used to proxy perceived technological change. Q7 aimed at measuring the continuous observation of technological change relevant to one's industry while Q9 aimed to measure monitoring competitors' changes due to adoption of technology. In each of these cases the index would collapse to a single item with $J=1$ and $K=0$. Thus the regressions were re-run twice using the responses to Q7 and 9 as separate measures (*PERC1* and *PERC2*) of perceived technological change respectively.

The results obtained when the regressions were rerun using *PERC1* are reported in Tables 6A1 and 6A2 (for product and process innovation respectively). Table 6A1, where the dependent variable was product innovation indicates no significant difference from the results shown in Table 6-10 for the original regression. Table 6A2, where the dependent variable was process innovation, indicates again no noticeable change, in comparison to Table 6-11. The only difference was in the interaction terms: the only significant interaction found in table 6A2 was between *ED1* and technological change in comparison to Table 6-11, where other interactions of external technological change (*PERC*) with *ED4* and *MAG* were also found to be significant.

The results obtained when the regressions were rerun using *PERC2* are reported in Tables 6A3 and 6A4 (for product and process innovation respectively). Table 6A3, where the dependent variable was product innovation, indicates no significant difference from the results shown in Table 6-10 for the original regression. Table 6A4, where the dependent variable was process innovation, also indicates no noticeable change in comparison to Table 6-11. The only difference was in the interaction terms: the only significant interaction found in Table 6A3 was between *ED1* and technological change in comparison to Table 6-11, for which other interactions of external technological change (*PERC*) with ED4 and MAG were also significant.

For the management culture index, most of the items included in the original index were retained except for Q52 and 54. Question 52 inquired how innovation activities were aligned with the company's goals, however, two others questions later in the survey (Q58, 59) unpack this as well; hence, this question was excluded from the new *CULT1* index. Q54 focused on whether employees participated in the formation of organisational goals. As the question related to the participation of employees in their firm, a similar question (Q55) could be used as a proxy, which aimed to understand whether employees are able to voice their opinions and hence Q54 was excluded. The index was named as *CULT1,* with $J=9$ and $K=0$.

The results from these new regression models using *CULT1* are reported in Tables 6A5 and 6A6 (for product and process innovation respectively). Table 6A5, where the dependent variable was product innovation, indicates no significant difference from the results shown in Table 6-10 for the original regression. Table 6A6, where the dependent variable was process innovation, also indicates no noticeable change in comparison to Table 6-11.

For collaboration, the items that were the most important and contributed as a significant measure to innovation were extracted from the literature. Hagedoorn, Link and Vonortas (2000) and Mohannak (2007) argued that collaboration increases efficiency of an organisation and creates opportunities for growth. Therefore, items related to these issues were retained and rest were deleted from the original index, *COL*. The new index (*COL1)* would collapse, with $J = 2$ and $K= 2,$ since two questions were appropriately coded and two others required reverse coding.

The results obtained for the altered regression models using *COL1* are reported in Tables 6A7 and 6A8 (for product and process innovation respectively). Table 6A7, where the dependent variable was product innovation, indicates some difference in variability from the results shown in Table 6-10 for the original regression. The index *COL1* was no longer significant in any of the models in Table 6A7 in comparison to Table 6-10 where its original index was found significant. This result was surprising as we found that the old (COL) and new (COL1) collaboration indices had high correlation (Pearson coefficient of 0.92). Table

6A8, where the dependent variable was process innovation, indicates no noticeable change in comparison to 6-11.

Another set of models using both *CULT1* and *COL1* were regressed and are reported in Table 6A9 for process innovation as dependent variable. This allowed the observation of the impact of these two variables together. It was found that rather than ED4 (employees' management education) interacting with *PERC*, it was ED3 (managers' management education) which had a positive significant coefficient.

Correlation between the original indices and new indices were calculated to check possible variability in the results. It was found that *PERC* had a strong correlation with *PERC1* and *PERC2* (Pearson coefficients of 0.71 and 0.85 respectively), as well as old and new collaboration indices (0.92). On the other hand, *CULT* had practically no correlation between the old and new measures (-0.02). This lack of correlation suggests that changing the models to use *CULT1* rather than *CULT* would bring a significant change in comparison to opting for the less deviant *PERC1* and *COL1* indices. It further indicates that the original technique of choosing the variables for *PERC* and *COL* was promising.

Taken together, by using altered indices and substituting the original indices in redone regression models, the results were by and large similar. While coefficients of the models varied, their direction and significance typically remained in step with the original models shown in the various regression tables of Chapter 6. This suggests that even if subjected to alterations, the indices were still able to represent the constructs under study and remain useful in modelling their effects for the purposes of the present work. It should be noted this general tendency did not hold for the collaboration index. As such, some reservations towards the faith in this index apply, which in turn puts forth a case for its investigation through other means (e.g., in the qualitative chapter to follow).

6.4 Discussion

A number of broad themes may be observed from the regression results reported above. The first is that technological change indeed affects innovation outcomes of the studied SMEs (thus providing an answer to SRQ1). The combined evidence from Tables 6-10 to 6-13 is strongly supportive of there being important *direct* effects of the general education of managers and the degree to which firms collaborate on the likelihood that a firm will engage in innovative behaviour. This is true for both product and process innovation. There is also strong evidence that firm expenditure on training positively influences process innovation although care must be taken in interpreting the effect of expenditure on training since this could easily be the *result* of greater process innovation. These results are consistent across most of the regression models reported above, thus answering SR3.

There is weaker evidence that the motivation of CEOs is also important although the effect of motivation is more complex because the direct and indirect effects work on opposite directions. The strongest part of this evidence across both product and process innovation regressions is that the direct effect of firm owners motivated by profit is positive for innovation. There is also strong evidence that a firm's marketing agility and culture positively influence process innovation (thus providing an answer to SRQ6).

The broad result that emerges from our results is that it does appear that internal firm characteristics are important *mediating factors* on the effect that external technological change has on SME innovation outcomes. There is also some evidence for a positive interaction effect between the education of firm owners and external technological progress on process innovation (a partial answer to SRQ4). There is also weak evidence for a negative interaction effective between the motivation of firm owners and external technological progress for product innovation. This suggests that firm owners motivated intrinsically are more likely to use external technological change to engage in product innovation than other firms outcomes (a partial answer to SRQ7). The surprising result, however, is that there is weak evidence for a *negative* interaction effect between marketing agility and external technological progress on process innovation which is interpreted above to imply a limit to the complexity with which firms can cope in innovation activities. There is also weak evidence for a *positive* interaction effect between firm cultures that foster experimentation on process innovation outcomes (a partial answer to SRQ7).

It should be stressed that a number of qualifications must be added to these conclusions. The sample from which the survey was drawn was a relatively small sample of firms, self-selecting from within the manufacturing sector only. Further work could usefully be done with large samples to further explore the nature of the results presented above. However, the fact that only manufacturing firms have been included and that there is some evidence of innovative behaviour in the resulting data is itself interesting, and suggests that there might be productivity-enhancing lessons to be learned from a sector that has been characterised as internationally uncompetitive. Such further work would also have the potential to clarify which firm characteristics have a role to play in mediating the effect of external technological change on SME innovation.

6.5 Conclusion

This chapter has presented and described the data collected from a survey of Australian manufacturing SMEs to investigate the possible interaction of internal and external innovation drivers in determining innovation outcomes. It has also outlined the econometric methodology that used this data to provide a preliminary, quantitative exploration of the relationship between SME innovation, external technological change and various internal firm characteristics, and it has reported key results from this exploration. The following chapter uses these results to inform an in-depth qualitative analysis of how Australian manufacturing SMEs make decisions with respect to innovation and how various firm characteristics might mediate the impact of external technological change on these decisions.

Chapter 7: Qualitative analysis

7.1 Introduction

In the previous chapter, the data collected from a survey of Australian manufacturing SMEs were described and the results of a series of regressions using this data were reported. These regressions attempted to explain the probability that a firm in the sample would undertake certain types of innovation in terms of key innovation drivers identified in the literature considered in Chapter 3, and using the model of innovation developed in Chapter 4. The results from those regressions indicate that the degree to which firms collaborate, the level of managers' general education, and motivation of a CEO to earn profit has an important direct effect on SME product innovation, while the nature of CEOs' motivation has a weaker indirect effect on this kind of SME innovation by mediating the impact of external technological change on innovation. The results of Chapter 6 also suggest that managers' general education, technological change, money spent on training, marketing agility, and the culture of an SME play an important direct role in affecting process innovation. The educational background of an SME's manager and CEO (and/or owner) and marketing agility has an indirect role in moderating the effect of external technological change on innovation. A complexity was noted with which firms can cope in innovation activities because of the negative interaction effect between marketing agility and external technological change on process innovation.

These quantitative results were used to inform the design of a set of case studies, the objectives of which were to explore the mechanisms *by which* the key factors identified in Chapter 6 affect the innovation behaviour of SMEs. The case studies thus sought to investigate (among other aspects) *how* collaboration and CEO motivation can affect product innovation, and *how* firm non-knowledge capabilities can affect process innovation. This further prompted questions such as *why general education was more important than management education.* Considering that managers deal with day-to-day operations, it would be reasonable to think that their management education influences innovation. Thus attention was paid to explore the contribution of education towards innovation. Because a weaker positive interaction effect between technological change and a firm's culture was found, we were instigated to understand the type of culture in these SMEs and how it contributed towards innovation when interacted with external change. The complexity of combining technological change with modification to the resources of the firm to meet customer needs may be too great for firms to cope with. We already have questions which covers nature of agility, and will probe us to see how much information the firms can cope with, and, whether complexity affects innovation in a firm. This helped to set out questions to investigate *how* the case study companies identified innovation opportunities (for example, to explore new business). Further details of questions stemming from the quantitative study are provided in *Appendix 5O*.

Section 7.2 explains the method by which firms from the sample were selected for further investigation through case analysis and how the case investigation was structured. Sections 7.3 through 7.6 then report the results of the four case studies. Section 7.7 provides an overview of these results and Section 7.8 draws some conclusions in relation to the research questions posed at the beginning of the thesis.

7.2 Selection of case studies

The organisations which gave consent to be interviewed within the survey were sorted into different sectors as shown in Table 7-1. The major respondents belonged to the metal and machinery sectors, providing an additional reason to choose the case study companies from these sectors, as well as their contribution to manufacturing GDP as outlined in Chapter 2.

Table 7-1: Number of respondents based on sectors (source: survey response).

Sector	Number of Respondents
Food, beverage and tobacco products	4
Textile, clothing and other manufacturing	1
Wood and paper products	4
Printing and recorded media	3
Petroleum, coal, chemical and rubber products	4
Non-metallic mineral products	1
Metal products	9
Machinery and equipment	3
Other	8
Total	37

To choose cases within this sector, companies were categorised based on the number of employees. This criterion was chosen to allow comparison of differences and similarities between very small (<20 employees), medium (21-100 employees) and larger (101- 249 employees) SMEs. The classification for a small enterprise follows the Australian Bureau of Statistics standards. However, for medium enterprises the ABS range is from 21-200 employees. Treating all companies in this range similarly was not appropriate for this study for two reasons. First, the strategies and the culture of a business are likely to differ when you compare a business of 21 employees with one having 190 employees. Next, the financial investment, including for that of innovation opportunities, differs across medium and larger enterprises (Drucker 1985a).

The list of respondents from the machinery and metal sectors as outlined in Table 7-2 provides details of the selected companies and their responses. Initially, nine companies[13] were approached through an email invitation to participate in further studies. In total six owners of companies agreed to be interviewed and, after negotiations, some of the businesses also agreed that their employees could be participants as well. A pilot study was conducted, while four case study companies were chosen and given pseudonyms – GOLD, COBALT, NOBELIUM and TELLURIUM. These case studies are discussed individually followed by a summary discussion.

Table 7-2: Selected Metal and/or Machinery companies - responses to request to participate.

Company	First Request	Institutional Response	Headquarter in the State	Number of Employees	Reason for not pursuing SME as a case
Company 1	13-June-14	Approval	New South Wales	190	
Company 2	13-June-14	Approval	New South Wales	75	
Company 3	13-June-14	Approval	New South Wales	14	
Company 4	13-June-14	Approval	Western Australia	45	
Company 5	13-June-14	Approval	Victoria	22	**PILOT** study
Company 6	13-June-14	Refusal	Queensland	23	Relevant person overseas – with "too much work to catch up upon return" to participate
Company 7	13-June-14	Refusal	South Australia	250	Due to time constraints
Company 8	13-June-14	Refusal	Queensland	45	No reason provided
Company 9	19-June-14	Approval	Australian Capital Territory	15	CEO approval after many contacts but too late to participate. Would only provide CEO for interview.

[13] The UTS Human Research Ethics Committee approval required anonymity of the companies in this research. Therefore no company names or specific locations are disclosed in this thesis.

7.3 Case 1: GOLD Pty Ltd – We innovate with 'like-minded people'

GOLD began business as a service to the mining industry in 1995 when expansion of mining in regional New South Wales was predicted and supported by government. The founder grew the company and by 2014 almost 200 people were employed. GOLD currently manufactures and supplies different types of steel equipment (machinery) and provides maintenance services (see Table 7-3) to various sectors such as mining, construction, cotton and wool, food processing, structural steel, electrical power generation, agriculture industries, and also to some government agencies. Their customer base extends to local, national and international markets.

Table 7-3: Products and services provided by GOLD.

Engineering design and drafting services	Design and drafting maintenance services	Project management
Planning and site installations	Planning and site maintenance services	Fixed and mobile plant component rebuilds
Steel fabrication and welding	Plasma cutting	Beam saw cutting
Computer numerically controlled (CNC) machining and milling	On-site line boring and machining	Horizontal boring
Fitting and hydraulics	Wear-resistance material applications including: rubber and ceramic lining	Circuit breaker racking units (CBRUs) and remote switching actuators (RSAs)

Table 7-4: GOLD case study sources.

Interviewees	Document Type	
G1 – Managing Director	Company information (hard copy and website)	1
G2 – Technical Manager	Products information (includes both goods and services)	1
G3 – Employee (the designer of one of its recent innovations)	Account statements	2
G4 – Business Development Manager	Budgeted account statements (Yearly)	2
Factory view by G4 (not recorded)	90 day Business Plan	1
	5 year Business Plan	2
	Newsletters	8
	Company website	1
	Videos available on the website/YouTube	0
	Total case documents	18

Data collection involved the use of individual in-depth, semi-structured interviews from amongst a group of people (as shown in Table 7-4) who had been involved in innovation development and implementation within GOLD over the previous three years.

7.3.1 Innovation and business model

GOLD argued that their major focus was on services, but in the past three years there were no process innovations mentioned during interviews. However, some new products were discussed, which could be classified as their inventions. One such product was a *spring machine* for mattress recycling. The machine specifications reused s*teel springs*, foam*, husk, felt pad* and *fabric* for recycling. The product idea was co-created with a customer to whom two of these machines were sold.

The second product, that they were in the process of launching in the market, was incremental in nature. Feedback from customers for the past 20 years and the safety of miners was the motivation for its development. This machinery was known as the *circuit breaker* and had extra features in comparison to the original version. Three different system changes were introduced in this product. One was to improve on the original design and come up with a solution to use standard industrial switches. This assisted the machine operator who used gloves while operating the machine and, as standard switches would be easily available, it was a consistent and practical design (G3 2014, interview, 27 June). The next system change was its *brain* that included new mechanisms and a different method to operate which GOLD was in the process of patenting at the time of the interview. The third system change was the redesign of a machine to make it lighter and more mobile around the mine.

The third innovation was influenced by a change in their business model. GOLD's 2014 newsletter revealed they went into a collaborative agreement with an American company to import an item of machinery. They would sell the machine at a margin but also provide after-sale repair services. GOLD had aimed to be a *best service provider* as evident in in their business value statements and interviews, however this was the only service-oriented product evident in GOLD's case study.

However providing high quality customer service was also interpreted by G3 as the cause of disruption in the existing business. While working on a circuit breaker machine, he argued that his work was constantly interrupted when a welder immediately had to leave whenever a client's needs had to be met. This meant the job on hand stopped, causing an increase in the cycle time, and indicated a weakness in GOLD's operational planning. GOLD's customers would not have known nor cared about GOLD's job on hand, and delay, thus they would not be aware of the *real* value that GOLD was aiming to provide, namely a superior *service*.

Like other businesses across Australia, GOLD had been through a number of cycles (G1 2014, interview, 27 June) but their success, as interpreted in their vision, stems from the will "*to excel in business innovation, diverse engineering, and team commitment*" (GOLD 2014a). The catalyst for their team commitment was the fear of losing their business to overseas competition due to the price of labour. The business was initially set up with an aim of providing engineering support services to the rural and mining industries, with a focus particularly on the mining sector. Its vision to become the *best employer of the year* and *service employer to the customer* led it to diversify and create a space where like-minded people worked together (G1 2014, interview, 27 June). Its core values included a commitment to provide an ethical environment and a safe workplace, keeping customers happy, and having trustworthy employees (GOLD 2013b).

In 2001, GOLD acquired a local engineering firm to improve their equipment and facilities by investing in Research and Development (R&D). In the first half of 2003, they began construction of a new workshop. This construction enabled GOLD to meet the demand from COPPER (pseudo name for its major customer) to whom it was supplying various products to automate work that COPPER had previously conducted manually. At the end of February 2004, GOLD was at full capacity supplying material to COPPER. However, by 2007, COPPER had contracted its manufacturing to Chinese suppliers due to cost benefits. Nonetheless, by December 2010 GOLD expanded by acquiring the plant and equipment of a structural steel business in the same region. By the end of 2014, it had five different branches across NSW but net profits for the year were just 3% of total sales.

7.3.2 Research and Development (R&D) investment

Investment in R&D projects by GOLD was significant during the period when COPPER was its major customer. GOLD'S previous knowledge about machinery was important for their R&D, but new knowledge spillover, and learning by doing, were also key. An ability to be able to exploit their acquired knowledge was consistent with Cassiman and Veugelers (2006), and the innovation outcomes were breakthrough innovations within their industry, a cause of pride for the company (G1 2014, interview, 27 June). However, GOLD underwrote its own R&D even though the primary beneficiary was COPPER and this investment also created risks for GOLD as it had become dependent on COPPER for most of its operations during that period.

There are a number of benefits of investing in R&D projects: a potential increase in a firm's productivity (Cuneo & Mairesse 1983), promotion of collaborative projects (Cassiman & Veugelers 2006), and an increase in knowledge of the firm (Cohen & Levinthal 1990; Griliches 1991). However, there can also be risks: a greater variability in outcomes and likelihood of failures (Li 2012), a possibility of negative impacts on the immediate performance of the company (Hitt et al. 1991), and technology development and technology uncertainty costs (Von Zedtwitz, Gassmann & Boutellier 2004). The decision not to charge COPPER for the development of this new technology shows that the financial risks linked to such investments were underestimated by GOLD (G2 2014, interview, 27 June). This was also evident as the managing director (G1 2014, interview, 27 June) believed that GOLD took strategic decisions to capitalise on their development of R&D premises on the basis of maintaining COPPER as its customer.

By September 2005, 75% of COPPER's requirements were outsourced to China due to lower cost, with a major impact on GOLD's business. The rest of COPPER'S business (25%) was transferred away to China in October 2007.

If GOLD had been absolutely sure that they had the number of contracts and guarantees that COPPER would be their customer for a certain amount of years, the investment made by GOLD would be justified. However, this was not the case. GOLD, being over-reliant on their existing contracts, thought COPPER to be their customer for the foreseeable future and consequently did not look at expanding their customer base. The impact was significant because of this over-reliance. Neither did they have any agreement with COPPER to share the cost of innovation. Finding competitors of COPPER, creating new product offerings from their invention, and promoting and advertising these, could have helped GOLD to recoup their investment from other customers. While GOLD was indeed practising innovation, the strategic implications, as well as risk assessment of such a pivotal investment, were not fully considered.

After recovering from the loss of such a significant customer, the management claimed to have learnt two major things: first, R&D expenditure should be charged to the customer; and second, to not rely on investing in only one major customer, as diversification was the key to the survival.

GOLD had demonstrated they were excellent in focusing on customer needs and designing solutions (inventions), for example through their innovative bed mattress recycling machine and a safety machine for mining units. The missing element in their investments was a failure to maximise the potential of their inventions through finding new customers. This was evident by one of the comments of the managing director (G1) during his interview: "...

we have built products here (at GOLD), but we haven't been great at marketing those products." GOLD had been too focused on its current customers and did not consider the other uses of the inventions they were designing. Commercialisation of these new innovative products therefore was needed through, for example, collaborating with external parties. Gassmann, Enkel and Chesbrough (2010) argue that if an organisation can codify its knowledge and capability they can commercialise by strategically connecting with external entities, that are willing to multiply the new technology. This they describe as *multiplicative capability*.

Theorists such as Hall, Lotti and Mairesse (2013) and Kohtamäki, Partanen and Möller (2013) have argued that R&D investment contributes towards innovation and profitability on the condition that R&D activities are co-created with a customer (Kohtamäki et al. 2013). In GOLD's case, it was unable to commercialise its inventions in such a manner that the return on investment was maximised for the company, as well as current and future customers. GOLD is a case that suggests that not all R&D activities may generate positive outcomes for both innovation and long-term profitability of a firm.

7.3.3 Technological change

GOLD's managers felt that maintaining customer relations became difficult for two main reasons. First, rapid changes in technology impacted on their industrial machinery which quickly became out-dated as is evident from: *"... like you buy a brand-new machine today and six months down the road it is out-of date. It's the speed with which things change is the hardest to keep up with…"*(G2 2014, interview, 27 June). An increased difficulty in customer relations was noted due to price competition from offshore products resulting in lost business: "... *customers are getting exposure to the new technology, seeking catalogues from the net and they are always wanting to go to the next step. So it is very hard to say this is our new product, design is finished so let's just build it for ten years."* (G2 2014, interview, 27 June).

The type of technological change that affected GOLD was mostly due to Internet access (digitally enabled transformation) by their customers, which opened access to global competitors. GOLD was well aware of endogenous technological change, that is change in technology within their own industry. GOLD understood the importance of keeping abreast of the technological change directly affecting their industry and started to explore opportunities outside the mining sector. This aligns with the findings of the quantitative study that technological change has a positive impact on innovative activities. It was the technological transformation enabling different forms of relationships between different organisations that stood out as the main issue affecting GOLD. Further, Schumpeter's (1942) argument was restated that external technological change helps in continuous development of existing and new technology in a firm, and this change also has an ability to make organisational routines and procedures obsolete (Henderson & Clark 1990; Tushman & Anderson 1986). To overcome the challenges of technological transformation and the loss of its customers due to price, GOLD decided to collaborate with other institutions.

7.3.4 Collaboration

GOLD collaborated with different organisations to decrease both costs and uncertainties associated with technological change, sharing these with its new partners (Mohannak 2007). Dodgson (1994, p. 193) argues that collaboration can be of two types: vertical and horizontal. Vertical includes collaboration that occurs throughout the supply chain while horizontal collaboration *"occurs between partners at the same level in the production process"*.

Based on the Dodgson (1998) definition, GOLD collaborated vertically with two different companies, Irish and American, to import equipment and become the suppliers of this equipment across Australia. During the interview, G4 (2014, interview, 27 June) said they were thinking of importing the technology from an Irish company into the Australian agriculture sector, which could potentially change the way the sector operates in terms of energy. GOLD also signed a distribution deal in 2014 with an American company to sell its machinery in Australia and New Zealand. GOLD thought that this distribution deal would open opportunities for them to provide services, including repairs, for this machinery. This was evident from their newsletter *"... we anticipate that this partnership will be a great addition to (GOLD's) already vast range of services…"* (GOLD 2015).

GOLD collaborated by being partners with foreign companies to expand their product range. However, collaboration was not undertaken with a mindset to innovate or produce new products. Instead, they undertook collaboration to find different ways to acquire more business. They implemented changes to their business model, and to reach other sectors they built on their capabilities to find opportunities. Further, changing their business model, diversifying, and looking for opportunities, could not be achieved without a culture that supports the development of these innovative activities.

7.3.5 Culture

The vision of the company has been to *create excellence through innovation*. GOLD was an interesting case due to the common values shared amongst its employees. This was evident from all interviewees who consistently used words such as *honesty, fairness*, and *safety* which matched the vision found in its capability statement (GOLD 2014a). Maintaining company values, creating a positive workplace environment, and getting the best employer and best customer service provider position was so important to them that they focused on recruiting like-minded people.

The hiring process was based in part on the perception of the managing director who looked for dedication towards one's work. When questioned what he meant by dedication and how he assessed it, he answered (G1 2014, interview, 27 June), *"… I see the face, see how dedicated (you are in) what you are doing, I think that works for me."* On another occasion within the same interview he elaborated on his definition of dedication and included qualities such as honesty and fairness:

> *"Everybody has a key (to access the whole building and any office)… and are told… we trust you, don't let us down… if you want to make something for yourself or if you need something to help you at home, you can come to work here and make it here. You only have to ask your boss… the answer is yes, you can have it. Just be fair!… the most simple powerful things we use here is trust. You have to earn trust. It's not God given. I'm boss, I don't get it by that role. I have to earn my trust, every day."*

The emphasis on trust and open communication, with management taking responsibility for losses rather than blaming its people, made GOLD different from the other companies studied. The idea that anyone could walk in the managing director's office was further confirmed by the employees' interviews: *"If you have any issues, you can just walk into G1's [name omitted] office"* (G2 2014, interview, 27 June). The business development manager (G4 2014, interview, 27 June) claimed that it is a *"very open door policy [at GOLD], so if you have something to say you could, that's one of the benefits of working here"*. Interestingly, it was evident that both the business development manager and the managing director had similar thoughts on how to handle management problems. An excerpt by the managing director (G1 2014, interview, 27 June) explains this:

> *"I try to educate all our management team that if there is an issue here, it's your problem… so that's the key to the culture… if there are two guys out, arguing and fighting with each other, it's because they are not managed well… which created*

that problem. So it's not an individual problem, it's a management problem. So they [managers] are here to manage the culture."

The emphasis on how people should be managed could be seen from the above excerpt. Aligning employees' goals and company goals was regularly practised by GOLD's business development manager (G4 2014, interview, 27 June). This was also consistent throughout the interview with the managing director. It seemed achieving high ethical standards to honour its employees, customers, competitors, suppliers, and the society was important for him. Fairness to others, safety of its people and its customers, and honesty of employees were common shared values in this organisation. The challenge of keeping standards in a business and employing like-minded people was important to the managing director. Employing like-minded people meant that the goals of the company and their employees could be aligned thereby fostering both innovation and excellence in the business processes (GOLD 2014a). GOLD's managing director stated that he treated every employee as his family member, and this meant that he looked after everyone and their needs and in return he wanted honesty and their best possible performance. The strong values of this organisation and the support of its employees were visible in all the discussions with employees and informal discussions with one of the family members of a particular employee. The emphasis that was placed on the way GOLD was managed distinguished it from all other companies studied. Selecting people who had similar qualities was precious to this organisation.

Although GOLD had 190 employees, they were not unionised. The owner, whilst explaining his previous background, especially in the policy of creating jobs and the management positions within mining, said that he had learnt from his previous experiences that strikes and work stoppages affects productivity. To overcome this within his company, he himself drafted the enterprise agreement for GOLD. When asked what his previous qualifications were, he said had completed high school pass and worked as tradesman, and so he understood the workforce. He felt that he was *the best union delegate* that his employees could have.

"The men know that they don't need a union delegate here; they know if they are entitled to something they will have it. They don't have to negotiate with me; they will get it, without being asked. That's the difference."

To keep the firm's values, and have a family-like culture, was a focus of G1, who insisted that his son should follow a similar path. During his interview, G1 (2014, interview, 27 June) discussed how much his values meant to him:

"… just last week my son came to me, really pissed and twisted with somebody just letting down. He wanted to change something. I said… you have a belief that is so strong. Don't let a bad experience change you. Don't become bitter and twisted."

It seemed that this style of management worked in GOLD's case. From an alternative viewpoint, however, treating his employees like a family, catering to most of their needs and providing them with a comfortable environment, can mean that some employees might not challenge existing ways, thereby hampering innovation (Chirico & Nordqvist 2010, p. 498).

The business development manager (G4 2014, interview, 27 June) revealed that he did not think anyone during his last four years at GOLD had been fired. He further said the ones who left GOLD did it either because they were not the *right fit* or wanted a *new challenge* in their life. The business development manager did not specify the type of challenge sought. However, GOLD had significant losses in the year 2012-2013. Maintaining the workforce and not making anyone redundant meant that GOLD was using its limited resources to keep the family-like culture together.

It could be argued that a cohesive, inclusive culture is a prerequisite for trust (Dovey 2009). Trust is fundamental for innovation as it enables a company's employees to take risks, provide opinions, and engage in lateral thinking (Clegg et al. 2002). At the same time, such a culture can stifle innovation because there is a tendency to maintain the existing team rather than introducing a change that might bring in fresh ideas.

7.3.5.1 Open communication

The family-like culture was examined and every interviewee's response to working at GOLD was governed by their love, commitment, and support provided by G1 and his son, who was also part of the upper management. The business manager (G4) proudly explained the endless opportunities to grow within the company:

"One benefit of working with GOLD [name replaced] in particular is being able to share (openly) information… I have never come across one single company like this, that's been so open in terms of asking each and every personnel… 'What do you want to do?' and then paid for the guys to do degrees and paid for team members to do specialist courses because they (employees) want to do it."

The communication was not limited to discussing the issues prevailing in the company, but included the flexibility that GOLD gave to develop new products and also showed in its appreciation of new ideas. It was evident in the conversation with the managing director that the culture practised was to promote the ideas of employees and, more importantly, to reward them through extrinsic and intrinsic benefits such as appreciation and providing support to them when needed.

He gave credit to one employee (G3 [substituted actual name]) for new product development for the mining industry and said (G1 2014, interview, 27 June):

> *"G3 is very proud of it and should be, because he has done all the work. It's his brain power, plus our marketing guy's, the guy who does the sales, he provides feedback and the feedback comes back to us and G3 has taken that feedback and has developed a new model using all that feedback."*

There are three main questions that emerge from this. First, why did G1 support open communication – was it to innovate? Second, whether the continuous feedback shared among all employees, referred to by G1, helped in developing new products or services. Third, whether appreciation for one's work, promulgated in GOLD, was used by its managing director to promote innovative solutions in his company. These three points are explored further.

Through conversation with the managing director around his motivation to support open communication, he revealed he had experienced difficulties in communication in his previous job within the mining sector. This had become a motivating factor for him to create an ideal environment for his employees – with the business manager saying, *"Fortunately, for us, and part of the culture within GOLD [name replaced], is that they encourage everyone to step up…"* The technical manager (G2 2014, interview, 27 June) had a similar view: *"If you have any issues, you can just walk into G1's office… He is very employee oriented. He [is] awfully [good and] thinks [of the] employee first…"*

The open communication was a result of the previous learning experiences of G1. He understood the needs of his employees and he treated them equally, which motivated them to stay in the company (G2 2014; G4 2014, interview, 27 June). G4 commented that looking for new opportunities and wanting to develop a sustainable business model were the reasons for his motivations to develop new business ideas. G2 never discussed if he was innovation driven.

It was noted that anyone could visit management and communicate one's ideas. However, relying on open communication made some employees feel that management did not communicate their ideas formally and instead relied on informal communication channels.

Further analysis of the issue of communication, raised by different GOLD employees on various occasions, related to a lack of a central inventory system for its workers. The technical manager and an employee (G2 & G3 2014, interview, 27 June) argued that the company was too broad and reactive to customer demands (GOLD 2014a). GOLD was unable to predict where the demand for their employees would occur and this meant that if a customer had a breakdown in machinery, service staff who were busy with another project had to leave it and attend to the customer needs. The technical manager (G2 2014, pers. comm., 27 June) argued that GOLD did maintain a labour logistics *Excel* file, shared between relevant departments. However, because they changed the jobs so often, employees who were working on developing new products did not necessarily receive all the communicated changes, and this might have caused some dissatisfaction. During a factory visit to the main branch it was observed that the employees' schedule for that branch was written on a white board, which meant communication existed but lacked the consistency of more formal communication through emails on a regular basis. This had led to 'Chinese whispers' (G3 2014, interview, 27 June). Customer support provided did help in acquiring knowledge for the business, but the agility needed to respond to customer services undercut the focus on product innovation.

The informal channels of communication are important, but when an organisation starts to expand reliability on formal channels becomes important in order to plan activities and deploy labour appropriately. GOLD plans to overcome the communication issues by installing Skype across the branches and aimed to invest $1 million in its IT systems and infrastructure (GOLD Business Plan 2014). This investment in improved IT systems and infrastructure should result in more transparent systems, and better communication of how jobs are going to be distributed. A better strategy was required to deal with the matter of how labour should be allocated across different jobs.

It is important to note that some formal channels of communication did exist between the managers. Managers in GOLD communicated daily through 15-minute early morning meetings, toolbox meetings, monthly meetings, and annual planning day meetings included all staff. The daily 15-minute management meetings focused on day-to-day issues. Toolbox meetings, which included managers and some selected employees, were held on every Friday afternoon during which issues were discussed in more detail. Sometimes customers were invited to provide their feedback on how GOLD's products could be improved. Monthly meetings included managers from different sites and focused on discussing how things could be improved. There was also an annual planning day where people from all the branches joined together to discuss the details of the future plans, capital expenditure and business growth. Employees were also encouraged to become involved and explain their new ideas.

The above discussion suggests that an *alignment* between formal and informal communication is essential and contributes towards sustaining innovation. Further alignment between formal and informal communication could help GOLD to overcome its operational challenges.

7.3.5.2 Motivation

The motivation for GOLD's employees to develop new ideas was intrinsic in nature. All GOLD interviewees were motivated to initiate new and innovative projects, not by money, but by *"the desire to do... the job accurately and professionally"* (G4 2014, interview, 27 June). G4 (2014, pers. comm., 27 June) further emphasised:

> *"my wife would tell you that money doesn't drive me… It's the challenge, the idea, getting that and developing… and putting that [idea] on [the] table, getting [it] accepted and making that work and then look up for the next idea… and then next…"*

Another employee (G3 2014, interview, 27 June) was unable to stop thinking about new products and service and said *"I enjoy doing it, I enjoy coming to work every day"* and considered that as his motivation to produce new products.

Every manager and employee interviewed at GOLD emphasised that the freedom and the support provided by GOLD's managing director helped them develop new ideas and further motivated them to stay with the company. When asked on plans to leave, all of them responded that they wanted work with GOLD until they retired. The motivation of the employees was driven by the supportive *family-like* culture of GOLD.

Therefore, the people involved in the innovative ideas were driven by intrinsic factors of motivation and were able to engage in lateral thinking. However, the family-like culture was possibly found to obstruct the development of new ideas and entrepreneurial skills. This obstruction was found in a discussion with G4 regarding misalignment between customers' needs and the supplied quality standards, as discussed in the sub-section on quality management.

7.3.6 Marketing agility

A part of the communication of ideas was the importance of customer feedback for developing new products and services. The managing director (G1 2014, interview, 27 June) argued that continuous customer feedback over a number of years inspired the employees to develop new and improved products which helped in increasing the safety standards for its mining customers. This statement was consistent with the developer of the product who argued that *"… 20 years' worth of customer feedback... [customer's asking] can you do this,* *can you do that, oh this is a bit of problem, eventually we got at a stage… of making a relatively high cost and low volume product… which is safer than previous versions"* (G3 2014, interview, 27 June). The newsletters (GOLD 2013b, 2014b, 2015) available on its website also focused on the marketing, suggesting how customer feedback helped to improve a product, thus enhancing the safety of the people using GOLD's products.

In another example, customer feedback was considered imperative to GOLD in *"building a business pipeline"* (G4 2014, interview, 27 June). The business development manager (G4) argued that customer feedback helped improve their services and find new work references for GOLD.

Understanding customer needs was important for GOLD to attract new and retain old customers. Having acknowledged this, the business development manager argued that he looks for opportunities across different companies. In addition, he emphasised identifying customer needs before selling his product. This was a newer approach in GOLD, leading towards business improvement and development of innovative ideas. Indeed, most of the current product innovations found within GOLD were a result of discussion and co-creation with the customer, where the emphasis was on identifying opportunities.

7.3.7 Previous experience, education and motivation of the managing director

As discussed previously, the GOLD managing director was not highly qualified but his considerable experience in various management roles and policy development around the mining sector was the biggest source of his knowledge. His understanding of the workforce and the motivation to change how businesses in mining operated years ago motivated him to not only start his business but also bring a change in his culture. It could be argued that his previous experience influenced GOLD's practices in culture and quality management.

7.3.8 Quality management

The managing director's views (G1 2014, pers. comm., 27 June) and the company's business plan (GOLD Business Plan 2014) both attribute attention to quality as providing its competitive advantage. For them quality was what distinguished their company from its competitors.

GOLD invested heavily in maintaining its quality standards through gaining certifications such as ISO9001, ISO48001, ISO18001, ISO148001, and maintaining these standards through continuous audits and training of its people (G1 2014, pers. comm., 27 June; GOLD

Website 2014). However, its competitors did not value the quality standards to the same extent as GOLD. The maintenance of the certification of quality standards is an expensive process that increased GOLD's business overheads. As competitors did not invest in similar quality standards, they were able to compete for various jobs at cheaper rates, thus causing GOLD to lose customers. GOLD tried to signal being the best service provider to its customers and competitors through the accreditations that they held, but without much success.

This was evident from the views expressed by the managing director (G1 2014, interview, 27 June):

> *"... from a competition point of view, ... my overheads are a way higher than others. The cost of doing my business, than the guy down the road. This is because I educate my people, because they [competitors] don't care. They don't have ISO 8001, ISO 9001, that cost me $22,000 just to do the audit from ASI globe. They come in every year to give the accreditations, just to say that I have world standards, they [competitors] don't have to pay for that."*

This raises the question whether this difference was even noticed by its customers. The managing director claimed they did, but argued that its customers were not willing to pay for it. He said, *"It gets you in the door but you never get the job. It's always good as the last job you did, and if there is somebody at the end who sells at half the price, he will get the job. That's the issue."* Further newsletters from the website also emphasised meeting the world's best standard was important to GOLD's managing director (GOLD 2015).

The quandary here is that the supplier (GOLD) thinks the customer should require standards and quality assurance, but the customer is mainly interested in the lower price of a product. Mines are regulated and need accredited standards due to the risks to health and safety but many customers in other industries did not face such risks and hence did not see the need for accredited standards. The existing price competition had led GOLD to have substantial accounting losses in the year 2013-2014 (GOLD Business Plan 2014).

If customers were comparing GOLD based on the cost of the competitor's equipment, GOLD had to change its strategy of how they were positioned in the market. To avoid comparison with competitors, GOLD developed a focus on explaining to customers that it was not selling just machines, but also a *guarantee* that the customers would get *x amount* on their return on investment. It was found that GOLD was inventive but unable to integrate and *bundle* different innovations together as one offering, nor could it highlight its service sufficiently in terms of customer gain. GOLD clearly needed to innovate their business model as it would help them to describe their *"rationale of how an organisation [GOLD] creates, delivers and captures value"* (Osterwalder & Pigneur 2010, p. 14).

The business development manager agreed that price competition was the main reason for GOLD's limited ability to attract many new customers but he also questioned whether all customers wanted such quality standards. As one of the company's values was to provide the best quality, GOLD diversified into different sectors where its competitive advantage could be used.

Drucker (1985a) argues that quality is in the eye of the customer and is not determined by the input of suppliers, and in defining quality he provides a different perspective from GOLD:

> *"'Quality' in a product or service is not what the supplier puts in. It is what the customer gets out and is willing to pay for. A product is not quality because it is hard to make and costs a lot of money, as manufacturers typically believe. That is incompetence. Customers pay for only for what is of use to them and gives them value. Nothing else constitutes 'quality'"* (Drucker 1985a, p. 228).

The business development manager recognised that customers' views were important but were at odds with the company's values system, which prevented GOLD from finding a solution to the price competition by investing less in those standards that were not demanded by customers. This was an interesting feature that goes back to the initial argument that GOLD's protective management style may obstruct development of new ideas and innovations, as the manager who had a different view of quality was not able to communicate with the CEO, probably because of the respect which he had for him.

The issue identified is that the supplier (GOLD) believes that the customer demands a particular level of quality, however in reality this is not every customer's expectation. This means that GOLD was providing more services to its customers than they were willing to pay for. This was consistent with the argument of Christensen, Anthony and Roth (2013) who divide such potential customers under the category of *overshot customers*. The overshot customers are unwilling to pay for any further improvements in a product that historically had merited attractive price premiums (p.5). This meant that GOLD was adding extra features which its customers would not use. Christensen et al. (2013) argue having standards involves trade-offs and compromises which over time can hinder both innovation as well as the opportunity to gain new customers.

Both the owner and the business development manager want to make the business profitable (GOLD 2013a). Arguably, if price competition was so important to GOLD, then they would have tried to decrease their overheads over recent years, but this was not the case. Drucker notes: "*... the only way to get a higher profit margin, except through a monopoly, is through lower costs*" (Drucker 1985a, p. 228). Based on this principle, GOLD developed a new product for the mining industry, which they were in the process of having patented. This product was an improvement over the previous versions with extra features. Its development was based on customer feedback. Thus seeking outstanding products was an outcome of the dilemma they faced in attracting customers while still maintaining high quality standards.

7.3.9 Conclusions

The GOLD case study exemplified that culture and motivation affected product innovation, while a recent collaboration was undertaken for business model innovation. This finding was consistent with the quantitative analysis. However, what stood out during the GOLD case study was that a *balanced* culture mediated the technological change effect on innovative activities.

A supportive culture helps people to try new things and make mistakes and learn from them. If one is too scared to make mistakes, or is always under the patronage of the boss, it is difficult to challenge the old ways of thinking, or doing a particular task, and thus be innovative. In the context of a close-knit group such as GOLD, failure on the part of a boss to treat employees as *family members* or members of a community, might have a negative impact on staff engagement level, reducing intrinsic satisfaction and deterring employees from investing their time for the benefit of the company. Striking the *right* balance in the culture is an essential component of innovation and GOLD moved to achieve this balance.

Paradoxically, having a close knit *family-like* culture could hinder innovation, since it can lead to conservative policies aimed at preserving relationships with underperforming employees or failing to bring in *fresh blood* causing the company to suffer losses. GOLD used its limited resources to keep and maintain its people, rather than letting some go. A very low turnover, in this case, while maintaining engagement and morale, can limit the potential for innovation. GOLD provides one example where an inclusive culture can be favourable for innovation yet through its stability also hinder innovation.

GOLD's case exemplified that innovation is not a matter of absolutes limited only to internal or external factors, nor is it limited to gaining an understanding of customer needs, or maintaining a supportive innovative culture, or just producing solutions. Innovation is about striking a *balance* between listening to a customer, assessing the risks, and looking for opportunities to re-use any inventions or innovations. A balanced culture would constitute support provided by the owner/manager on the one hand, as seen in this case, and freedom to come up with new ideas on the other. Related to culture, a balance between formal and informal communication is required; a company cannot rely on only one type of communication mechanism. Culture has been widely discussed in the literature as an important driver of innovation, however I argue that a *balanced* culture is a key driver for innovation in any organisation, including SMEs.

The motivation to innovate was found to be intrinsic. While G3 and G4 had *direct* intrinsic motivation that impacted on innovative activities, G1 had *indirect* intrinsic motivation. G1 was motivated to have a family-like, transparent culture where his employees could openly communicate their ideas that can improve business processes.

Despite the fact that GOLD fulfilled all the standard requirements depicted in the literature on innovation, and in terms of the framework developed in Chapter 4 managed to achieve much, it failed to achieve the full value from its innovations. It was unable to maximise its potential by commercialising those innovations to a wide range of customers, and it has been unable to find a solid business model that incorporates its specific strengths and capabilities.

It could be argued that technological changes in GOLD was observed and understood by both employees and the management. For instance, G3 followed the changes in technology in various sectors, understood the needs of their customers while using past customer feedback (marketing agility) and applied his education and experience when he developed his ideas into an improved product. With this improved product, the specifications developed were of radical nature, especially in establishing a safer environment for working miners, hence GOLD decided to patent this configuration. They measured the significance of the improved product through its efficiency and safety for their clients. Similarly, the business development manager understood GOLD's technical capabilities and how external technological changes were occurring. Thus, the interaction of technological change with the agile marketing techniques such as listening to the customer, maintaining customer relations and co-creation with its customers helped in developing a spring press. Building on employee capabilities, education and experience helped GOLD to not only monitor but also adapt technological changes within its business to be able to generate new ideas and implement them in new and improved machinery. Not many process innovation examples were leaned from the discussions with GOLD. Furthermore, the internal collaboration for idea generation to gear technological changes were found to be limited within GOLD. However, it was found that culture played an important role which motivated employees to come up with new ideas and to interact with external technological change to create new and/or improved products.

Table 7-5: GOLD – Table of attributes.

Factors	Managing Director	Technical Manager	Employee - Developer	Business Development Manager
R&D Investment	Strategic decisions undertaken to capitalise in the development of new machinery to maintain a customer (COPPER). *Current policy* changed based on earlier experiences. Now all R&D investment is charged to the respective customer.	Robotic technology was developed for a particular company. This company eventually went off-shore for its activities. Huge losses were seen.		
Technological change	Technology-enabled transformation was affecting GOLD's business.	Continuous development is needed to keep up with the speed of introduction of technological change. Learn about technological change: via internet and customers.	Machinery gets out-dated quickly.	GOLD is losing business due to technology-enabled transformation. Did not prefer communication through digital channels
	Fierce competition due to globalisation.			Cut-throat competition.
Culture	Fairness, safety of the people and trust. He treated every employee as his family. <u>People were hired</u> – based on their dedication, honesty.	Being fair, safe and honest in whatever GOLD does.	Safe for its people and customers – hence developed an innovative (safer) circuit unit for the mining industry.	Motivate people and see if their goals can be aligned with the goals of GOLD and gain a win-win situation.
	<u>Open door Policy:</u> Anyone can communicate with the managing director and other employees.	<u>Open door Policy:</u> Anyone can communicate with the managing director and other employees.	<u>Open door Policy:</u> Anyone can communicate with the managing director and other employees.	<u>Open door Policy:</u> Anyone can communicate with the managing director and other employees.
	Management practices: Management is considered accountable for issues to prevent individuals being			Make sure that management takes care of all the individual problems.

	blamed. It is a family-like culture			
Communication of Ideas	Prefers informal communication with his employees.	Formal meetings – Toolbox, monthly meetings.	Toolbox and monthly meetings.	Talked with employees to understand what their goals and objectives were. He looks where he can align his employees and GOLD's goals. Talked with the customers and invited them to the toolbox meetings. Toolbox, monthly and annual planning meeting.
	Anyone can contact him and say what change they want.	Communicated with different departments for the labour division. Informal communication was preferred as he communicated with employees on a daily basis.	Preferred formal communication channels, such as emails, etc.	
Previous Education	High School	TAFE/trade diplomas	TAFE/trade diplomas	Management diplomas
Marketing Agility	Talk with government officials and customers	Thought they gained customer feedback from surveys	Customer feedback helped to develop new CCI unit	The customer needs were explored and required for the development of new products. Personal visits and cold calling was commonly practised to gain business. Also used references from previous business.
Motivation	To supply the best service to its customers and become the world's best in their services.		Challenge in work motivates. Sub-consciously worked towards the solution.	Challenge in work motivates.
Quality	They met the accredited standards.	Proud of the quality and checked it through sophisticated measurement systems.		Didn't think the quality standards which they were delivering to the customers were aligned with customer needs.

7.4 Case 2: COBALT Pty Ltd: 'Give me a chance'

COBALT is an Australian engineering company engaged in the design, manufacturing, and maintenance of hyperbaric, diving, and gas systems across Australia and Asia and belongs to the machinery industry within the Australian manufacturing sector. It has been active for about 60 years and currently employs 75 people across two different divisions within Australia. The data sources for COBALT'S case study were used from the interviews as well as documents as specified in the Table 7-4. This high-technology business focuses on a niche market.

Table 7-6: COBALT case study sources.

Interviewees	Document Type	
C1 – Executive Director	Company information (hard copy and website)	1
C2 – Factory view	Product information (includes both goods and services)	1
	Account statements	1
	Budgeted account statements (yearly)	0
	90 day Business Plan	0
	5 year Business Plan	0
	Newsletters	0
	Company website	1
	Videos available on the website/YouTube	0
	Total case documents	4

Prior to 2006, COBALT had an annual turnover of between $8-9 million, concentrating on defence industries, including a major defence project. Their sales fell once this project finished and it became difficult for COBALT to stabilise its markets. Both its global and Australian markets were affected by global price competition and foreign policies that restricted the purchasing of supplies to a country's local suppliers or placed tariffs on foreign goods. This made it difficult for COBALT to produce goods and sell them across various countries (C1 2014, interview, 4 July). COBALT required a solution to overcome these business challenges. They decided to create a niche, through solving technical problems in gas and fluid engineering systems. COBALT decided to diversify into different markets and sectors which needed similar solutions (C1 2014, interview, 4 July). From defence, they started to expand into the oil and gas sectors and provided technical solutions to highly complicated problems in gas and fluid engineering areas. They realised their core technical capabilities could also assist other sectors, thus a small proportion of its products/services were provided to industries such as building, water, and rail. They focused on high-end products and services whilst providing customer manufacturing services, logistic support, technical writing, systems engineering, technical investigations, and technical risk management services (COBALT Website 2014). They argued that it was the method with which they approached their customers, and a recently changed business model, that led to innovation. This is explored further below.

7.4.1 Innovation and business model

COBALT realised that the scale and speed with which technology-enabled transformation was occurring, and with the emergence of globalisation also affecting their business, a new and innovative business model could assist them in transforming their industry. They made it their goal to solve customer problems while maintaining customer relationships (Osterwalder & Pigneur 2010).

The executive director (C1 2014, pers. comm., 4 July) argues that it was their business model which changed the way COBALT worked, and he claimed that they were "*awarded the Australian Manufacturer of the year, we knocked off* [other well-known company's name omitted] *and won still, hurray for us*" (C1 2014, interview, 4 July). He explained how this was achieved and emphasised two main approaches. First, COBALT realised that their core capabilities, designing solutions for the technical issues, was something the company excelled in and they decided to build on this capability. They argued that being customer-centric and designing technical solutions based on customer needs was the key to help them survive. Second, unlike traditional manufacturing where customers found their suppliers, COBALT insisted on finding its customers by visiting likely user companies and exploring opportunities for expansion in different industries that might need their expertise. Both of these reasons were mutually supportive.

Another novel concept was how they changed their supply chain processes. COBALT's managing director argued that they were unable to influence the decision of Australian government to (not) buy Australian products. They believed that the Australian government did not support Australian businesses and bought cheaper products from overseas, nor did they trust the capabilities of Australian companies to provide innovative solutions (C1 2014; C2 2014, interview, 4 July). The new strategy of COBALT was to export their source components to another country, manufacture them according to Australian standards and then import the finished products to Australia. They believed that it was still an Australian-made product, because it was designed using Australian components and labour, and documented and used in Australia for an Australian project.

It could be argued the way they changed their business model was itself an innovation as it not only improved the productivity and efficiency of their business but also improved the turnover four-fold to over $35 million/year. COBALT's views reflect those of Chesbrough (2007a, p. 12) on the importance of business model innovations rather than simply relying on technology and R&D.

The executive director (C1 2014, interview, 4 July) mentioned that the change in their business model helped them to concentrate on becoming service solution providers rather than product manufacturers only:

> *"Also [we] changed our offering from being, rocking up to a customer and saying here is our [product], here is a component which is best in the world, to, a what do you need, what solution do you need? So we have changed it to a service offering from a product offering ... we try to uncommoditise [not commoditise] our business as much as we can, to survive."*

Uncommoditise meant rather than creating an economic value for their products, they wanted to market themselves as a problem solver. COBALT's views were similar to Teece (2010, p. 175) who argues that *"Customers don't just want products, they want solutions to their perceived needs."* COBALT invested its resources in changing its business model. This was itself a radical innovation which was influenced by its understanding of customers and their needs. To build on their technical capabilities, it was expected that there is a need for substantial investment in R&D.

7.4.2 Research and Development (R&D) investment

The executive director (C1 2014, interview, 4 July) argued that they produce a *pretty mature technology* while speaking about R&D expenditure. This meant that most of their products were customised technical solutions with small-scale production. Because they were willing to take on very specific projects requiring specific solutions all the time, COBALT needed to be innovative in its design. These solutions would not be possible without COBALT employees possessing high technical qualifications and, in some cases, special trade diplomas (C1 2014, interview, 4 July).

The executive director at no point claimed that they heavily invested in R&D. However, they were tailoring technical solutions for each customer; something other competitors in the market were not doing. Similarly, at no point did R&D play a significant role in making COBALT exceptionally innovative.

7.4.3 Technological change

One of the other questions that emerged from this discussion is whether COBALT experienced any changes in external technology that influenced its business or its operations. Considering that COBALT was a high-tech company, changes in technology were expected to have a higher impact than for other case study companies.

As mentioned, COBALT was using highly sophisticated technical solutions, hence they argued that did not have any direct competitor *per se* (C1 2014, interview, 4 July). However, the executive director stated that technology-enabled digital transformation and globalisation affected their business, so that the company could not escape *cut-throat price competition*. As a consequence they were forced to change their business model. Technological change or any definition that could describe this concept was not mentioned in COBALT's interviews. Instead the focus was towards their technical capabilities that were internal to their organisation. It could be concluded that they were well aware of the technological change within their industry and had chosen to respond via their customer-centric approach.

7.4.4 Collaboration

During the factory visit, the executive director argued that COBALT was short on ideas that were developed internally. When asked whether COBALT collaborated with outside companies or government for any projects, especially for the development of innovative activities, the executive director (C1 2014, pers. comm., 4 July) laughed and said:

> *"Australia was worst in collaboration. We would [like to] collaborate, but could not, as a lot of that is going to do with Australia… because there is no vision for what Australia wants to be, that means that its every man [is] for himself… if you do a map, maps of Sydney for whatever defence business, is absolutely everywhere. Are there projects where there are meaningful business, meaningful projects, which encourage collaboration, alliance? nah…"*

It seemed that even if COBALT was willing to collaborate, they did not think there were many opportunities available within Australia. The executive director gave numerous Australian examples where businesses did poorly or government support was questionable. He believed government did not take risks or trust in the innovative capabilities of Australians, nor did it have a vision of where Australia should be in a certain amount of years. He argued that *"… a lot of decisions at a political level are made at ideology instead of vision"*. He provided an example of how Australia loses its potential earnings from manufacturing to other countries:

> *"… for example, we are going to be largest exporter of LNG (Liquid Natural Gas) in the world, 2016, 2017… Right, we are going to lead the world in LNG technology because we will be exporting all the stuff. Or, let's be smarter again and recognise LNG is not exported as energy... According to Industrial Bureau of Mechanics, we sell LNG a cubic meter, which is of peanuts [value]… 2 or 3 bucks. We then export it to Korea… and they then make plastic for meat wrappings from it. They [Koreans] then export it to us, which we then import at 2200 times the cost."*

His view of the state of Australian businesses made him feel, metaphorically, that he was fighting this battle all alone. Every company within the manufacturing sector in Australia was by itself. He constantly noted that a forum was missing where companies and universities could come together for collaborating and developing innovative activities.

It could be argued that none of the innovative activities within COBALT were influenced by collaborating with outside institutions, *per se*. Although all the innovations in COBALT were designed based on customer needs, customers were not treated as partners who were responsible for co-creation. But the objective was to create customer value. In their case, they not only tried to identify the problems and to find solutions for the customer, they placed emphasis on delivering the best performance to their customer. They constantly visited their customers, asked for feedback and sold their products as a service in which they guaranteed proactive actions to meet the customer's needs and expectations. The customer centric business and ability to build on the technical capabilities of its employees also directs what type of culture COBALT practiced, and which in turn contributed to the innovative activities. Therefore, this will be discussed before marketing agility.

7.4.5 Culture

The executive director previously worked in one of the organisations under the Department of Defence, which also contributed towards the type of culture he followed and the method of operations undertaken within the business of COBALT. COBALT divided its day-to-day operations in a structured way to practise its new business model. While the executive director claimed to pay attention to sales, marketing, and finding work for the company, other people who worked as engineers or technicians in COBALT for several years had progressed as managers. They were responsible for maintaining different divisions of the business. Each of these managers was trained to run their division's *"own P&L… where any of the employees at any time can [could] look into the accounting systems and see how the business is [was] performing… as a result… managers have [had] a lot of conversations…*

about their profit and loss statements, sales, cost of goods and gross profits" (C1 2014, interview, 4 July). Every quarter, all managers would meet to discuss profit and loss accounts (P&L), or there would be project management workshops held where any challenges faced during business operations were discussed and strategies were designed to overcome them. The executive director stated that the managers were given flexibility and were made responsible for their business unit's performance, quality and security.

Along with independence and working within one's team, supervision was intense as *walking around* in the premises was emphasised (C2 2014, factory view, 4 July). The executive director stated that COBALT was regulated on a day-to-day basis as an army or a navy would be trained: following the protocols, and the integrity and honesty of its people expected. COBALT did have monthly meetings where business unit data were discussed with staff members and financials, including any issues in the company, were closely examined. For daily operations, the executive director (C1 2014, interview, 4 July) emphasised it was *"very hands on."*

COBALT followed a mix of both formal and informal communication as it also operated a workshop in another region of Australia. Formal communication techniques were online systems and emails, which were regularly exchanged between the employees. However, the executive director (C1 2014, interview, 4 July) stated that their reliance on informal channels such as walking and talking to employees was common. This was evident by his comments such as *"… we are not that big, you know… the team is pretty small… we are not like MNCs (multi-national corporations) where the ideas cannot get up… We are not short of cash, we are short of ideas."* The constant use of the term *walk around* for the process of identifying problems and supervising whilst talking with employees (where 80% of the total workforce had technical qualifications) emphasises this as a way to find new ideas – something he and his team were always looking for.

COBALT's independent culture embedded the delegation of duties. This included accountability of the employees/managers to their team on the one hand, and on the other supervision and open communication. It could be argued that COBALT tried to strike a balance between the openness given to develop ideas, but also emphasised accountability and supervision. The balance within their culture was designed in such a manner that it could contribute towards innovation, and their balanced culture also supported the business practices and their business model.

A significant observation in relation to innovation was the passion of the executive director. When visiting his office for the interview, it was observed that the office floor was covered with different papers based on different policy documentation, current projects of the company, etc. Nonetheless, a structure was visible and, when asked, the executive director (C1 2014, interview, 4 July) said this was how he divided his work so that he could clearly see which projects needed attention whilst he was working. His passion for success and his projects was not restricted to his office. This energy was also visible on a tour of his factory (C2 2014, pers. comm., 4 July). He expressed his excitement on a number of occasions and his fascination with his work and the products they developed. At one occasion, admiring one of their packaging boxes and products he said, *"… I don't know how someone can't be excited after seeing this. I will show you some more things around… this is like Indiana Jones of Australia…"*

His passion towards the work, the culture practised, along with the factory view which I observed, made it clear that COBALT prioritised investment in the technical side of R&D development. Further, it encouraged its employees to have open communication channels to discuss with management their ideas for expanding business operations. Its internal interactions with its employees to encourage new ideas helped in creating innovative and unique solutions, whilst having clever features to eliminate errors, improving product longevity by reducing metal-to-metal wear, etc., was innovation driven (COBALT Website 2014). Interestingly, none of the company's business values were provided on its website or spoken of during the interview conducted in the executive director's office. The culture and passion of COBALT was working towards finding sophisticated technical solutions for its customers.

7.4.6 Marketing agility

The executive director (C1 2014, pers. comm., 4 July) emphasised that they were able to be a profitable business because they understood the customers' needs and preferred methods of communication. Once they knew what the customer requirements were and saw that they were unable to match the price from overseas (which was easily ascertained using the internet) they would direct a customer to the best supplier. Maintaining customer relationships did not stop here. The executive director argued he would travel and have a *"lot of interface with customer… follow up with people [customers]. Ultimately, if we are not getting follow up from people, that means that something is going wrong. We need to go and see them."*

The hands-on approach of customer satisfaction was their biggest marketing expense (COBALT Account Statements 2014). They used proactive and aggressive strategies such as cold calling new potential clients, or people they met in the industry associations, trade shows, and any recommendations from their previous clients (C1 2014, pers. comm., 4 July).

COBALT's agility practices were largely different from those covered in Goldman et al. (1995) and Jacobs et al. (2011). Goldman et al. (1995), for instance, believed in detecting competitive market opportunities for innovation and then seizing these opportunities to manufacture with speed. Jacobs et al. (2011) define manufacturing agility *as "quick and effective response to demand changes including customer responsiveness, shorter manufacturing lead times than competitors, and rapid delivery of good".* Both Goldman et al. (1995) and Jacobs et al. (2011) concentrated on seeking speedy opportunities from their customers, which was one of the activities practised by COBALT. However, COBALT also focused on maintaining long-term relationships with its customers and improving from their feedback. COBALT built on agility/rapidity with sustainable long-term r*elationship management* which contributed in not only building trust and relationships but also helped in maintaining its new business model innovation.

This is consistent with the arguments of Ramani and Kumar (2008) who argue that good customer relations within the manufacturing sector helps to retain customers, generate new products and services and maintain one's competitive advantage. Further, a recent study (Lin, Chen & Kuan-Shun Chiu 2010) on manufacturing SMEs in Taiwan suggests that the companies that did not have high R&D budgets, but desired to have product and process innovations, tried maintaining strong customer relations with their clients. In the Lin et al. (2010) case, SMEs wanted to obtain the necessary resources and support and that was the reason for the customer relationship. However, in COBALT's case, it was to obtain opportunities to showcase that they were the best solution providers. In summary, it can be argued that the marketing agility of an active response to customers' needs and finding opportunities, while also maintaining customer relationships, contributed towards COBALT's innovation.

7.4.7 Previous experience and education of the executive director/owner

In analysing the influence of the executive director, the major shareholder in this company, it seems he was influenced by his previous work experience where decreasing the error rate was of utmost importance. The executive director (C1 2014, interview, 4 July) of COBALT had worked for many years in defence where his approach was to reduce the error rate on the operational side. Using the *six sigma* approach to improve the supply chain processes within the business was a result of his previous experience as well as education. He emphasised that his education assisted him in learning *frameworks* to communicate with various people across the industry as well as at his workplace. His postgraduate business degree gave him the basis for understanding contracts, communicating with human resources, marketing, accounting and finance people across his business, while his first degree in science ensured his understanding of the technical side of the business.

Thus, the previous work experience of the executive director was important for ensuring quality standards and maintaining the culture of his organisation. Both education and previous experience contributed to the adoption of new ideas, business model innovation, and improvement in processes.

7.4.8 Quality management

COBALT did not define quality as having standards or accreditations (COBALT Website 2014) – they were producing a high-end product and believed every competitor in the market was able to produce to a similar standard of quality (C1 2014, pers. comm., 4 July). Rather, the executive director (C1 2014, pers. comm., 4 July) stated that, as it was difficult to decrease human error, he had started to invest in supply chain solutions, as their business model relied on it. The investment seemed to be both financial and process related where the major aim was to reduce delays and ensure cost effectiveness. Thus quality as defined by COBALT aligned with the definition of Fynes, Voss and de Búrca (2005) of meeting conformance standards, which means reducing the supply chain errors. In COBALT's case, improving business processes contributed towards its business model innovation which in turn related to maintenance of quality standards.

7.4.9 Conclusion

The case of COBALT exemplifies how this company adapted to the changing technology-enabled transformation, where customers' access to digitalisation and globalisation caused it to lose business before 2006. COBALT understood that to succeed and still stay in the market making profits, a new business model was required providing a balance between its internal and external factors. They built on their capabilities in two ways – excelling in technology solutions and non-commoditising their business, and by focusing on exploring customer needs by talking through what they were seeking and understanding their problems before offering any solutions.

The technical challenges drove COBALT's managers and employees to try new solutions based on customers' needs within the new business model (C1 2014, interview, 4 July). As a consequence of using this approach, COBALT found they had scope to expand and start a new third manufacturing workshop in another state within Australia. Profits increased by about 13% of sales for the year ending June 2014. Although COBALT's after-tax profit and

Table 7-7: COBALT – Table of attributes.

Factors	COBALT Executive Director	Factory view with the Executive Director/General Manager
R&D investment	Considered technology to be mature.	
Technological change	Digital technology: the biggest impact in the technology change was in the marketing space. Customers had close to full information on products and costs. Technological change has caused them to change their business model. Had no direct competitor.	Continuous development is needed to keep up with the speed of the introduction of technological change. Learn about technological change via internet and from customers.
Culture	Disciplined, honesty, and integrity were expected from its people. Focus on people and their performance.	
	Management practices: divided the organisation into different units and had a manager trained for each unit. These units were individually managed by their managers, who reported back to the company with their P&L accounts. These P&L statements were transparent and could be accessed by any employee.	
Communication of ideas	Meetings – monthly and quarterly. Co-creation with customers.	
Open communication	Preferred communication technique was open; he walked around the company. With the other branch, emails were often used.	Believed in walking around and supervising work.
Previous education	Honours degree in sciences; MBA.	Honours degree in sciences; MBA.
Marketing agility	Cold calling techniques and visiting customers in person. The reason for their success was that they identified opportunities based on customer feedback, and customer referrals.	
Motivation	Passion towards making new things. The challenge which they received from a customers' technical problem motivates them.	Enthusiasm, passion and excitement.
Quality standards	Reducing the error rate – conformance.	
Innovation/business model	Uncommoditised their business – by becoming a customer-oriented solution provider, rather than a seller of products.	
Collaboration	No, he did not think any platform for collaborative projects for innovation existed in Australia.	
	Collaboration did not exist and argued that "every man is for himself".	

return on capital employed decreased from the previous year 2012-2013 (by about 20%, and 40%, to around 33%, respectively) it distinguished itself from other companies and was an inspiring example for other SMEs of success in manufacturing in Australia.

A prominent finding in this case was that the technical education of both management and employees contributed to innovative activities, which was consistent with the quantitative analysis. However, no evidence was found comparable to the quantitative findings that management education in COBALT contributed to innovative activities. According to the executive director, management education gave him an understanding of terminology to understand the divisions of his business (most importantly accounting).

It was not just technological change which drove COBALT to innovate. A combination of technological change and consumer demand interacted with the business's marketing agility to explore its capabilities. The upper management realised its employees' technical capabilities (based on their education and problem solving skills) that motivated COBALT to innovate their business model as well as their products and services. In summary, the persistence of the executive director in finding and determining customer needs, and asking potential and current customers to *give us a chance* to provide COBALT services, indicated the company's faith in its people and work team, which further led to innovations in the firm.

7.5 Case 3: NOBELIUM Pty Ltd: 'Do it better'

The third case study was of NOBELIUM, which designed and manufactured waste product machinery in Australia for its global customers. The data gained for NOBELIUM'S case study was acquired from the interviews with the managing director, director, and an employee and documents gathered as specified in Table 7-8, which included account statements.

7.5.1 Innovation and business model

NOBELIUM was a small business that was incorporated in a backyard shed in New South Wales in 1996 with their innovative product, a foot pedal bin (NOBELIUM Website 2014). NOBELIUM has since grown from 2 to 14 employees. Other innovations were introduced by NOBELIUM from 1996 onwards for the Australian machinery sector. Most of the product innovations were incremental and were influenced by either customer feedback or employee ideas. However, the radical innovation was *organisational innovation* developed from September to December 2013 and implemented in January 2014. The managing director

Table 7-8: NOBELIUM case study sources.

Interviewees	Document Type	
N1 – Managing Director N2 – Director N3 - Employee/recently appointed (promoted) business development manager	Company information (hard copy and website)	1
	Product information (includes both goods and services)	1
	Account statements	2
	Budgeted account statements (yearly)	0
	90 day Business Plan	0
	5 year Business Plan	0
	Newsletters	0
	Company website	1
	Videos available on the website/YouTube	1
	Total case documents	6

made a decision to work with employees on the shop floor to understand their perspective and the business operations more intimately. This decision was made as NOBELIUM had incurred two-years of continuous losses. The result was a change in NOBELIUM's employee structure, where people were moved from shop floor to administration, or were made redundant, based on the performance level and the feedback of other employees. Further, during this structural change, the existing operations at the shop floor were modified to make the work time efficient, leading to process innovation. The process of how innovations were introduced and which factors affected NOBELIUM are discussed in detail below.

The business began when the current managing director helped one of his friends (an owner of a Laundromat service) to receive a bulk order from a university. The requirement of the university was to have a foot pedal bin for baby nappy wash to meet the hygiene standards of the university.

After gaining the bulk order from the university, the managing director commercialised their idea as a separate business and focused on selling their product (foot pedal bins) where demands for hygiene standards were essential. Initially they focused on selling their product to households but realised that it was unaffordable and unnecessary for residential purposes. Hence, they shifted their customer base to supermarkets and hospitals, who had started to place more emphasis on health and safety standards.

However, the partnership of the businesses dissolved after a couple of years. To help with the legal obligations the managing director involved another close friend. They won the case and the managing director employed this close friend to help him in the business.

According to the managing director, the close friend's (N2) full time involvement in the business was useful as she brought a different perspective to his business (N1 2014). Currently she is a second director at NOBELIUM. Even if their perspective was different, the director (N2 2014, pers comm. 7 July) argued, *"We work very well together… and question each other's response to the problem."* This explains that generating and discussing ideas was a common practice among the upper management of NOBELIUM. When asked what her (N2) role in NOBELIUM was, she said apart from her experience in writing and marketing, her passion for mechanical objects had been with her since childhood. She grew up assisting her father in repairing trucks. Gender-based discrimination limited employment opportunities in certain industries and meant she was unable to pursue her dream career in mechanical engineering. Now in this business she thought she was able to pursue her long-term passion. The managing director argued that developing new ideas for business expansion was gained through recognising the right opportunities and responding promptly:

> *"… And then Health and Safety got strict, … they (customers) went to manufacturing and asked them (other suppliers) that can they bring it up to the required standard and… then we went and made our own (name is missing to de-identify), patented it, made a mechanism, its design etc. which nobody else had done so far."*

The above excerpt suggests that NOBELIUM was not only involved with inventing, but was also good at responding to demand, that is commercialising their inventions by maximising the use of their products in various industries. Although NOBELIUM was a small organisation, it was actively involved in spending on development-related projects and patenting their ideas. The zeal to improve products was evident when the managing director repeatedly said, *"We always look for how can we do it (products) better."*

7.5.2 Research and Development (R&D) investment

Patenting the developments of their products seemed to be important for NOBELIUM who took out Australian, New Zealand, US and European patents on their design of the tipping mechanisms. Their financial investment in their products was not extremely high, as evident from the investment in machinery and its technology. What differentiated them was using their ideas to improve tasks and safety standards for their customers, patenting these innovations, and reaping financial reward from the patents. This approach seemed to work well for this company and it could be argued that in this case R&D investment was related to innovation of their products.

7.5.3 Technological change

Changes in technology seem to have influenced NOBELIUM to explore new product ideas and find companies with which they can collaborate for future products or business expansion. However, the company's products rely on hydraulics technology, for which mechanisms are fairly stabilised, and the managing director argued that there was not much to be changed in the machinery, *per se*. On the other hand, the managing director did see keeping up with technology as their main challenge: *"The technology is going that fast that it is very difficult to keep up."*

He referred to technological change as the technological transformation that internet provided them, its competitors, and moreover their customers with access to the global market. This technology-enabled change helped them to change their business model, especially when products from Hong Kong were imported and sold by NOBELIUM in Australia with documentation provided to meet the Australian standards. This change in its business model was new and was implemented after mid 2014 because of a decline in profits over the past years.

7.5.4 Culture

After-tax profits declined from 6.9 % to 3.4 % of net sales for the financial years ending 2013 and 2014 respectively. There were two main reasons identified by NOBELIUM'S director for this sudden decrease in profitability. First, the managing director retired for two years, which meant others ran the business. They were less experienced and also did not share the same values regarding customer needs. They intended to use a push strategy instead (N2 2014, pers comm. 7 July). Second, a negative culture started to build in NOBELIUM when sales suffered and staff was negative about coming to work. To discover why the performance of the organisation had declined, the director and the managing director held interviews with staff members in January 2014 (N2 2014, pers comm. 7 July).

The confidential in-depth discussions with every employee revealed the production area was collapsing and faith in management was plummeting. To improve the situation and learn from their mistakes, a decision was made to have the managing director spend time working on the shop floor at the lowest position for three months. This meant the return of the managing director to the business.

The time spent in the workshop showed an inefficiency in processes and the poor management of stock. He found that the production manager disregarded any new ideas of the staff. The office and administrative staff also had their differences which meant that the overall work culture was having a negative impact on business income.

Through working on the shop floor, and the interviews with the employees, management realised their need to recruit a previous employee – N3. She was considered to be a responsive employee, effectively taking care of production, inventory management, and other office duties. Due to gender inequality and the negative culture prevailing at the time, N3 had left the job. She was offered a higher salary to come back and work for NOBELIUM as a business development manager. Accepting the offer and feeling privileged, she (N3 2014, pers comm. 7 July) joined NOBELIUM once again and emphasised that her job had been *hands on* since she was back, but she loved it.

Currently, the business has developed strategies for better performance. NOBELIUM has expanded its markets over the years and contributes with its products to industries such as waste management, construction, material handling, mining, food manufacturing facilities, hospitals, and aged care homes. The current expansion includes industrial balers, polystyrene reducers, glass crushers, drum crushers, electric vehicles, along with previous products such as industrial bins and bin tippers. The company stated that it is the positive attitude of its people that has helped improve and diversify products.

Other recent developments were a revamp of employees' roles through the organisational structure innovation. For instance, the production manager was no longer working on the shop floor but working in an administrative position. To further improve the culture, the business manager and the upper management – both director and the managing director – used open communication with all employees. This change in the organisational structure was innovative as it was designed to improve business processes, and to not only encourage employees to develop new ideas but to communicate them to the management. The shift in the positions ensured gender equality now existed, and emphasis was placed on how people are recruited to the company. A happier workforce across NOBELIUM and more efficiency since January 2014 was evident through the interviews.

The NOBELIUM case exemplified that a supportive and inclusive culture is a much-needed factor for innovating in any business. The transition that NOBELIUM chose during the time they were interviewed was considered a factor that developed and brought new products and ideas into practice. Furthermore, being a small company, they seemed to have an internal collaborative culture after the change management.

7.5.5 Collaboration

Apart from internal collaboration, from the discussions it emerged that NOBELIUM had considered expanding into European markets as they invested in European patents. The managing director noted that a company from Denmark had recently approached them with a collaborative proposal. Their proposal included designing in Australia and manufacturing in Denmark to sell to European markets so that they could save on freight costs, as the machines for import were heavy. In this manner both companies could add value by adding their services and expand their operations and profitability. This is consistent with Dodgson (1994) who argued that collaboration entails two companies achieving mutual benefits when they are at the same level of a production process.

Another collaborative project was importing electric vehicles from Hong Kong to sell to their customers, providing documentation based on the Australian standards. They found that manufacturing electric vehicles in Australia would require a very high capital investment and it would be difficult to arrange for resources to undertake this.

It could be argued that collaboration helped NOBELIUM to change its business model as they started to expand into other markets. NOBELIUM had limited financial resources for major capital investment. By importing machinery and selling at a certain margin they would compete on price, and by vertically collaborating with a Danish company they were able to tap into European markets. Changing their attitude towards collaboration, providing a supportive work culture, and listening to their customer feedback and demand led to a change in their business model.

7.5.6 Marketing agility

Interestingly, new ideas were created with the help of its customers and employees, which is consistent with ideas from the literature (Prahalad & Ramaswamy 2004; von Hippel 1988). The creation of innovation was based on their philosophy of listening to their customers and employees and being willing to try new ideas, as evident in the interview with N2 (2014). *“N1 [name replaced] and my approach was, let’s find out what they need and we can fit with them (customers), so that both of us do well.”*

During the conversations it was found that every interviewee in the company was customer focused and had a *can do* business attitude. *Listen/act* was a core philosophy shared by the current employees. *Listen* meant they aimed to listen to their customers, identify their needs and look for opportunities to serve them, while *act* was to pursue these opportunities.

The definition of the *listen/act* philosophy by the managing director was limited to customers, but in practice it seemed that it was also applicable for employees. Listening to the ideas of employees was important. He stated, *"Most of the innovation comes from in-house, from people here."* He described an occasion where an employee's idea was taken up saving $6 per item used in their products. The *listen/act* philosophy was regarded as essential by its director and business manager, as captured during the interviews.

The evidence from interviews and their website was that NOBELIUM was a customer-centric business. The managing director (N1 2014, interview, 7 July) argued:

> *"We have a culture here that if a phone rings more than twice, why? This means we do pick up on second call or before... an inquiry needs to answer within the hour and that's it! Deal with people (customers) and how they would like to be dealt with and know how they operate."*

NOBELIUM claimed that they were a reactive company, which meant that they wanted to meet customer needs and were open for customisation. The managing director (N1 2014, pers comm. 7 July) argued, *"We are pretty open to, make and thus fit it."* He further emphasised that listening to customers' needs and then determining whether they need products of NOBELIUM or not was necessary and important for them. Similarly N2 emphasised the value of customer feedback and at one point complained that the reason for losses in the previous two years had been because their former sales manager would not listen to customers' needs and their feedback. When questioned why this was, she pointed to his attitude towards his work and the consequent need to change personnel, including making a few redundant who developed a negative culture in the company. When questioned what was meant by negative culture, she said gender inequality, performance on the job which was below acceptable standards, and making shopfloor people feel inferior due to their job positions. A negative culture has been linked to inhibiting innovation (Cameron & Quinn 2011).

The above discussions highlights two major aspects of this company. First, the use of customer feedback within NOBELIUM for the development of the products and services. Second, and more importantly, the kind of culture the company had developed. One of the director's claims was that a negative culture in the company had started to emerge, regarded as the main reason for their losses. She further argued that the negative culture had impacted not only on the sales but also on innovation within the company: *"He (former sales manager) didn't promote new products properly… It was all about him, rather than the customers or our innovations."*

NOBELIUM products were developed based on knowing a customer's needs and the company aimed to create and enter the markets based on customer response. Customers were found by direct interaction in trade shows, or follow ups, or through personal visits. Marketing capabilities such as trade shows and advertising campaigns were also used to attract new customers. The agility with which NOBELIUM aimed to identify customer needs focused on new opportunities.

New opportunities were explored by N2 whilst using her previous research background. She explored markets through trade articles and found opportunities across all the sectors where the potential customers were thinking to strengthen their commitment to human health and safety, especially from a waste management perspective. She then forwarded the details and the background to the marketing and sales manager. Finding potential customers and visiting them was common practice at NOBELIUM.

Being responsive to customer needs and maintaining customer relationships were two of the main components of being agile within their market, and hence contributed towards innovative activities.

7.5.7 Previous education, experience and motivation of the managing director

The managing director's education was limited to high school and some trade diplomas. Yet, he mentioned that it was his experience with hydraulic goods and working at the shop floor that made him aware of techniques needed at work. Beside that, he did rely on his other director's advice who had a university degree in communications and had worked as a research assistant.

When asked about the reason for the success of NOBELIUM, the common values shared by the managing director and director were highlighted as these helped them to expand into different markets. Both argued that *money was not the driving force* but what motivated them to be part of the business and innovate was the *sense of achievement.* This sense of achievement was driven by the nature of the created products, which were useful to society and which also helped in creating employment opportunities for the region. This finding was consistent with the quantitative finding that the motivation of the upper management contributed to innovative activities developed in a SME.

The core values that the company looked for in its recruits were hard work, open communication, honesty, and dedication. Its managing director (N1 2014, interview, 7 July) had learnt from the company's previous failures and believed: *"You can teach people to do* *jobs, but you can't change their attitudes. Attitude is what makes people work effectively."* Thus they concentrated on employing those people who had a positive attitude and passion towards their work.

Something stood out from the discussions: even with the losses faced over the past few years, they had still won the business excellence awards for industrial and manufacturing business for the past three years. Winning these awards was in contrast with NOBELIUM's decreasing profits. The managing director attributed this to the quality standard of their products.

7.5.8 Quality management

NOBELIUM clearly stated that, for them, quality meant meeting customers' standards. The managing director **(N1 2014, pers comm. 7 July)** argued that meeting quality standards at a given price was the reason that its customers still wanted their products. None of the other members who were interviewed talked about quality and, based on the available information, it is not clear whether quality standards were contributing or not towards innovation in NOBELIUM.

7.5.9 Government assistance

The expansion of markets, according to the managing director (N1 2014, interview, 7 July), was due to exploring international markets through: *"Google, help from AUSTRADE and… we try to utilise government agencies where we can."* Later, the managing director acknowledged he received help from the agencies to prepare business plans and strategies – although, for a small business, he thought business plans were not essential. This may be because he considered his business was flexible and changed with the changing market conditions, especially customers' requirements. The director of the business shared this sentiment towards the limited usefulness of business plans (N2 2014, interview, 7 July).

The contribution of the government assistance was found to support innovations indirectly as it was related to exploring new markets.

7.5.10 Conclusion

In NOBELIUM's case, marketing agility, collaboration and culture were found to affect innovative outcomes. The managing director argued that NOBELIUM had identified its niche in the waste management sector and, based on customer feedback, tried to improve its

Table 7-9: NOBELIUM – Table of attributes.

Factors	NOBELIUM Managing Director	Director	Business Manager
R&D Investment	Patents – Australian, US and European patents for tipping mechanisms. Australian, European and New Zealand patents for its other new product.		
Technological change	Difficult to keep up with technology. He felt because dealing with hydraulics, the required changes are not so much in machinery. Technological change did affect how they had to deal with customers in a new way.		New IT systems for day-to-day operations have improved efficiency.
Culture	Understanding the needs of its employees was essential. Work as a community to have a healthy workspace.	Gender equality and treating everyone right and equal. Informal BBQs and drinks.	Positive attitude of the people.
	Attitude of the employees towards other employees and their work.	Attitude of the people working in the company towards others.	
Open communication	Co-creation with customers. Followed listen/act philosophy for both customers and employees.	Co-creation with customers. Prefers informal communication with the employees.	Prefers informal communication with employees.
	Can talk with any employee.	Talk with any employee.	Open communication with the shopfloor and the office employees.
Previous education	High School	Communication degree	Diplomas related with management
Marketing agility	Customer-centric: wanted to know customer needs before selling them their product. Believed in customising their products for its customers. Visiting in person and asking customers for referrals. Met customers through websites, trade fairs, and talking with people.	Customer-centric: wanted to know customer needs before selling them their product. Believed in customising their products for its customers. Looked for potential customers in trade magazines, and used her research skills to understand their business before contacting them.	
Motivation	Providing community with best products.	Challenge in work motivates, as does working for the community.	Challenge in work motivates, as does appreciation by co-workers for her job.
Quality	Meeting customer standards is what quality is, at the agreed price.		
Collaboration	Collaborate with government institutes such as AUSTRADE to explore foreign markets. Collaborated with a Danish company to manufacture and sell their product in European markets.		

business operations. Identifying regular opportunities for expansion and talking with its customers suggest that customer needs and wants were at the centre of this business.

Technology-enabled change with the use of internet helped NOBELIUM in finding global opportunities across various sectors which led to the development of new products and services. NOBELIUM used changes in technology to its advantage by making its marketing abilities agile such that it can collaborate with both customers and other organisations around the world to expand into new markets. This interaction of technological change and marketing agility was dependant on NOBELIUM's internal culture. It could be argued that NOBELIUM understood the importance of this interaction hence facilitated a change in their organisational structure, which according to one of the directors was much needed to promote their innovations, respect others at work and listen and develop products for the customers.

7.6 Case 4: TELLURIUM Pty Ltd: 'Sometimes we just do what we know'

The fourth and final case studied was TELLURIUM, an Australian business serving the construction industry with welded frames in rural cyclonic regions. The data sources for TELLURIUM'S case study concerned three interviews with the managing director, business accounts manager, and an employee. Additionally, five case documents and seven videos were included, as specified in Table 7-10.

Table 7-10: TELLURIUM case study sources.

Interviewees	Document Type	
T1 – Managing Director T2 – Business Accounts Manager T3 - Employee	Company information (hard copy and website)	1
	Products information (includes both goods and services)	1
	Account statements	2
	Budgeted account statements (yearly)	0
	90 day Business Plan	0
	5 year Business Plan	0
	Newsletters	0
	Company website	1
	Videos available on the website/YouTube	7
	Total case study documents	5

TELLURIUM was established in 1997 in North Western Australia by its owner, the current managing director. The business prospered. In 2013 an opportunity arose to buy out another similar business within the metal industry. Both businesses were involved in similar crafting of residential framing, which involved steel stud walls, steel roof systems, and steel frames. This merger of the two companies into one meant that business could expand in terms of equipment capabilities, acquiring trained employees, and, ideally, an expanded customer base. As a result of the acquisition TELLURIUM grew from 9 to 50 employees. The services provided to customers were the same as before, namely providing steel fabrication, steel supply, project building, and detailed drafting of architectural and engineering designs to its customers. Few innovations were accounted for the company during the data collection process.

To the surprise of the owner, customer demand started to fall after the merger. Finding it difficult to retain all 50 employees, the owner had to make the difficult decision of making 50% of employees redundant. The loss of the net sales for the financial year 2013-14 made it evident that the company was unable to find sufficient work during the period and redundancies were made (TELLURIUM Account Statements 2014).

The business was built on government contracts and had a policy of supporting Aboriginal employment opportunities. However, given the reliance on these government projects and policies, management did not seek alternative project opportunities in the private sector. They argued that their success in gaining these contracts from the government was because of two reasons. First, the welding technique that they used was more effective in the cyclonic regions in comparison with the alternative, bolted frames. Next, 20% of their employees on each project were of Indigenous background and this helped in gaining government contracts. The accounts manager, who had previous experience in such processes, submitted the tenders for these government projects.

Apart from redundancies, measures such as reduction of inventory and disposal of unwanted assets were taken in the financial year 2014-2015, which helped recoup some of the losses (T2 2015, pers. comm., 4 February). The business/accounts manager (T2 2015, pers. comm. (email), 4 February) emphasised that: *"... most importantly, we (they) have attracted more customers and worked hard at achieving better margins".* Although they never specified which customers, it is expected that they won more government tenders. At no point did TELLURIUM discuss involvement in any private projects.

7.6.1 Innovation and Business Model

TELLURIUM did not have many product and service offerings to qualify as an innovative company. The interviews revealed mixed information in regard with the underlying innovation. The managing director claimed that most of their innovations related to the design of steel frames as evident: "*… possibly a lot of innovation has come from design team.*" On the other hand, another employee argued "*we are reluctant to [*pause*] engage in the innovative things."* These disparities in answers may be the ascribed to the fact that the managing director was referring to actual design ideas, whereas the employee included the outcome of these innovations, that is design failures. These failures occurred because the designs were modified based on customer ideas, ignoring the principles of engineering, which led to unsatisfied customer(s). Rather than learning from their mistakes, TELLURIUM took a defensive approach and blamed customers for design suggestions. Any other specific product and process innovations were not accounted during any of the interviews or archival analysis.

7.6.2 R&D investment

The nature of products for TELLURIUM suggests that R&D investment was not the type of expense which they usually engaged themselves in. A recent machinery investment was a metal cutter to make existing tasks more efficient as in the past they did those manually. Limited financial resources were a plausible cause for less engagement in R&D activities: *"we know that innovation needs to be done, so* [due to the] *initial outlay, we haven't been able to buy the stud rolls again.*" However, with the changing digitalised environment, it indeed questions how the company was dealing with changes in the external technology.

7.6.3 Technological change

Out of the four business case studies TELLURIUM was the only one which discussed how technological change affected their machinery and equipment. TELLURIUM's managing director argued that as the building of frames has shifted from welded to bolted ones, its effect on their business was immense. Welded frames required more manual labour in comparison to the bolted frames, for which labour can be mechanised. Due to high labour costs welded frames were expensive, hence a market shift towards bolted frames was visible. However, TELLURIUM did not want to change because they argued welded frames were stronger and better able to withstand the pressure of winds than bolted frames. This advantage helped them to retain their existing customers, such as government housing in the cyclonic region in which they operated. TELLURIUM had maintained their niche by focussing on the welded frames based on its advantages, however selling these advantages to the private sector was one of their biggest challenges.

At the same time, the company was involved in gaining ideas for their business development from all over the world. The managing director (T1 2014, interview, 7 July) argued that he searched online for developments in welded frames in different countries such as the United Kingdom, the United States, and Germany such that they could cope with changes in the technology. However, incorporating those changes proved difficult given the cost of the machinery. Thus, while the managing director was aware of the changes in the external technology, employees had less awareness of changes in the technology. Most staff had limited education when they started working at TELLURIUM. Although they did get training in the areas needed, this educational deficit may have contributed to a lack of understanding of the landscape in which TELLURIUM operated.

Reliance on existing technology was affecting TELLURIUM, and they started to lose their customers. Innovation in this company was found to be limited. For TELLURIUM, innovative solutions to reduce cost with welded frames technology would be welcome. Additionally, their selling of services required attention, as its' methods to attract and retain customers were primarily applicable to the cyclonic region in which they operated. Looking for other opportunities in different sectors that may require their skills of welding and carpentry could also have a positive impact on their business.

7.6.4 Culture

TELLURIUM employed mostly *apprentices*. This was evident as TELLURIUM was supported by the government and had won various awards, including that of best employer, due to its *innovative training programs* which involved Australian Apprenticeships (TELLURIUM Website 2014). The majority of their employees lacked experience in the field: *"I had no prior experience… and all my experience is from this company"* (T3 2014, interview, 7 July). Similarly, videos available on its website (TELLURIUM Website 2014) indicate most employees were trained on the job. A broad knowledge of the industry was lacking in most of the apprentices, which seemed to be affecting the business.

An employee (T3 2014, interview, 7 July), commenting on the culture of their company, noted that a change in the recent strategy of open communication and delegation of responsibilities in TELLURIUM had helped him and others to express ideas more effectively. When asked what type of ideas, he replied it was related to variations in the way things were done, for example to improve efficiency. As the employees had limited experience, they mostly submitted ideas for approval to the managing director who, because of his expertise, was supervising their work. A family-like culture was apparent, in which every employee looked to the managing director for approval.

While there was a lack of experience and innovative ideas, the support provided by the managing director, and the family-like culture, motivated its employees to be part of TELLURIUM. The managing director provided support to his employees and his enthusiasm to succeed was aligned to providing skills to the local Aboriginal community. The managing director acted as a supervisor who encouraged his employees and it was observed that the employees respected his expertise, as is evident in the videos as well as one of the interviews (T3 2014, interview, 7 July). The employees' faith in their managing director was seen through comments, such as: *"[He is] the main one we (employees) talk, because… he (managing director) is probably one of the people I know best in his industry… If I do something I always ask him."*

To create a friendly and open communication culture, the managing director organised activities such as weekend BBQs and drinks to bring staff together as a team. The family-like values were supported by sometimes inviting employees' families to these occasions, to encourage a community spirit. The satisfaction of employees was depicted in videos and in comments like: *"... happy to go to work, you know when you are working with your good mates... I love my job"* (T2 2014; T3 2014, interview, 7 July). While there was a friendly culture, critical feedback and encouragement of innovative ideas was missing. A balance between supervision and family-like culture, as well as encouragement of critical thinking for undertaking innovative activities, was much needed in TELLURIUM.

Regarding innovation, the business manager, who was an accountant by background, argued that not having a similar background to others in the firm helped him provide many ideas to the director for modifying processes. He stated he was *"... not scared to put my ideas forward and get rejected or feel stupid"* (T2 2014, pers. comm., 7 July). Therefore, having diverse experiences could contribute to innovative ideas. It is argued that for TELLURIUM its open communication and supportive culture towards employees did not contribute to innovative activities. Perhaps this was so because the employees were not aware of TELLURIUM'S value proposition and goals. A family-like culture was not supporting the creation of new ideas and ways of improving. Employees' goals at no point seemed to be aligned with TELLURIUM's goals, or innovation per se, and those interviewed were found to have a narrow vision of their role. The general encouragement for its employees to innovate and come up with creative ideas whilst using customer co-creation or customer feedback was missing from the observations made.

7.6.5 Marketing agility

A firm is able to look for opportunities with the help of co-creation and marketing their business where customers are the most important link in a supply chain (Prahalad & Ramaswamy 2004). While the managing director (T1 2014, interview, 7 July) emphasised that TELLURIUM was dependent on *word of mouth* to find new work, he claimed that their company was *"very high on our customer relations and service"*. However, the aforementioned inconsistencies in customer relationships within the firm were difficult to ignore.

It became difficult to judge the importance of customer needs, as the evidence was contradictory. They argued that customer feedback was captured, but whether this was used was questionable. Furthermore, they could build relationships with customers when projects were delivered to the desired quality, but because there were issues with this, it would impact on such relationship building. However, the managing director did want to build this kind of relationships. The apparent problem seemed that the managing director's communication of customer feedback to the employees was restricted, and learning from their failures was limited. This is evident from various excerpts included below.

T2 argued that customer feedback was often not formally recorded in their systems or books:

> *"… we don't do enough of that [documenting of the feedback]. We do document some of it. It tends to be documented in a quarterly reporting to our board of directors. If it happens immediately after the board of directors meeting, it will get lost… I record it within my outlook calendar and write in two or three months into the future. So then, it pops up. And we will be like that, oh yes, we had that huge argument with so and so and what we actually have done to remedy that…" (T2 2014, interview, 7 July).*

When asked whether they tried recording the feedback, the business manager (T2 2014, interview, 7 July) argued that they tried using surveys to collect feedback, but the response was not good and hence they relied on talking directly with the customer. The managing director stated that he would visit customers and ask whether they were happy with the outcome, where improvement was needed, and to seek referrals for future work (T1 2014, interview, 7 July). This led to the question of their use of this information for product or service development.

One of the employees (T3 2014, interview, 7 July) indicated that customer feedback was sometimes shared verbally within the organisation. However, most of the time this feedback was about what went wrong rather than what went well. Using customer feedback for creating new or improved activities was not common in TELLURIUM.

This helps to explain how the degree of importance given to customer feedback was dependant the customer's reaction to TELLURIUM's services. If the customer was very unhappy, then some remedies were undertaken to rectify TELLURIUM's mistakes. The business and accounts manager (T2 2014, interview, 7 July) further stated:

> *"Our quarterly reporting to some of our directors is trying to identify some of that stuff… we are reluctant to (pause) engage in the innovative things. We need to undertake or do different kinds of things. Sometimes our senior staff are kind of reluctant to include that (feedback) either because they don't value it particularly. That is a reflection, … they (Board of directors) are too challenged by it (feedback), … so that's the reason of how we document it."*

The senior management's limited business outlook, and inability to act on customer feedback, might have further led to a lack of innovative ideas. This restricted their thinking and ability to cope with external changes, such as technological change and shifts in customer demand. Additionally, learning from past experiences in order to maintain customer relationships was lacking and, more importantly, not embracing customer feedback was an inhibitor for the development of innovation.

Falling profit margins and redundancies suggest that TELLURIUM needed to identify effective mechanisms to work with customer feedback. It could be argued that communicating both positive and negative customer feedback to employees helps them to get a closer understanding of customer experiences, which further creates knowledge and learning from past routines (Nelson & Winter 1982). Rather than portraying a seeming lack of enthusiasm and stating *"there were not many ideas to exploit in their industry"* (T1, T2 and T3), TELLURIUM would get an opportunity to explore diverse sectors from their employees' perspective.

No evidence was found that TELLURIUM developed or aimed to develop any product or process based on marketing techniques, customer relationship management, or customer feedback.

7.6.6 Previous education, experience, and motivation of the owner/managing director

Of interest was why the managing director persevered with the business, as its customer base was declining and the company's value proposition and goals did not seem to reflect its current challenges. It seemed that two things motivated the managing director. First, 30% of its staff came from the Indigenous community and by providing them training the managing director felt that he was giving something back to the community. Second, he had a sense of achievement when customers appreciated his work and praised him. Both the above factors were intrinsic and at no point throughout the interview did the managing director talk about profitability or money as drivers for success. The managing director concentrated his creativity towards areas that needed very high standards of perfection. He understood the business thoroughly and he had advanced trade qualifications in carpentry, boiler making, engineering, and structural framing which assisted him in effective supervision of the business operations. The creativity and motivation of the managing director helped the company's survival, but did not support innovation or clarity of business improvement process.

TELLURIUM's recent business statement for the six-month period from 1 July 2014 shows profits almost equivalent to the losses of the previous year. The question is what changes TELLURIUM implemented in its approach to achieve this financial stability. First its vision was explored, which indicated a desire to provide the highest standard of service by meeting three important needs of its clients: delivery on time, meeting budget requirements, and providing superior quality (TELLURIUM Website 2014). The customer-centric vision indicated that customer satisfaction was central to their vision to meet quality standards – aligning with the definition of Drucker (1985a) that quality lies in the perception of the customer. However, the interviews revealed that the definition of quality varied.

7.6.7 Quality management

Quality as defined by TELLURIUM'S managing director (T1) was *"doing it right when no one is looking"* (TELLURIUM Website 2014). There were inconsistencies found with this definition throughout the interviews as well as in the secondary information gained through their website. The definition of quality was meeting customer needs by managing the supply chain of its business. The supply chain focused on continuous three-way interaction with its employees, customers and suppliers (T1 2014, interview, 7 July). Customers approved product designs before raw materials could be ordered from the supplier.

Quality as defined by the business and accounts manager was defined as engineering of the products to withstand the cyclones in that region (T2 2014, interview, 7 July). The business manager's (T2 2014, interview, 7 July) definition of quality did not recognise meeting customer demands or its needs. In fact, he showed his resentment when they had to meet customer needs, stating that in the past when they tried to address customer needs the end product had flaws. He claimed, *"… we are experts in what we do, and what we don't like is, when customers rely on us".* The implication is that meeting customer needs was not a strong point, and that the company was confined to old methods rather than introducing any new innovative solutions. The statement was contrary to the company's vision of meeting customers' needs.

The business/accounts manager stated that he felt that sometimes the purpose of the designed products did not meet appropriate standards of quality and customer satisfaction. He further stated that their response to customer complaints was defensive and they blamed a customer for ordering wrong designs. The next excerpt helps to explain this scenario:

> *"We like to think about us who provide a high quality product and if something goes wrong in a job, [customer's think] well why didn't you [TELLURIUM] pick up that?… [TELLURIUM]… become(s) defensive… we put it back to customer… We not always walk what we talk."*

He then explained where TELLURIUM was lacking:

> *"We power ourselves as experts, innovative and have ability to be flexible; but sometimes we just do what we know, what we did last time, and we follow through that. And I think we miss some opportunities to really excel and really deliver our product, an amazing product, to our customers" (T2 2014, interview, 7 July).*

It appeared that customers were seeking innovation in the quality delivered to them. However, TELLURIUM was unable to change and bring a shift their thinking. They listened to the customer but did not co-create with them and lacked an understanding of their needs. They could have explained to their customers, who were in cyclonic regions, that certain designs were not necessarily suitable for that area. Rather than explaining this, for fear of losing customers, TELLURIUM went ahead with the customer's suggestions. TELLURIUM's attempt to argue their case, namely to believe in their capabilities and experience, and to explain the potential risks of the designs suggested by customers was seemingly needed. They did have customer communication, but it was not two-way: they allowed customers, who might not have expertise in the building area, decide what was good for the building frames and they followed their designs. Blaming customers for any mishaps with the designs later on was not an effective way to manage the relationships. Overall, the discussion of the quality standards, and the disparity between customer expectations and the delivery of the project, suggests that no contribution towards innovation was made.

7.6.8 Investment in its employees

An interesting activity of this organisation was the training and investment in its employees. The level of education and previous work experience of its employees was limited, as mentioned previously. TELLURIUM's direct labour costs were its major expense, accounting for 47% of its total sales income. Yet, spending money on training its employees did not change the way they worked and did not lead to the introduction of new products and processes. TELLURIUM is highly dependent on government grants. However, none of this financial assistance from the government was related to introducing new products or techniques to manufacture new goods or services.

A few of its employees were recruited on 457 (temporary skilled work) visas, had expertise in some relevant areas, and were happy to move to a regional area in Australia. The number was mentioned as quite low but the exact number of people was never specified. The business manager was the only person who had previous education and professional experience to administer the financials of the business. His expertise was in the budgeting and working out budgets for their jobs which assisted TELLURIUM in making the work process more cost efficient.

An obvious question to be asked is, as TELLURIUM was spending so much on training its local community, why were they unable to persuade their people to create new ideas and innovate? The answer appears to be that all the training was for the employees to work and learn the operations of the business and none aimed for them to practise or develop new and innovative ideas. The employees were paid above the norm due to the high cost of living in their area.

7.6.9 Conclusion

TELLURIUM was in a different place compared to the three other case study companies. Due to financial constraints the investment in new technology was found to be minimal. The company tried to come up with design frame ideas, which however did not see much success as the final product did not meet customers' quality expectations. It could be argued that TELLURIUM facing such challenges in developing and commercialising ideas is due to a number of reasons. First, the managing director was responsible for most of the idea development, expanding the business, and finding contracts. Although the employees did mention that he started to decrease his workload, most of the employees did not trust their own ideas and rather relied on their managing director for approval. Next, and probably the most important reason, TELLURIUM did not take responsibility for their failures, and occasionally blamed it on their customers for agreeing to or suggesting some ideas. In principle, the business aimed to understand customer needs, followed by building a prototype before committing to the final frame. However, learning from failures and trusting one's own capabilities are much needed within the process of innovation (and, it should be noted, are easily financially attainable).

Losing customers to the newer mechanised developments in bolted frames had put financial pressure on their business. As a corollary to this, their target market was reduced to their regional area and its niche requirements. The impact was evident in their financial statements showing a loss for the year ending 30 June, 2014. Moreover, no capital depreciation appears in the account statements and the return on the capital employed in the business showed negative results of approximately 4%. The company's labour costs remained a major expense, even after making 50% of its employees redundant in 2013.

In TELLURIUM'S case external technological change, along with the managing director's education and experience, helped them to realise a need to innovate. However, the inability to take risks and learn from their failures held them back. It seemed that this company was short on opportunities, both in terms of ideas and finance. The inexperience of employees did not contribute towards innovation or innovative ideas. That being said, the overall work culture was good as employees enjoyed coming to work. Yet, they were not encouraged to generate new ideas or innovate. The latter issue corroborates the seeming inability to use customer feedback and be agile in its marketing. Thus it can be argued that these challenged abilities to respond and interact with changing technology led to little innovation. In summary, TELLURIUM was found not to be the innovative company it claimed to be in its responses to the survey and through the information available on its website.

Table 7-11: TELLURIUM – Table of attributes.

Factors	Managing Director	Employee	Business and Accounts Manager
R&D investment			
Technological change	Competitor: the competitors in the market have new technology which has impacted TELLURIUM's business as the competitors' technology is price efficient. TELLURIUM has decided not to adopt the competitors' technology as they want to create their own niche. They are not trying to explore any new or global markets.		
	High competition due to globalisation.		

Culture	Delegation of responsibilities to employees has helped to concentrate on marketing the company. Work as a community to have a healthy workspace.	Delegation of responsibilities has meant reliance on trust in employees. Informal BBQs and drinks.	Maintaining a positive attitude of employees.
Communication of ideas	Prefers informal communication with his employees. Co-creation has been tried, but led to unsatisfactory outcomes.	Prefers informal communication with his employees.	Prefers informal communication with his employees. Upper management may be afraid of taking customer feedback on board, he feels that ought to be more prevalent.
Open communication	Can talk with any employee.	Communication with the managing director and other employees was informal. Positive feedback from customers was often not communicated, in contrast to problems faced by a customer.	Open communication with the managing director and other employees.
Previous education	TAFE/trade diplomas	Trade diplomas	Accounting degree and Environment degree
Marketing agility	Visiting in person and asking customers for referrals.	Thought they gained customer feedback from surveys.	Maintaining relationships with customers and especially government departments.
Motivation	Providing Indigenous community with experience. Sense of achievement when they are successful.		Challenge in work motivates.
Quality	Doing it right when no one is looking.	Meeting the demands of his supervisor.	Engineering of the products to withstand cyclones common in regions C and D.
Collaboration	Government departments, but only for tenders.		Government departments, but only for tenders.

7.7 Discussion

In this section the findings from the individual case study companies are synthesised into a discussion on the interactions between factors. In the framework developed in Chapter 4, technological change was seen as the major external factor. The sub-sections will explore in more depth how culture, education, experience, marketing agility, and collaboration interact with technological change to generate innovative activities. The themes explored in this study were based on the quantitative analysis. Through these case studies it became clear that innovation was not just a matter of absolutes, limited to internal or external factors derived from these themes. It was the *right balance* between each of these factors that contributed towards innovation. From the evidence, it appeared that rather than technological change by itself as a driver for innovation, co-creating innovations with a customer and finding opportunities across different sectors helped Australian manufacturing SMEs to innovate, recoup their investment, and strengthen their competitive abilities. Along with the role of a *balanced* culture, these were the essential pieces of the innovation puzzle.

Table 7-6: Comparison of factors across the four case studies.

Companies Factors	Gold	Cobalt	Nobelium	Tellurium
R&D investment	*	*	**	-
Technological change	***	****	****	***
Culture	**	**	****	***
Communication of ideas	*****		****	*
Open communication	****			
Previous education:				
Owner	*	*****	*	**
Managers and employees	***	****	**	*
Marketing agility	****	****	****	**
Motivation				
Passion		****		
Success	*****	****		****
Social cause			****	****
Quality, as defined by customers following the definition of Drucker (1988)	**	*****	****	*
Collaboration with external companies to innovate	*	-	***	-
Inventions	****		**	-
Innovation in the companies	*	*****	***	-

Reliance on the indicated factor ranked using stars ranging 1 to 5, with 5 indicating highest reliance. A minus (-) indicates that particular factor did not apply or was not sufficiently developed.

A common theme among the case study companies was that while technological change was acknowledged, finding opportunities for new ways to drive the business was considered a stronger impulse for innovation. In particular, finding opportunities based on customer needs provides an opening to commercialise inventions as these are directly derived from a value-creation perspective. GOLD, COBALT and NOBELIUM did not aim to emphasise their own ideas, pushing them onto a customer, but focused first on identifying customers' problems, and then built on their company's capabilities as a solution provider. Customer co-creation does not work in isolation but needs the support from other internal factors.

The most significant internal factor found was a culture which mediated the effect of external factors to create innovative activities. The culture includes the CEO/owner/upper management supporting their employees by nurturing their intrinsic and extrinsic needs and also giving them an opportunity to think critically about the existing processes. This type of culture, providing both support and freedom at the same time, is known as a *balanced culture* and was found to be important for the generation of innovation.

To adapt to a newer strategy to co-create with customers, internal factors such as knowledge capacity and implementation capabilities are required. The relationships between external and internal factors will be explored in the sub-sections that follow. Data from the sources, summarised in Table 7-6, emphasised that the way these factors interacted in each case to generate innovative activities was different. People interviewed from the different companies responded differently to the changing external conditions (including technological change). While some considered their culture as the driving factor to respond to the changing conditions, others thought their marketing capabilities differentiated them. The common themes that emerged from the qualitative data are discussed in the following sections of this chapter.

7.7.1 Innovation: the agenda for survival

The qualitative evidence indicated that innovation within Australian SMEs may not be always driven by collaboration with other enterprises, or the need to produce better designs in one's company, or spending large amounts on educating employees. The main driver may be something else, namely survival. A quote by COBALT's executive director explains this different perspective of innovation and why it was undertaken:

> *"So innovation, collaboration, alliancing all little stuff is the luxury you have, education and all that stuff is a luxury you have, when you have profitable business… if you are scrambling to make ends meet, you don't have the luxury to be a person to sit and design something*."

He argued that innovation was a luxury item and this argument was consistent across different cases in which these companies created innovations to survive. A common theme was that all case study companies had changed, or needed a change in, their business models. Close examination of the case study companies suggests that exploring customers' needs has helped the selected companies to create innovative products and services, and, more importantly, innovate their business models. Throughout the interviews, COBALT explained how a new business model had affected their product development and revenue stream, while NOBELIUM and GOLD were involved in introducing innovative products and processes that unknowingly started to change their business model to attract new customers. COBALT (C1 2014, interview, 4 July) emphasised its new business model and noted their role had changed from a product supplier to a solution provider. NOBELIUM did not characterise themselves particularly using the term *solution provider* but stated that they first wanted to understand customer needs before identifying a suitable product (N2 2014, interview, 7 July). Although GOLD made some developments like importing machinery and supplying services such as repairs, it clearly needed a redefined business model because the current model was not aligned with its objectives and goals. GOLD was considered to be very inventive in their thinking, but they needed to find different uses for their inventions, or different customers for the same inventions.

TELLURIUM had a completely different ideology from the other three case study companies. It did not seem that they believed in customer co-creation. TELLURIUM believed that whenever they accepted a customer's advice on a design, the resultant outcome had errors, and they blamed their customers for these failures. TELLURIUM was not a risk taker, nor did it learn from failed experiences. The overall impact of not exploring customer ideas, based on their expertise, was losses. TELLURIUM was the only case that had mixed views about diversification and co-creation with its customers. For instance, at one point its managing director said: *"There is no job too small or too big when it comes to steel… pretty much we can do anything to do with steel."* When asked whether they were thinking to adapt to change as many competitors were producing different products in the market, he answered that they focused on different markets. He argued, *"We do government departmental works, residential housing, it's a requirement that they have to be welded – that's the market that we are targeting."* It can be argued that TELLURIUM's target market was too narrow, and not finding opportunities in other areas, had the potential to cause the business to close.

This chapter has discussed the interactions of various factors such as customer demand, agility within a market to respond to customers' needs, and the skills possessed by the people who contribute to knowledge capacity and implementation capability – all were found to have some role assisting SMEs to innovate. It is noted that GOLD was inventive rather than innovative and needed the development of a new business model. COBALT and NOBELIUM tried to commercialise their ideas in the best effective manner, while building on their capabilities and differentiating themselves through new business model innovations. TELLURIUM was found to be neither inventive nor innovative.

7.7.2 Coping with external technological change

Studying these companies, a common pattern emerged concerning the perception that changes in technology, especially in digitally-enabled technology, adversely affected profit margins as it gave their customers easier access to competitor information (i.e., specifications, prices, etc.). Technological change within a company's own or other industries could affect one's business. From the cases, it appears that companies dealt with such pressures through increased awareness of their own markets, employee education, and seeking collaboration.

It was found that every case study company was aware of the technological change in their industry. Knowledge about their own industrial technology was mostly gained from their customers, competitor's newsletters, suppliers or trade shows. The internet era has made technological changes across the world readily accessible. Most of the suppliers argued that customers discussed what other companies had to offer with their new technology, which was another helpful way for these SMEs to learn about technological change.

The awareness of technological change meant that GOLD, COBALT, and NOBELIUM had made the necessary adaptations in their own industry. This was consistent with the argument of Dodgson and Gann (2014) who looked at the consequences of using technology on management, and on the process of innovation. They highlighted that the configuration of the technological change was dependent on the choices made by the managers, rather than the technical factors. The external technological environment affected the products and service offerings of all the case study companies except TELLURIUM. The continuous development of products was commonly seen amongst every case except TELLURIUM.

All case study companies (except TELLURIUM) were looking to innovate because knowledge of technology enabled their customers to access globally competitive markets. One strategy companies used to retain their previous customers and attract new customers, was changing their business model, for example to offer solutions based on their capabilities. An example was COBALT, where its executive director discussed the reasons for changing their product offerings to gain customers:

> *"… So what we can do is to find a way to survive, is to work out where we can compete, … or work out those places customers have really nasty technical problems [that] they can't solve, and that's where we come into the full…"*

The new service offerings meant that continuous planning and organisation of skills to promote its products were needed. Employing appropriately educated personnel or training existing employees could achieve this. Consistent with Dodgson and Gann (2014, p. 378) that *"the impact of technological changes for work and organization are… likely to both destroy old skills and create new ones…"* all case study companies invested in training and educating their employees.

The important components here were the skills gained to innovate. For GOLD, NOBELIUM and COBALT, gaining skills to develop new ways of thinking were important. This implies that technological change affected education within the company. They used education as a means of keeping up the technological changes, that is, in anticipation of future change. GOLD invested in its employees to obtain skills to meet the quality standards that were a key part of its vision. This may be considered training in response to changing standards both inside and outside of the company. Such patterns were seen for TELLURIUM, which trained its employees to learn basic trade skills, as its employees were either apprentices or had little relevant educational background. This finding on the perceived importance of training for dealing with technological change resounds with the outcomes noted in the quantitative chapter (i.e., that training mediates the effect of technological change on innovation).

The technology-enabled transformation had motivated all selected companies except TELLURIUM to move outside their local area and collaborate internationally, at least for some of their projects. To cope with the increasing cost of manufacturing in Australia, and to get the best quality product, it was easier for these companies to import some parts from overseas. For instance, GOLD imported lithium batteries from Italy and large machinery from the USA to be sold in Australia, while COBALT and NOBELIUM imported those items that they could not produce price-competitively in Australia. A common pattern was evident where all these companies argued that changes in technology had helped them to identify opportunities globally. As Drucker (1988) argued, *"information technology would demand a shift"* in how technology would be used by companies to process available information. Similarly, technology-enabled change has led to a transformation of how businesses interact inside the company and collaborate with external organisations, as well as how their customers locate new suppliers.

Unlike the argument of Dodgson and Gann (2014) and Mohannak (2007), none of the companies seemed to collaborate with outside companies to develop new ideas. Collaboration by all selected case study companies, except TELLURIUM, took the form of either the import or export of their products. However, it is noted that all the case study companies, except TELLURIUM, had commonalities with their business models in importing offshore components, making the final products to their standards, providing appropriate documentation, and selling the products within Australia. This was a unique strategy that had been successfully used by COBALT since 2008, while the other two case study companies, GOLD and NOBELIUM, were progressing towards this approach. Although none of the firms mentioned they knew of any other company doing the same, all saw the potential opportunity to exploit this resource as all the three case study companies were known for their quality standards and were focused on enhancing their capabilities through new approaches. NOBELIUM mentioned that it needed government assistance, such as through AUSTRADE, to exploit the international market (N1 2014, interview, 7 July). Further, this expansion strategy to access wider markets was used to survive, reduce the cost of production, provide new service offerings, and cope with the changing technological capabilities.

The evidence suggested that most of the case study companies were able to cope with the technological change in their own industries. This finding was consistent with the quantitative findings. Intriguingly, technology-enabled transformation was a major antecedent for these companies to evaluate and identify their capabilities and change their business models. Overall, the impact of technological change and technology-enabled transformation was found to be significant in the way business was conducted, as collaboration with other companies and customers alike opened up avenues for innovation.

7.7.3 Adapting changes internally: Building a culture to innovate

Innovation within Australian metal and other machinery manufacturing enterprises was dependent upon both managerial support and a culture conducive to innovation. This finding was consistent with Dodgson and Gann (2014). Because of the relative reliance on informal communication processes within SMEs, organisational culture affects how ideas, values and challenges are disseminated.

The quantitative findings suggest that culture had a positive direct effect on product innovation. However, the qualitative findings emphasise that culture was important for both product and process innovations. It was evident across all the cases that each company had its own strong value system that in some way supported generating innovative ideas and generated a positive environment so that people wanted to work within this company. Most importantly, *striking a balance* within the culture was needed, where both support for one's employees as well as encouragement to challenge existing systems and methods was important. Recognising the need for this balance is an important finding in this research.

From an owner's/director's perspective there were three primary reasons to support a positive culture. First, all owners interviewed were trained in a work environment where they created or developed new products and, as such, had a passion for this. Second, the observations suggested that all the owners/founders were driven by values and they wanted to create a similar environment that nurtured these values for everyone. GOLD focused on working with like-minded people, and the ones who did not fit in with the culture of the company did not stay there long. The consistent use of the words *fairness, safety* and *honesty* was evident throughout all the interviews with the members of GOLD, as well as in its company documents. NOBELIUM and TELLURIUM shared a sense of responsibility towards the local community, perhaps because both were located in a regional area and both had 25 or fewer employees.

> *"Most of our company… single income families… so it is important to have jobs in regional areas"* (N1 2014, pers comm. 7 July).

> *"I think we get a lot of satisfaction out of what we are doing for the community and Indigenous people… Overall it's a sense of achievement! Yeah, we are very proud of that!"* (T1 2014, pers. comm., 7 July).

Third, and perhaps most significantly, open communication and the openness to consider new ideas was important in every case. What distinguished some companies from others was that the *family-like* culture could also hinder the development of new and better ideas. Both GOLD and TELLURIUM were the case study companies that shared a family-like culture, and where the owners showed paternalistic values while dealing with employees. Although support was provided, innovations were lacking because many employees were not encouraged to think critically, nor to voice concerns regarding the processes they were undertaking. GOLD did invent but failed to recoup their investments to their maximum potential. On the other hand, NOBELIUM did involve itself in community programs and gave its employees the freedom to think differently and come up with new ideas resulting in innovations that were generated in-house. One such innovation came from an employee suggesting changing the source of a component in a machine; this saved NOBELIUM around $6 in every product. In this way, what may have restricted a company like TELLURIUM from coming up with new ideas was a lack of balance in their culture. Management practices, where employees are under the patronage of their boss, can hinder the development of new and innovative ideas. Generally speaking, a culture in which ideas and external developments can be, and are, readily discussed is better suited to face external challenges, such as technological change.

All the case study companies had formal channels of communication between the managers, such as morning, toolbox, or monthly meetings. GOLD even included an annual planning day meeting for its entire staff. Nonetheless, it seemed that GOLD mostly relied on informal communication and this had led to considerable confusion and possibly an increase in their inventory costs. This highlights the importance of an appropriate balance between formal and informal communication. This balance may be dependent on company size, co-location of a business, and other organisational factors. For example, TELLURIUM and NOBELIUM had a high dependency on informal communication, rather than using a company-wide approach. This was likely due to the smaller number of employees in both companies. Within the context of the present study, it can be argued that balancing communication channels did help in generation, identification and development of new ideas into commercial innovations. Hence, organisational culture affected internal communication and contributed towards innovative activities.

7.7.4 Building an agile internal environment: Marketing agility within the process of innovation

The impact of technology on the wider access of customers to competitive product price details was discussed earlier. However, there were two other components within the marketing sphere that also influenced the process of innovation. First, continuous customer feedback encouraged these companies to improve their products. This argument was consistent with a previous study by van de Vrande et al. (2009) on medium-sized businesses in which it was argued that market-related activities, such as meeting customer demands and keeping up with competitors, made the businesses involve themselves in innovative activities.

Second, it was expected that communication with their current and potential customers would have been influenced more by technology-enabled transformation due to easy internet access. However, this was not true in every case. Each business argued that they had started going back to the traditional way of marketing themselves, where cold-calling and personal visits to their customers, both potential and current, were preferred modes of communication.

All the case study companies received customer feedback, however how it was used was different for each of them. While GOLD and NOBELIUM used this feedback and turned it into the creation of new products, COBALT used it as a learning experience for the development of future products, development of their employees, and most importantly maintaining customer relationships. TELLURIUM was quite different from the others. It collected feedback and saved it for future use, but no evidence was found that they used this feedback to innovate. When the feedback was negative, this was communicated to their employees as a learning experience for them. Most importantly, the company became cautious with the type of customer who provided negative feedback, rather than undertaking steps to reflect and learn from it.

Apart from using customer feedback alone, the companies interacted with their existing or potential customers to look for new opportunities across different sectors (see Table 7-7). For GOLD and NOBELIUM, this interaction could be treated as co-creation. GOLD's invention of a *spring press* for mattress recycling, for which the idea generation, including the production test, was conducted with the help of their customer, could be treated as co-creation. COBALT, on the other hand, visited customers overseas in search of work opportunities. Most of their process involved negotiation with potential customers and understanding customer needs by seeing what jobs did not go to other tenders (showing a lack of suppliers for those products). These highly technical niche products required the strong technical capabilities that COBALT possessed. This process could not be treated as co-creation because identifying the opportunity, idea generation for the product, and its implementation was undertaken by COBALT. For them, the skills of their employees, and knowing their company's capabilities and maintaining customer relationships, were the main drivers that affected innovation. NOBELIUM was a co-creator as the idea generation of the pedal bin was co-created with the help of the customer. In fact, they talked with the customers on a regular basis and were happy to customise products for them. The evidence for TELLURIUM suggests that whenever they co-created with the customers, they were unable to understand and communicate the flaws in the customer ideas and later blamed them for the failure of the products. Co-creation for them did not show any evidence of creating new innovative products or services.

This also helps to unfold a very important phenomenon, especially in regard with two case study companies, TELLURIUM and GOLD. As evident from the description provided earlier in this chapter that TELLURIUM took customer feedback, saved it, but found it difficult to revisit it while focusing on other aspects of the business. Nevertheless they observed technological change, but were unable to cope with the complexity of the interaction between this change and agility to respond to customers' needs and feedback. This further limited their ability to cope with innovative activities.

Second, GOLD was found to be great at invention where they co-created with their customers, in comparison to innovation. Perhaps this was because they were able to develop new ideas based on feedback, but when external changes occurred, they found the complexity of using this agility with technological change limiting innovation activities. As evident GOLD knew that they were unable to meet customer needs to provide products and services at a cheaper price, which made its competitors' capture their potential market and clients. Their resentment to lost business was visible "…*that's the disappointment, when you are at this end* [referring to their company]. *Never mind that you have standards, culture to meet the best practices, it gets you in the door but you never get the job*" (G1 2014, interview, 27 June). Their inability combined with new technology with fast responses to customer needs despite their wish to do so confirms the possibility identified in the quantitative results outlined in Chapter 6 that there may be a limit to the ability of firm to cope with the complexity of this task.

All of these case study companies wanted to provide an extra service; they travelled to customers' businesses to identify problems first hand, then they exploited these opportunities with the aim of providing unique and innovative solutions. COBALT claimed that all its business opportunities were gained through visiting its potential customers' sites.

Table 7-7: Comparison of customer feedback and co-creation in each case.

Features	GOLD	COBALT	NOBELIUM	TELLURIUM
Customer feedback	Regular customer feedback was undertaken.	Travelled overseas to get feedback. Also interacted with customers to discuss the new projects and looked for opportunities across various sectors. Discussed what components of their product were not taken up and created technical niche solutions for each customer.	Listened to customer feedback and developed new and modified products based on them.	Got customer feedback
Co-creation	Included customer in the journey of product development and testing – customer was co-creator.	Not co-creation – the idea was identified by them, as well as its application and usability.	Customer co-creator	Co-creation was missing
Product developed due to co-creation	Spring press, safety guard for mining	None	Pedal bin	None

When questioned how they communicated with their customers, COBALT's executive director emphasised:

> *"Email is very important responding to tenders, backwards and forwards, but there is no substitute for phone and check, there is no substitute for, you know, if you have made an effort to fly 13 hours to (country missing), … and then the big guys*

make effort to see you. And if you don't, you are exactly the same like everyone else in Australia, sitting and waiting for something to happen. There is a bit of saying in place, that hope is not a strategy. Being in office, and wanting someone to call and give you a great big order is not a strategy. So we are very proactive and aggressive in getting out and meeting customers and working our way to big business and finding a way to who you speak to."

Other marketing capabilities include cold calling to industry associations and recommendations from trade shows. GOLD, COBALT and NOBELIUM budgeted for trade shows and advertising campaigns to attract new customers. GOLD, for example, had planned an extensive advertising campaign for its newly developed service capability to attract new customers (GOLD 2014b).

The marketing effort in every case focused more on the expansion of the business to new sectors, identifying opportunities to create and commercialise new ideas. The undertaking and implementation of new opportunities was influenced by the skills of its employees, owners and the management team. Agility in marketing affected innovation in the organisation as business models were changed, and most importantly the companies started to look for new opportunities across various sectors (except TELLURIUM). The quantitative and qualitative study results were contradictory in this. The quantitative results *did* show a direct or indirect affect of marketing agility on innovation and hence were consistent with the qualitative results.

7.7.5 Developing skills and capabilities: The role of training, education, experience and motivation in the process of innovation.

The quantitative findings intriguingly showed that general education, CEO experience and intrinsic motivation impacted innovative activities in Australian SMEs. This was an important point of discussion in the interviews with the case study companies. Data from the interviews led to the conclusion that a set of skills was required in the process of innovation to generate and sustain innovative activities. These sets of skills were gained through education, training, or experience. These skill sets were also important in gaining learning experiences enabling SMEs to become better able to adapt to external changes.

Leiponen (2005) examined employee skills and their complementarity with the number of innovative activities generated in organisations and she stated that high technical skills were essential for undertaking product and process innovations. In her study, these high technical skills were measured through the higher (university or master) degrees in technical or natural sciences.

The pattern observed in the qualitative data here was partly consistent with Leiponen's findings. It was found that the companies needed technical skills for undertaking product and process innovations, but they were dependent on their experience and training rather than on the formal university study of natural or technical sciences. Contrary to expectation, people who had TAFE qualifications were considered to be more innovative as they mentioned that working on the shop floor as a tradesman, and learning through their failures, taught them the trade skills, in contrast to a university education. GOLD's director argued that he started his career on the shop floor as a tradesman, learning the difficulties and challenges of the workshops and understanding the processes which could be improved for better productivity and efficiency. Thus he argued that working as a tradesperson helped him to maintain realistic expectations from his people. He believed that creativity of people was underpinned by their experiential capabilities rather than educational degrees, and he sponsored TAFE and trade diplomas for his employees to gain certain skills. This finding was also consistent with the quantitative data (Chapter 5), which showed that most of the people who worked in the metal and machinery sector had obtained TAFE/trade diplomas. COBALT mentioned that because of their high-technology work, technical skills were essential in their business; hence approximately 80% of its employees had technical university degrees. It was found that higher technical qualifications are needed when businesses produce highly sophisticated technical products as in COBALT.

Every company argued that training its employees was helpful to update their skills, provide them with job security, and also assisted with generating new ideas. Some used this training effectively to introduce new products, processes and services (GOLD, COBALT), while others (TELLURIUM) were unable to use this training to generate new ideas.

All the case study companies prioritised training of their employees for relevant certifications. GOLD and COBALT had conditions of work to stay with the company after education was completed but NOBELIUM and TELLURIUM did not. For instance, the managing director (N1 2014, interview, 7 July) of NOBELIUM believed in the philosophy that, *"If you got to do that (training agreement), maybe you gave it to the wrong person in the first place."*

While training helped in gaining skills, the role of experience was also of importance in creating, generating, and implementing innovative activities. For instance, the business development manager of GOLD started his career as a tradesman, later owned a real estate business, and had worked in diverse areas. He was good at handling customer complaints, and used his service experience skills in finding new ideas, and new sectors, to implement innovations and to maintain relationships with GOLD's customers. His experience in different sectors worked to his advantage to find opportunities, to assist other staff members in developing new ideas and also to commercialise its products and to maintain customer relationships. Similarly, an employee, who had previous experience in industrial design, developed one of the new safety products for the mining industry. The owner of NOBELIUM mentioned that his previous banking experience helped him with budgeting and exploring opportunities with customers. Indeed, previous experience helped in every case to develop a culture that either supported its employees or created opportunities for innovation.

Another component found across the case study companies was the passion of upper management to develop new products and services. While GOLD's founder wanted to acquire the best position in the market as the best employer and best service provider to its customers, COBALT also had a vision to expand and grow. At one point, COBALT's general manager (C2 2014, pers. comm., 4 July) mentioned the happiness that he derived from developing new products, with the expansion of the business as his motivation. Both the owners of NOBELIUM and TELLURIUM were motivated to serve their communities and make their employees happy. Only COBALT's executive director claimed that excelling in innovative products was the cause for the development of innovation in their organisation.

It was expected that employees would be motivated by monetary reward to innovate. However, all seemed to be motivated by intrinsic factors, such as the culture of the organisation, support by owners/upper management, and a sense of responsibility towards the community through implementing and commercialising their ideas.

Given that technology is always evolving, gaining education and experience are both important to keep abreast and be able to identify and capitalise on opportunities for innovation. Notwithstanding the precise degree to which the education, training or experience of both owners and employees seemingly affected innovation directly, the contribution of these elements was important for solving business problems. This would not be effective if the knowledge gained was not put to practice.

7.7.6 "Do we need networks and alliances to survive?": Role of collaboration for the process of innovation

From the quantitative analysis, it was concluded collaboration had a direct impact on product innovation, although in the case studies such a relation could not be discerned. Collaboration for innovation was divided into two different groups. First, internal or *vertical* collaboration, that is, people collaborating within different departments. Second, *horizontal* collaboration with outside organisations. As discussed previously, there was open and informal communication seen within all the case study companies, that is, people sharing their ideas, and *vertical* collaboration between departments was common.

With outside organisations *horizontal* collaboration only existed in the case of NOBELIUM, which collaborated with a company in Denmark for machinery production. Thus both NOBELIUM and the Danish company aimed at achieving mutual benefits by exploiting new markets. Collaborative linkages were thereby explored with the aid of the internet, in this case, from its website.

The current selection of companies could not provide enough material to comment on the role of collaboration in relation to technological change and internal factors directly. However, previous work by Dodgson (1994) and Mohannak (2007) has illustrated the potential value of industrial linkages and collaboration. While such collaboration may be something these companies have yet to capitalise on, the interviews did explore the businesses' experiences with other forms of collaboration.

Collaboration to innovate with outside enterprises such as other institutions, suppliers, government sectors, and universities, was not seen in any of the other companies besides NOBELIUM. Although customer feedback was important for the companies to generate new ideas, the remainder of the process of innovation was considered to be solely their own development within the Australian metal and machinery manufacturing sector.

There were three primary reasons identified why networks and alliances were not used for generating innovative activities. First, within government alliances, their grants focused only on a few companies and most of them were small companies. NOBELIUM and TELLURIUM both had received government help in the past in the form of financial grants and advice. For example, TELLURIUM's grants were used to provide training to their employees, who typically had no prior trade education. When questioned whether the employees were able to design new or improved products or processes, it was evident from the interviews of both the managing director and an employee that it helped them to learn the basics of the business rather than developing new products and challenging the old methods. It was found that training is an important component for employees. However, if they are not brought into the strategic picture for the company and its competitive landscape then their contribution to innovation may be limited.

Second, on the basis of data collected from the case studies, both GOLD and COBALT suggested that the Australian government manufacturing policies did not support manufacturing. GOLD's managing director complained that he believed that SMEs could be provided with more subsidies; his view is consistent with a recent news report (Bingemann

2015) which states: *"The way the Australian government taxes SMEs makes it incredibly hard to raise capital. It's just not an easy environment to start a company."* One of the owners from these companies argued that the Australian government did not trust Australian businesses with innovations, yet expected everyone from the other parts of the world to buy Australian-made goods. This person further compared the policy support in the USA and South Korea with the support available to Australian industries and argued that appropriate government support was lacking. Indeed, the various levels of government ordered many products from overseas, as price was also an important factor for them.

Third, the Australian economy as a whole lacks a common vision of where it wants to be. It lacks a platform to support collaboration and alliances, that is geographically well-located, and which could bring academia, government, industry and the companies together for meaningful projects. Progress has started in Australia to support start-ups such as ATP Innovations which helps technology-based start-ups and entrepreneurs to grow, achieve success and find investment through the support of personalised assistance and mentoring. It tries to bring academia, government and industry together. While they are targeted to a limited group, the challenge is to extend such schemes to businesses that have been in the industry for many years. A wider-scale initiative by government was missing. Field interviews with upper management illustrated their views on government support:

> *COBALT: "Are there projects where there are meaningful business, meaningful projects, which encourage collaboration, alliance? NAH!"*
>
> *GOLD: "I don't need governments to hand me money… and when they do give you a grant, it's only half anyway. And the (word missing)* restrictions on that grant are so great that you mind why you took that half, there is so much red-tapeism on that. It's just a nightmare to manage and control. It's just frustrating. I have been lobbying government for over 10 years…"*

All these case study companies had mixed feelings about government support. Both the bigger organisations were unhappy with the government policies and thought that *giving handouts* was not an effective and efficient solution. Rather, they considered a change was needed in policy making. None of the companies acknowledged that they had introduced new or improved products or services with government support.

7.8 Conclusion

Within this chapter four case study companies – GOLD, COBALT, NOBELIUM and TELLURIUM – were selected from the metal and machinery manufacturing sector to explore the phenomenon of innovation within SMEs. These sectors were chosen, as outlined in Chapter 2, because the metal and machinery manufacturing sectors were active contributors to GDP, as well as employment and productivity within the Australian economy. Furthermore, the metal and machinery sectors were among the top three sectors that responded to the survey (Chapter 6), with the four case study companies being selected from a pool of twelve candidates.

Qualitative comparisons of the case study companies suggest that external factors such as technological change have increased the competition for Australian manufacturing businesses. To cope with such changes, businesses needed to alter their practices. Listening to customers, understanding and exploring their needs and wants, and providing solutions to their problems were exemplary approaches for these companies to create value for their customers. Customer demand was affected by changes in the available technology. Further changes in technology (e.g., availability of online information) also enabled these customers to access their suppliers globally. The global price competition was high, which meant Australian manufacturing with its relatively high labour costs had to create extra value for its customers to survive this increasing competition and be profitable. Reaction to technological change and global competition was dependent on how internal factors, such as educational skills, culture and training, mediated technological change to introduce innovative activities.

To acquire knowledge, education was found to provide a conceptual understanding to the companies' managers, while having a trade background helped their CEOs understand the function of the workshop as well as how products were created. Thus, it seemed that practical knowledge of a company's product development process was beneficial to them, whereas no such value emerged for management-oriented education. It was found that training helped, not only in providing skills to one's employees, but it also boosted the morale of employees who felt their management believed in their capabilities. Because education and training present a major investment for an SME, with the potential for those receiving the benefits to contribute to innovative activities, businesses need to evaluate the outcomes from the investment. As shown in the case of TELLURIUM, significant investments lifted the capabilities of the employees but had little discernible effect on innovation. Taken together, the qualitative findings on the value of education align with and elucidate the significant position of education within the statistical model analysis of the previous chapter.

One of the main findings from the research was that the implementation capability of an SME was dependent on a balanced organisational culture that mediated the effect of technological change and competition, and led to the generation of new ideas. A balanced culture was found to be one where an SME's owner expressed confidence in its employees, had faith in their capabilities, and treated them like a family, but also gave them freedom to critically analyse decisions in order for new ideas and processes to be undertaken. Further, having a balance between formal and informal internal communication helped in creating a healthier culture and, most importantly, was conducive to the generation of innovative activities. Having such a balance was critical for a company to be involved in innovative activities. The importance of organisational culture constitutes a significant finding in this thesis.

The other main finding from these case study companies concerned marketing agility, that is, the lengths which an SME would go to maintain customer relationships, for example through involvement in continuous feedback. It emerged that doing so was positive for creating new ideas and their implementation into products and services. Some case study companies such as GOLD and NOBELIUM affirmed the value attached to such feedback loops by engaging in co-creation with their customers while exploring opportunities for expansion of their businesses.

Collaboration was not limited to customers. These SMEs collaborated with external institutions to either tap into new markets or, most commonly, import machinery from overseas. Three of the four companies studied thought that if they could not compete with overseas prices, they could become the supplier of the overseas products. GOLD and NOBELIUM aimed to benefit from providing after-sale services, whereas COBALT viewed such reselling as a way of establishing and maintaining customer relationships (with a potential to expand the relationship to their own products). The case studies showed the execution of a different business model was adapted successfully by COBALT, while NOBELIUM and GOLD were similarly evolving. However, transforming from a product manufacturer to become a problem solver had its own challenges which was mediated by the SME's culture. What differentiated these companies from each other, allowing them to be solution providers, was not being limited to product or process innovation, but being able to build on one's capabilities to enable the shift in their business model. Additionally, this change had to be accepted and understood in the whole organisation.

Furthermore, the case studies revealed that having high quality standards, although helpful to gain discerning customers, may impact an SME's competitive edge with customers who do not require high quality products. Therefore, understanding the quality of a company's product is highly dependent on a customer's perception of potential value and consequent willingness to pay a particular price. Innovations relating to quality thus interact with price-competitiveness, as discussed in the case study companies of GOLD and TELLURIUM.

Although both GOLD and TELLURIUM noted customer needs, the inability to meet such needs also explains that when external changes occur an SME's (limited) capacity to take on such complexity affects the innovation outcomes. In other words, their inability combined with fast responses to customer needs despite their wish to do so confirms the possibility identified in the quantitative results outlined in chapter 6 that there may be a limit to the ability of firm to cope with the complexity of this task.

The case study data showed that there was a focus on maintaining competitive advantage in different ways. GOLD did not differentiate itself from its competitors with regard to the products and services sold by them, but instead focused on excelling in quality. Although the owner reasoned that their certifications differentiated them, in reality it appeared to be the investment in its people. GOLD appeared skilled at being able to develop products to solve customers' problems but lacked the ability to commercialise them. COBALT, on the other hand, was solely dependent on differentiating itself through a new business model which helped in developing unique features in their product and service offerings. This change in their business model led them to claim that they did not have a direct competitor. TELLURIUM was different in that it explored changing technology overseas but was unable to get a clear grasp on how it could diversify. TELLURIUM had skills but lacked the vision to expand its business markets. NOBELIUM was the smallest businesses interviewed, but special in its own way. They collaborated with their competitors and differentiated themselves with their quality standards. The company had suffered huge losses in the past due to a failing culture but had since taken up initiatives with a new vision, and additional changes, to address the culture issue.

In summary, the exposition of the various phenomena that contributed to innovation in the case study companies provides one of the core contributions of this study. Most importantly, the culture and skills gained through previous experience, training, and marketing agility were the main factors interacting with the external factors, such as technology-enabled transformation and customer demand – all affecting the ability of the different case study companies to innovate. This chapter reinforces the finding by Green et al. (2009) that support by managers, and management practices, creates an environment to nurture new ideas. All of the case study companies believed that learning generated through their failed experiences helped them to improve. The discussion on learning through failed experiences was not explored in depth within this study but could become the basis for future studies.

The value of experience mentioned above agrees well with the findings from the qualitative study. Related to this, the studied cases also emphasised the merits of training and education. Again, these two factors proved important for the companies surveyed before to mediate the effect of technological change (Chapter 6). Thus, the findings of this chapter on qualitative data align with the quantitative study discussed before and extend the statistical investigation with the additional discussion of general implementation capabilities. The final chapter will further examine the similarities and differences between the studies to answer this thesis' research questions.

Chapter 8: Summary and Conclusions

8.1 Overview of the thesis

This thesis has examined the relationship between the internal and external drivers of innovation in Australian manufacturing SMEs. In this work, a mixed methods approach was employed to study this relationship. In particular, the combination of survey data and case studies sought to investigate the effect of technological change on innovative activities, an effect potentially mediated by SMEs' particular internal factors. It has been shown that the absorptive capacity model of innovation is applicable to Australian manufacturing SMEs and evidence was found for interaction between non-knowledge management related internal factors and technological change.

Chapter 2 provided some context for considering innovation in Australian manufacturing SMEs by examining the relative significance of the manufacturing sector in the Australian economy and by looking at the contribution to Australian economic activity of small to medium firms. It showed that the contribution of manufacturing to Australian gross value added (GVA) in December 2014 was 6.7% but that this had declined from 14.6% over the previous 25 years. Since many economists argue that this decline was due to a fall in the international competitiveness of the Australian manufacturing sector, understanding the forces driving productivity in this sector may provide insight into how a previously important but declining part of the Australian economy could be rehabilitated. The link between innovation and productivity thus makes an examination of innovation in this sector an important exercise. Australian Bureau of Statistics data was also used in Chapter 2 to show that businesses employing less than 200 employees account for 99.7% of the total number of businesses in Australia, making small and medium businesses a highly relevant unit of analysis. It is thus useful not simply to examine innovation in Australian manufacturing but innovation in small and medium enterprises (SMEs) within this sector.

Chapter 3 reviewed the literature on innovation. This literature was examined in five broad segments. *Firstly* the mainstream economics literature on economic growth was shown to establish a link between innovation, technological change, productivity improvements and the economic growth of a nation. While this literature initially took innovation as given, and ignored work by Joseph Schumpeter on the role of entrepreneurs, innovation and economic development, a *second* segment of the literature was shown to have taken up and developed the main themes of Schumpeter's work. This segment fell mainly within the management discipline and eventually focused on innovation in large corporations. A *third* segment of the literature beginning in the early 1990s was then considered in which the role of knowledge as a determinant of innovation was central. This part of the literature also examined the interplay between new knowledge generated externally to the firm and how the knowledge capabilities within the firm adapt and use that external knowledge to generate innovation. This was expressed through the concept of *absorptive capacity* and a clear segment of the innovation literature was shown to have explored this idea.

A *fourth* segment, also beginning in the early 1990s and drawing attention to the unique role of SMEs in both the economy generally and in generating innovation, was then discussed. This literature had some similar features to the literature on innovation in large corporations, for example, drawing an important distinction between internal and external drivers of innovation, but those features were shown to take a different form due to the characteristics that make SMEs distinct from large corporations. A *fifth* segment of the literature was shown to have argued that firms, whether large or small, do not innovate in a social vacuum but draw on a range of supporting social structures in the process of making productive change. Such social structures include communications and transportation networks, education institutions, and financial systems. Because these social structures are the result of public policy decisions over time, this segment of the literature was said to have explicitly recognised the role of policy-making in the innovation process, and to reflect this role in the concept of national innovation systems.

In considering this literature on innovation it was shown that little consideration has been given to examining the interaction between non-knowledge management-related firm characteristics and external technological change in driving innovation outcomes. This observation, therefore, shaped the development of the thesis's main research questions as follows:

> Research question 1: What are the main internal factors that drive innovation in Australian manufacturing SMEs?
>
> Research question 2: Do internal factors, including non-knowledge related factors, mediate the effect of external factors on the degree of innovation that occurs in Australian manufacturing SMEs and if so , how?

To answer these questions, it was necessary to understand conceptually how internal and external factors interact. Chapter 4 thus built on the literature review to develop a model of innovation in Australian SMEs that separated the influence of externally originating technological change, the internal knowledge-related firm characteristics identified by the absorptive capacity literature, internal management-related firm characteristics to which this thesis pays particular attention, and how all of these various factors interact to produce innovation outcomes. In the process of framing this model, eight additional sub-research questions (SRQs) were developed to enable the main research questions outlined above to be broken down into smaller parts. These questions were:

SRQ1: Does technological change affect the innovation outcomes of Australian manufacturing SMEs?

SRQ2: How does technological change affect the innovation outcomes of Australian manufacturing SMEs?

SRQ3: Which knowledge acquisition characteristics of Australian manufacturing SMEs affect SME innovation?

SRQ4: Do the knowledge acquisition characteristics of Australian manufacturing SMEs mediate the impact of technological change on SME innovation?

SRQ5: How do the knowledge acquisition characteristics of Australian manufacturing SMEs mediate the impact of technological change on SME innovation?

SRQ6: Which general implementation characteristics of Australian manufacturing SMEs affect SME innovation?

SRQ7: Do the general implementation characteristics of Australian manufacturing SMEs mediate the impact of technological change on SME innovation?

SRQ8: How do the general implementation characteristics of Australian manufacturing SMEs mediate the impact of technological change on SME innovation?

Chapter 5 then laid out the methodological approach within which this model could be used to guide the investigation of internal-external factor interaction. A mixed methods approach was outlined in which survey data was collected from Australian manufacturing SMEs and used to estimate an empirical model of innovation by these firms. The resulting model could then be used to draw some initial conclusions about internal-external factor interactions, providing preliminary answers to SRQs 1, 3 4, 6 and 7, and both main research questions by identifying the factors that affect innovation by firms responding to the survey and the extent of quantitative interaction between these factors. Results from the model could then be used to frame a set of case studies in which the question of *how* key innovation drivers interact and *how* these lead to innovation outcomes could be explored. This would answer SRQs 2 and 8 thus providing more complete answers to the main research questions. Such a mixed methods combination of quantitative and qualitative analysis thus provided insight into which factors affect innovation at Australian manufacturing SMEs throwing light on the potential significance of non-knowledge related management factors in mediating the effect of external technological change on innovation.

Chapter 6 reported results from stage one of the methodology outlined above. This involved a quantitative examination of internal-external factor interactions for Australian manufacturing SMEs responding to the survey sponsored by Enterprise Connect. It described the data collected from the survey, provided further discussion of econometric estimation of the model developed in Chapter 4 using this survey data, and discussed the results in detail. A number of broad results were presented. The *first* was that education is a very important factor driving innovation across both types, product and process. This was particularly true of the *general* education of firm managers which is statistically significant and positive for innovation outcomes across the full range of models reported in chapter 6. But education positively entered the determination of innovation in number of ways not simply via this one important channel. The *second* broad result was that *specific factors* appear to be important for specific types of innovation. *Collaboration* and *motivation* were shown to be important factors for *product* innovation while *experience, training, marketing agility* and *firm culture* were shown to be important for *process* innovation. The *third* broad result that emerged from the quantitative analysis was that it does appear that internal firm characteristics are important *mediating factors* on the effect that external technological change has on SME innovation outcomes. Further work is needed to analyse this more carefully but our results suggest that *education* is again important in this respect but that *motivation* may also be important with CEOs who are more concerned with creativity and the core objectives of their businesses being better able to harness external technological change for innovation than those simply concerned with profit. It was also found that a firm's business skills are important in this respect whether this be market agility, people management or networking skills. Such things appear to have a *direct* impact upon innovation. The surprising result, however, is that there is weak evidence for a *negative* interaction effect between marketing agility and external technological progress on process innovation which is interpreted above to imply a limit to the complexity with which firms can cope in innovation activities. The quantitative study therefore helped in answering part of the main question through identifying which knowledge and non-knowledge related factors had a direct and indirect impact on innovation.

Chapter 7 then used the findings of Chapter 6 to develop four cases, GOLD, COBALT, NOBELIUM and TELLURIUM, in order to examine *how* technological change, the knowledge acquisition characteristics of firms, and non-knowledge management-related firm capabilities influence and interact to influence innovation outcomes. This qualitative aspect of the methodology reconfirmed the conclusions from chapter 6 however these qualitative findings also highlighted the significance of non-knowledge factors. This chapter helped to emphasise that previous experience of CEO, managers and employees whether in the *same* or *another sector* mediated the impact of technological change which assisted in generating innovative activities. Further, the case study companies that looked outside at various sectors for opportunities, not only collected but used customer feedback to improve their products and processes and co-created with their customers to develop new ideas were found to mediate the impact of technological change to generate innovative activities. Lastly, it was found that the case study companies that had a *balance* by providing support as well as freedom to do their work while allowing them to challenge the existing processes were able to mediate the impact of technological change such that innovative activities were generated.

8.2 Answering sub-research questions

As discussed above the aim of the research presented in this thesis was to explore the interactions between the external and internal innovation factors and how they affected innovative activities. This section revisits the sub-research questions and will discuss the related conclusions.

The quantitative results helped in determining that technological change had a positive effect on SME innovative activities (SRQ1). The qualitative data analysis emphasised that technological change has disrupted businesses, especially in how they carry out their operations with the existing knowledge of their people, and in the way they exploit markets. On one hand it elevated global opportunities and accessibility of information on competitors' prices while on the other it also gave customers a choice to select a supplier based on price, creating a negative impact where local suppliers started to lose their business to overseas suppliers whose prices were lower. Therefore technological change impacted Australian manufacturing businesses (SRQ2).

The quantitative study showcased that knowledge acquisition capabilities that had a direct impact on SME innovation were CEO's/upper management education, *general education* of managers and employees, *training* and *collaboration* (SRQ3). *General education* was also found to have an indirect effect, whereby it mediated technological change impact on innovation (SRQ4). Also employees' *management* education was found to have both positive *direct* and *indirect* impact on process innovation (SRQ4).

The fifth sub-research question (SRQ5) addressed *how* such knowledge acquisition capabilities affected innovation. It was evident that the education of a CEO, through TAFE or trade diplomas, gave an understanding of the shop floor and made them receptive to new ideas from their employees. Across the case study companies, it was found that providing training was considered as a reward for their services by employees, thereby building their loyalty to the organisation. Mostly, the training and education expenditure of these SMEs aimed to gain people or project management skills, which in turn assisted in the development of new ideas. Another way to acquire knowledge acquisition capabilities was by collaborating with external parties. It was found collaboration was mostly undertaken in response to increased price competition, and an increase in awareness of one's consumer needs and suppliers' product range, rather than to develop new products. Thus, the knowledge-acquisition characteristics of education and training were mediated by technological change for innovation outcomes (SRQ4, SRQ5).

The acquired knowledge capabilities were put into practice with the help of SMEs' general implementation capabilities. The SME implementation capabilities include experience, marketing agility, motivation and culture. Through the quantitative study it was found that experience, CEOs motivation, marketing agility and culture had a direct impact on the innovation outcomes (SRQ6). It was also found that motivation may be more important to CEOs who are concerned with creativity and who consider the core objectives of their businesses being able to harness external technological change for innovation than those CEOs simply concerned with profit (SRQ7).

The eighth sub-research question (SRQ8) focused on *how* the SME general implementation capabilities mediated the impact of the technological change on SME innovation. For the case study companies, experience helped SME members (especially CEOs/owners) to be aware of changes in technology and to provide solutions for customers' problems. These cases also highlighted that experience, which helped them to utilise their capabilities, was more important than the education itself. Quantitative results suggest a *negative* interaction effect between marketing agility and external technological progress on process innovation which can be interpreted to imply a limit to the complexity with which firms can cope in innovation activities. While case study companies that were engaged in acquiring and utilising customer feedback were not only able to develop new ideas but also were successful in identifying market opportunities (SRQ8). Understanding customer needs and co-creation were largely complementary. Co-creation in these cases meant either generating ideas with customers or solving customer problems. However companies found it difficult to use this customer feedback while there was a change in the technology at the same time as experienced in two case study companies – GOLD and TELLURIUM. This research highlighted the complexity of marketing agility when mediated with the impact of technological change on SME innovation and how customer relationship building can (SRQ8). There is also weak evidence for a *positive* interaction effect between firm cultures that foster experimentation on process innovation outcomes.

This thesis argues that it was the commitment of the upper management towards its employees that had a greater effect on innovative activities, as compared to having an organisational mindset to innovate, as argued by Laforet and Tann (2006). Therefore, it is not the organisational culture itself that contributes to innovation. A *balance* needs to be struck within the culture that provides an employee with both support and freedom to do their work. Achieving the correct balance is the key to organisational culture having a significant impact on innovation in Australian manufacturing SMEs. Commitment of upper management and/or the owner to use and share customer feedback with its employees fostered the generation of new ideas and the development of innovative activities (SRQ8).

There were other findings that originated from the qualitative study. First, a relationship between knowledge acquisition and general implementation capabilities was found. For instance, education and culture were seen to be interrelated. The education of upper management influenced the support provided and freedom granted to employees, allowing the latter to engage in innovative activities. This was not studied in depth within the present thesis but is nonetheless worthy of further investigation. Second, learning from past experiences (whether successes or failures) motivated all interviewed owners to develop new products, business models, and to shape the cultures of their organisations.

Third, from the case studies it appears that success of SMEs was dependent on their ability to use customer feedback to deliver a *quality* product. Samson and Gloet (2014), as well as cases like GOLD and TELLURIUM, defined quality from a supplier's perspective. However, here we noted that the quality of a product needs to be based on *customers' perception* rather than the *suppliers' perception* to avoid misalignment of priorities (cf. Drucker 1985b). Understanding the importance of this principle is crucial for Australian SMEs if they are to be innovative and survive within the market. If this study were to be repeated, quality would be considered an important component of an SME's implementation capability. Quality was missing from the original model developed in this thesis (Chapter 4), but the evidence of the case studies shows its influence on innovation outcomes of Australian SMEs.

Summarising the research conclusions, it was found that innovation was a continuous and an ongoing process in organisations which adopted technological changes, changed their business models to survive and create value, provided a supportive culture to its employees, were agile to customer needs, most importantly, recognised opportunities across different sectors. It was also found that there was a limit to the complexity with which firms can cope in innovation activities.

8.3 Why these findings matter

Australian manufacturing is facing a tough competition from the developing economies such as India, China, South Korea, Vietnam based on the cheap labour. To deal with this competitive pressure, Australia needs to increase its productivity, create value in the products and services sold by Australian manufacturers to have an edge in the global economy. Innovation is therefore key to raise productivity (Cosh 2006) and creating value in an organisation (Amit & Zott 2001).

The Australian manufacturing mainly consists of small and medium enterprises (SMEs) who face their own challenges to innovate, such as size, unaffordability to have R&D departments. Hence they use externally generated technology to develop and implement new innovative products and processes in their firm. The knowledge within a firm helps to identify & access external learning opportunities and apply this knowledge in its operations. Further this process also expands the firm's knowledge base and therefore collectively is known as *absorptive capacity* (Cohen & Levinthal 1990; Huang et al. 2010). Therefore this absorptive capacity has a big impact on innovation.

The concept of *absorptive capacity* treats knowledge in terms of an absorption perspective and an application perspective. Knowledge is absorbed from external sources with potentially some development through internal R&D processes and then applied internally to modify firm products or processes. But these internal application dimensions of absorptive capacity are *knowledge-related activities* that focus on how the externally obtained knowledge can be used internally *in a technical sense* to drive innovation. This study cast light on *additional* dimensions of this application process that focused on *management-related* dimensions of firm behaviour. It was found that motivation, firm's culture and being agile to the market needs play an important role in this process.

8.3.1 Contribution to knowledge

Three main academic contributions emerge from this study. First the model itself, as explained in Chapter 4, which covered two internal aspects of applying externally generated knowledge or technological change as *SME knowledge capacity* (the absorptive capacity insight) on the one hand and *SME general implementation capabilities* (the new insight investigated here). Second *general education* of both employees and managers contributes to innovative activities in SMEs. There was no evidence found that management education of the managers or employees contributed to the innovative activities. In contrast, quantitative results suggest, the higher the education of a CEO, the more negative effect it had on process innovation. It was found that technological change, when mediated by the education of the CEO, had a negative effect on innovation. This needs further exploration.

Second contribution was that organisational culture by itself does not contribute to innovation. It is striking an appropriate *balance* within their culture that helps SMEs to innovate – developing a culture in which employees find support as well as freedom to innovate and think differently. A family-like culture can both enhance and inhibit innovation, and it is distributed leadership, with responsibility and accountability shared with others, that enables an SME to innovate (also noted by Samson & Challis 2002). Similarly, an appropriate *balance* between *formal* and *informal communication* in a SME is needed to promote innovative activities. For example, a growing SME can no longer rely on informal communication of its organisational structure, responsibilities, potential areas of growth and improvement, nor maintain transparency and a shared mindset to allow for innovative activities. Third contribution was there does seem to be evidence that marketing agility plays a role in modifying the impact of technological change on innovation with agile firms making less use of this technological change than less agile firms possibly because these capacities are fully focused on meeting customers' needs using technologies with which the firm is already familiar. This may suggest a limit to the complexity a firm can cope with in innovation and can be further investigated.

8.3.2 Industry contribution

Through this study, it became clearer that competing with offshore companies which were able to produce high volume products at low prices was difficult for Australian manufacturing SMEs. To survive in such a competitive market a different strategy was needed. This could be done through adding value to products and services; value which in turn is recognised by customers and for which they, the customers, were willing to pay a premium price. As customers were identified as an important link in the supply chain, identifying their problems and designing products based on their needs would be an appropriate solution. Further, it was identified that the emphasis on customer needs was not limited to a particular industry or a sector. Companies that are able to identify potential customers across different industries based on their identified capabilities are likely to be both innovative and profitable.

Some of the knowledge gained through this study can be used as suggestions to improve an SME's productivity and these are explained below. While not exhaustive, these suggestions provide a guide which may help manufacturers to survive in a changing market.

1) ***Find opportunities outside traditional markets***: Australian manufacturing industries could look outside their traditional markets or industries for new opportunities rather than waiting for customers to approach them. This means that SMEs should be able to explore opportunities by analysing their strengths and building on their capabilities. The opportunities across different companies or industries could be investigated, for example through the wealth of online information on potential new customers and markets.
2) ***Understand customer needs***: Opportunities can be explored only when a customer's needs are understood, that is, changing traditional manufacturing to customer-centric manufacturing. Traditional manufacturing was based on producing a product and then finding a customer and pushing the products to a market. Considering the high cost of Australian labour, traditional manufacturing is not the solution, hence a change is required to customer-centric manufacturing. Customer-centric manufacturing is a more hands-on approach; identifying customer needs before products are produced helps a company to understand where its customers need solutions and whether the supplier (SME) has the capacity to provide such solutions based on its capabilities. Necessarily, this change will lead to a change in the original business model, from being a product manufacturer to being a solution provider. This may include co-creating with their customers to provide solutions through identifying their needs. Such cases are dependent on skills available within the organisation and the marketing techniques used. Traditional cold-calling or visiting one's (potential) customers could be helpful.
3) ***Understand quality requirements***: Re-emphasising Drucker's (1985b) argument, the quality of a product should be determined through the perception of a customer rather than a supplier. Thus the quality demanded by a customer means meeting the customer's required product or service standards at a particular price. Where a customer wishes a particular quality but is not willing to pay the quoted price, the company needs to realign its goals with those of its customers and look for the best solution, before letting its customers go to competitors. Although this might present many challenges on a practical level, a hands-on approach, and trying to decrease production costs whilst maintaining quality and creating value, should be the preferred approach of an SME.
4) ***Create a culture that allows risk taking and learn from failures***: To explore customer needs and find opportunities cannot the SME needs have a culture to support customer-centric manufacturing. This support is dependent on the owner or the upper management creating an environment where employees can generate new

ideas and openly communicate those ideas. Trusting the judgement of its employees helps a firm create an atmosphere to promote and develop new ideas. Culture therefore requires flexibility both by the SME owners and their employees in a changing environment. Changing the business model is dependent on the culture within an SME.

5) ***Support employee education and training***: To progress and challenge the existing norms both training and education are important for SME managers and employees. A culture where education and training is promoted so that new thinking to address existing or new problems is welcomed is important for encouraging and supporting innovative activities.
6) ***Collaborate to exploit new markets and ideas***: One feature often lacking in manufacturing companies is collaboration. Isolation, where companies feel it is *"every man is for himself"* while fighting global competition, is not productive. Instead, organisations may consider a change towards embracing collaborative networks in order to develop globally, implement new ideas, and explore new markets. Some Australian SMEs have initiated collaboration with overseas companies, capitalising on online communication tools to establish contacts.
7) ***Listen to customer feedback***: Probably the most important step, which relates back to step 1 above, is building relationships with customers by regularly meeting them in person or via other channels to gain valuable customer feedback on their products and services. Such feedback also provides valuable references when exploring other opportunities.

The above suggestions do not work in isolation but work hand-in-hand with each other and need to be adapted based on each SME's capabilities. It is argued that co-creation and collaboration are likely to become even more important for the future success of the manufacturing industry.

8.3.3 Policy contribution

The policy contributions of this study are: to recommend educational reforms; to suggest a realistic vision for Australia's manufacturing sector; and to promote a common platform for developing collaborative practices to support innovative activities.

One area of Australia's education system which needs improvement is raising the general education of the workforce. One of the common findings from both the quantitative and qualitative analysis was the need of SMEs for general education. Those analyses revealed that people who had qualifications, even if general and not particular to a sector, better understood the work requirements and were better able to contribute towards the development of new ideas. However, the trend is in the opposite direction. A recent report by the National Centre for Vocational Education Research (NCVER) (from September 2013 to September 2014) noted a decrease of 18.4% (341,300) in the number of apprentices and trainees. One reason for such a decrease could be the reduction in government funding to support such programs. Further, as Australia has few large manufacturing enterprises, policies and funding are needed to support SMEs in the training of apprentices. The current recognition of a crisis in STEM education (Science, Technology, Engineering, and Mathematics) in our schools is a necessary prompt for the better education of our workforce.

Australia lacks a vision for the future of the manufacturing sector. Most of the cases interviewed thought of themselves as alone. Phrases such as *"every man for himself"* were commonly heard. As every company is able to contribute towards the GDP and the productivity of the Australian economy, having a shared vision for the future of the manufacturing sector would be helpful for the growth in productivity. Hajkowicz (2015) argues productivity is an underlying driver of wealth creation within an economy, thus having a common vision could not just raise the output per worker, but also has the potential to lead to a better standard of living for a nation's people (Krugman 1997).

To aid achieving a shared vision, collaborative platforms are needed where industry, government and universities can work together on joint projects and develop innovative ideas within Australia. Apart from a limited number of Cooperative Research Centres (CRCs), there are no such platforms at this point. The more positive approach to innovation taken by our current Prime Minister Malcolm Turnbull (2015) may see such collaborative developments in the future.

8.4 Future work

In the studies presented in this thesis, it was observed that innovation in manufacturing SMEs was driven by certain factors. It was argued that these factors do not work independently of each other; it is the interaction between external and internal factors which contributes to innovation. Although the above findings are promising, further research is needed to more extensively explore the interaction of these factors and their impact on innovation in SMEs.

Before discussing four categories of potential leads for future work, one general remark needs to be made concerning the approximation of technological change in this work. This change was measured by a proxy variable of the *"perception of the owners about the impact* *of technological change,"* a novel approach to measurement of this factor is provided in this thesis, which needs to be further tested to evaluate its relevancy beyond the present thesis.

8.4.1 Exploring the relationship between different factors

With the aid of our study, an indicative relationship between some internal variables such as general education, training expenditure, employees' management education was found with external technological change, when the outcome variable was process innovation. When the outcome variable was product innovation, the interaction between motivation and technological change was found to be significant. Little evidence was found for other interactions. This might be due to the limited data sample size and therefore this could be tested on a larger scale.

Next, the interactions between the two dimensions of absorptive capacity (namely knowledge acquisition capabilities and general implementation capabilities) were not considered in the current model. However, as hinted at in the discussion above, these two dimensions do not exist in isolation from each other (e.g., education may influence SME culture, thus affecting innovative activities). Future work could consider the effect of such inter-dimensional interactions.

Further, the qualitative case studies were limited to metal and manufacturing SMEs, hence the conclusions drawn are limited to that industry segment. A wider study encompassing the whole manufacturing sector (or different parts thereof) would be necessary to test the interaction between the external and internal factors of innovation. Such future work would also allow for a comparison between subsectors.

The model proxies external drivers of innovation through structural technological change faced by businesses (changes which may be absorbed or not). The case studies highlighted that innovative activities are also (partially) driven by customer demand and competition, often from a desire to deliver a worthwhile product and/or service, or from a desire to survive in the marketplace. Prior literature has indeed discussed the relevance of technical change and competition (Schumpeter 1954), and consumer demand (Pasinetti 1981) under the umbrella of structural change. We found that these three external drivers were interrelated and therefore our work provides empirical evidence for the argument to consider these three drivers together in future modelling of innovation in SMEs. This requires attention both quantitatively (on a larger scale) and qualitatively within different industries apart from metal and machinery, for further verification. The results of future studies can help manufacturing not only within Australia, but in other developed countries whose economies are stagnant and who are experiencing competition from low-cost producing countries.

8.4.2 Exploring quality from customer's perception as a factor of innovation

The case studies indicated that the perception of quality (i.e., from a customer's or supplier's perspective) affects innovation. Taking a more customer-oriented perspective towards quality motivated the studied cases to consider customer needs, available technological developments, and how their products could be developed and priced along those external standards. Such an orientation towards delivering quality rather than a product per se motivated some of the studies cases to adjust their business to a more service-oriented model.

8.4.3 Exploring balance in culture as a factor (antecedent) of innovation

Another important contribution of this study was determining that a balance in culture was needed to influence innovation. In addition, a balanced communication – formal and informal – assisted SMEs in maintaining a transparent yet collaborative workspace within their own organisation. To my knowledge, the balance of culture supporting innovation has not been previously studied and needs to be further tested across a broad range of SMEs, including manufacturing industries. Further, the current study indicates an appropriate alignment between formal and informal communication appears to assist innovation; this hypothesis needs further testing.

Learning from failed innovations was often referred to within the cases, although the impact of failure was not studied in any detail as part of this research. However, when analysing the data it was found that failure could have both a positive as well as a negative impact on the innovative culture of an SME, and this could be a fruitful avenue for future research.

Further, as observations were limited, variable indices were used for narrowing down the constructs of culture in our quantitative study. The variables chosen for indices were based on the judgement of the researcher, captured from previous literature and the advice of experts in the field (such as my supervisor). With significantly more observations, techniques such as exploratory factor analysis could be used.

8.4.4 Distinguishing between general and management education

With this study it was found that the management education of the managers or employees did not contribute towards product innovation while a warrant was made for employee management education with regard to process innovation. Therefore, maintaining the distinction between general and management education in the modelling of innovation in SMEs could be further tested.

8.5 Final remarks

This thesis aimed to explore the interactions between the internal and external factors to test how the latter mediates the former to affect innovation. The quantitative findings found that general education had both direct and indirect impact on innovation, while culture had direct impact only on process innovation. While unpacking the qualitative study, it was found that a *balanced* culture mediates the effect of the external factors such as technological change and customer demand so that innovations can be generated in Australian manufacturing SMEs. This meant that employees should be given opportunities by upper management to innovate where support as well as freedom to challenge old ways of doing things was necessary. This is a promising finding. Perhaps we were not able to find the impact of organisational culture mediating technological change through the quantitative study as it did not capture items related to such cultural aspects. Another important finding is that meeting customer demand is not restricted to a particular sector only, SMEs should be able to exploit opportunities across a range of sectors and build on their capabilities. A willingness to change strategy in the face of changing circumstances is needed. Adaptability and agility, especially to technological change, are essential. Apart from changes at a firm level, policy support at the economy level is welcome, including better support for collaborative work between government, industries, and universities; something that is largely lacking in the Australian context. The policy support (and especially its implementation) will take time but can contribute positively towards the generation of innovations, raising the productivity of the Australian economy as a whole.

It is clear that Australian manufacturing has faced and will continue to face challenging times. It is hoped that this thesis has contributed to an increased understanding of the position and innovation potential of Australian manufacturing SMEs.

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Appendices

Appendix 3A: Categories of innovation

Innovation Types	Definitions	Conceptual Idea
Product Innovation	A combination of new or improved products, their design, or components that help to rehabilitate a product	• Often associated in the literature with scientific or technological developments (Garcia 2010; Garcia & Calantone 2002; Hine & Eve 1998; Hipp & Grupp 2005) • Product innovation helps to increase the utility of novel ideas • Successful product innovation increases productivity (Alegre et al. 2006)
Process Innovation	Davenport Davenport (1993) defines it as an advancement that helps to improve the structure of a business in an organization, due to a chain of 'key processes'	• Different terminologies to describe process innovation have been used in literature as follows: • process re-engineering (Keisler & Brodfuehrer 2009; Vidovic, Vuksic & Ieee 2003; Vuksic, Spremic & Ieee 2004; Yun, Liu & Ieee 2007), • process redesign (Broadbent, Weill & St Clair 1999; Crowston 1997; Davenport & Short 1990; Malone et al. 1999) • process improvement (Lu & Botha 2006; Repenning & Sterman 2001)
Technological Innovation	Technological innovation initiates a change within a product or a process, by delivering or facilitating a new technique (Damanpour 1987; Damanpour & Gopalakrishnan 1998), that contributes to generating knowledge (Castro et al. 2010) in an organisation.	• Technological innovation is dependent on degree of exploitation of knowledge for value creation • Technological innovation capabilities are measured through • expenditure spent on R&D; (Cockburn & Griliches 1988; Pakes 1985) • increase in number of patents; • increase in the number of cited patents or co-authored papers (Acs, Anselin & Varga 2002; Archibugi & Pianta 1996; Artz et al. 2010; Arundel & Kabla 1998; Narin & Noma 1987); and • absorptive capacity[14] (Cohen & Levinthal 1990).
Non-technological innovation	An innovation that relates to 'non-tradeable' assets and increases worker or customer satisfaction, which tends to increase administrative costs and decrease transaction costs[15] is known	• Determinants of non-technological innovation: a) structural variables, b) administrative process variables,

[14] Absorptive capacity is 'a firm's ability to recognize the value of new information, assimilate it, and apply it to commercial ends' (Cohen & Levinthal 1990).

[15] Transaction cost is a cost of a market transaction where goods or services are provided within a market rather than within a firm.

	as non-technological innovation (Stoneman 2010). Non-tradeable assets are the assets that are saleable in the market, such as goodwill	c) human resources or cultural variables (Damanpour 1991), d) complexity of structure of an organization, and e) size of an organization (Damanpour 1996).
Levels of Innovation		
Incremental innovation	A method to improve and expand upon the products and services in an organization, while using the current technological trajectories available in the market (Jansen, Bosch & Volverda 2006).	• Is done in a short span of time and attempts to fulfil the needs of current customers or markets (Ettlie, Bridges & Okeefe 1984; Taylor & Greve 2006) • The main reason to adapt incremental innovation is to sustain competitive advantage and adapt to changing market dynamics (Bhaskaran 2006)
Radical Innovation	A fundamental change in innovative activities.	• Radical innovation is a revolutionary change and often is described as radical invention from the technology perspective or radical innovations from the user or market perspective (Ahuja & Lampert 2001). • von Hippel (1988) defines a 'radical innovator' or 'radical inventor' as a primary actor that radically: a) invents the innovation instrument, or b) identifies advancement of the process or product, or c) builds a prototype, or d) demonstrates the applicability of the prototype, or e) provides an insight into a process of innovation diffusion by replication from another industry

Appendix 4A: Definitions of Agility

Definitions of Agility	**Performance dimensions of agility**	**Authors**
Involves the ability to respond quickly and effectively to changes in market demand	Proactive and reactive flexibility; delivery speed; design quality (customization); cost efficiency	Brown and Bessant (2003)
Ability to respond to sudden changes and meet widely varied customer requirements in terms of price, specification, quality, quantity, and delivery	Delivery speed; product introduction speed; stable unit cost; changeover flexibility	Prince and Kay (2003)
Ability to sense, respond to, and exploit anticipated or unexpected changes in the business environment	Delivery responsiveness; delivery speed; product model flexibility (customization); product introduction flexibility; volume flexibility	Sharifi and Zhang (2001)

Appendix 5A: Notation for Mixed methods studies

Notation	Explanation	Interaction	Key References
QUAL + QUAN	Both the quantitative and qualitative methods occur at the same time (simultaneous or concurrent)	Limited interaction between these two datasets, but the findings complement one another at the end of the study	Morse (1991)
QUAL→ quan	The methods occur in a sequence, with the qualitative methods occurring before the quantitative methods and building on them (sequential)	Qualitative method is completed first to construct a Likert scale. Quantitative methods ensure reliability and validity	Morse (1991)
QUAN →qual	Capital letters indicates theoretical drive or priority (core methods) given in a study; lower case indicates supplemental methods (sequential)		Morse (1991) and Morse and Niehaus (2009)
QUAN (qual)	The qualitative methods are embedded within a quantitative design		Morse (1991)
QUAN + QUAL	The bold letters for both identify the purpose or rationale for the design (convergence)		Morse & Niehaus (2009)
QUAL → **[QUAN→qual]** **[QUAL →quan]**	Square brackets indicate a self-contained project within a series of interrelated studies The larger font indicates core methods or theoretical drive; smaller font indicates supplemental methods		Morse & Niehaus (2009)

Source Adapted from Creswell (2011) and Morse (1991).

*“+” represents concurrent relationship and → represents sequential relationship

Appendix 5B: Survey Research

Table 1: Different views on the meaning of survey research.

Description of Survey research	Authors
Surveys are frequently conducted for the purpose of making descriptive assertions about some population, thus discovering the distribution of certain traits or attributes. In this regard, the researcher is concerned not with why the observed distribution exists but merely with what the distribution is.	Babbie (1990, pp. 51-52)
A survey, or a standardised set of questions administered to a number of respondents, allows researchers to gather information about a population. A population is a group of individuals under examination in a particular study.	Elliott (2004, p. 196)
Survey is a systematic process of data collection designed to quantitatively measure specific aspects of organisational members' experience as they relate to work	Terziovski (2003, p. 5)
Survey research is a method of collecting information about a human population in which direct contact is made with the units of the study (individuals, organisations, communities, etc.) through such systematic means as questionnaires' and interview schedules.	White et al. (1988, p. 2)
Surveys usually focus on people – facts about them or their opinions, attitudes, motivations, behaviours and so on – and the relationships among variables under study related to these people.	Rothwell (1989, p. 212)

Table 2: Advantages and disadvantages of using a survey.

Advantages of using a survey	Disadvantages of using a survey
Cost effective	Finding a survey data set with the same information could be expensive
Association is identified and validate a variety of explanatory models (Dillman, Phelps, et al. 2009)	Regressive relationships are determined rather than any in-depth analysis
More disclosure of sensitive information due to anonymity of the data (Dillman et al. 2009) Joinson (2001, pp. 189-90)	Uncertainty that potential participants will do the survey
Easily accessible globally	Getting enough participants as too many surveys have been launched in the market
Less time consuming as compared to the interviews or other qualitative techniques	Tested on predetermined questions which interrogates limited data (Di Zhang and Bruning (2011, p. 162)
Skip logic – dead end and orphan questions can be eliminated (Cummings, Kohn & Hulley 2013, pp. 226-27)	
More data can be collected in a limited time and space (Great Britain Treasury 2000)	

Appendix 5C: Letter of Consent for Survey

This study on innovation in manufacturing SMEs, supported by the *Department of Industry and Science*, is to understand the process of innovation in an organisation. The results of the study will facilitate manufacturing SMEs ability to understand the process of innovation, help identify internal and external factors that affect the development and implementation of innovation within business enterprises, as well as the relationship between the factors themselves. Furthermore, the copy of the final draft of the report (which includes the results) would be provided to the Enterprise Connect at least 2 weeks prior to its publication.

You have been asked to participate in this research because of your expertise and involvement in the innovations that are carried out in your organisation. Your participation in this research will involve an online survey requiring approximately 30 minutes.

Once data is coded, the online survey information will be destroyed. The coded data will be completely anonymous and will be kept in a secured area.

This research is part of a PhD at the University of Technology Sydney under ethics clearance HREC 2013000046 dated 6th February, 2013. You are free to withdraw from this research project at any time, without consequences, and without giving a reason.

If you have any concerns about the research you can contact Megha Sachdeva at +61 [redacted] or her supervisor Dr Renu Agarwal at +61 [redacted]/+61 2 9514 3624 or via email at (megha.sachdeva, renu.agarwal)@uts.edu.au.

CONSENT BY PARTICIPANT

I agree that the research data gathered from this project may be published in a form that does not identify me or my organisation in any way.

Appendix 5D: Online Questionnaire Survey

CONSENT BY PARTICIPANT

I agree that the research data gathered from this project may be published in a form that does not identify me or my organisation in any way.

- ○ Yes
- ○ No

Q1: Approximately how many "product innovations" did your organisation introduce in the last three years?
(*"Product innovation"* *is the development and market introduction of a new, redesigned or substantially improved good or service***)**

[ ] Product Innovations

Q2: Think about up to 5 product/service innovations in your organisation in the last three years.
Assign them a number from 1 to 5.

	1	**2**	**3**	**4**	**5**
Which of these innovations did you regard as radical? *("Radical innovation" is a major improvement in an existing product or a product which is completely new to the company/industry*)	☐	☐	☐	☐	☐
Which of these innovations were successful?	☐	☐	☐	☐	☐

Q3:

Which of the following indicators did you use to measure the success of each of these product/service innovations?

	1	2	3	4	5
Sales increase	☐	☐	☐	☐	☐
Profit increase	☐	☐	☐	☐	☐
Increase in turnover	☐	☐	☐	☐	☐
Speed with which product innovation was introduced	☐	☐	☐	☐	☐

	1	2	3	4	5
Product uniqueness (***"Product uniqueness"** means that the product offers special, innovative features to customers*)	☐	☐	☐	☐	☐
Product superiority (in comparison with competitors)	☐	☐	☐	☐	☐
Product newness (***"Product newness"** is when a product commercialises for the first time and influences the firm's existing resources and/or activities pertaining to marketing, technology, skills, knowledge, capabilities, or strategy*)	☐	☐	☐	☐	☐
Other, please specify [ ]	☐	☐	☐	☐	☐
None	☐	☐	☐	☐	☐
Don't know	☐	☐	☐	☐	☐

Q4: Approximately how many "**process innovations**" did your organisation introduce in the last three years? (*"**Process innovation**" means the implementation of a new or significantly improved production or delivery method (including significant changes in techniques, equipment and/or software)*).

[0] Process Innovations

Q5: Think about up to 5 process innovations in your organisation in the last three years.

Assign them a number from 1 to 5.

	1	2	3	4	5
Which of these innovations did you regard as radical? (***"Radical innovation"** is a major improvement in an existing process or a process which is completely new to the company/industry*)	☐	☐	☐	☐	☐

	1	2	3	4	5
Which of these innovations were successful?	☐	☐	☐	☐	☐

Q6: Which of the following indicators did you use to measure the success of each of these process innovations?

	Process Innovations				
	1	2	3	4	5
Sales increase	☐	☐	☐	☐	☐
Profit increase	☐	☐	☐	☐	☐
Increase in turnover	☐	☐	☐	☐	☐
Speed with which innovation was introduced	☐	☐	☐	☐	☐
Productivity of the firm	☐	☐	☐	☐	☐
Other, please specify [ ]	☐	☐	☐	☐	☐
None	☐	☐	☐	☐	☐
Don't know	☐	☐	☐	☐	☐

Technological changes in your organisation

About: **"*External Technological Change*"** *means a change in technology which is generated outside your organisation. This change can be adapted by your competitors or any other organisation within the same or different sectors but has or can have an impact on your business*

To what extent do you agree/disagree with the following statements?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	× Not Applicable
Q7: We continuously observe technological changes that	○	○	○	○	○	○

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	× Not Applicable
occur in any industry that is important to my organisation						
Q8: External Technological Change has a significant impact on the innovations implemented in my organisation.	○	○	○	○	○	○
Q9: We monitor what change our competitors have as a result of their adopting new technology	○	○	○	○	○	○
Q10: We are likely to adopt to the technological changes undertaken by our competitors	○	○	○	○	○	○

Q11: Within our organisation, we learn about External Technological Changes

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	× Not Applicable
through employees	○	○	○	○	○	○
through customers, suppliers of capital equipment/software or materials and components, partners such as horizontal partners with firms producing similar products	○	○	○	○	○	○

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	× Not Applicable
through competitors or their actions	◯	◯	◯	◯	◯	◯
through conferences, trade fairs, journals or media	◯	◯	◯	◯	◯	◯
through trade or industry associations, universities, public research / or design institutions, private technical services/ consultants	◯	◯	◯	◯	◯	◯
through government support services	◯	◯	◯	◯		

Q12: How does External Technological Change affect your organisation? (please answer below)

The role of customers (buyers of your products and services) in your organisation

To what extent do you agree/disagree with the following statements

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	× Not Applicable
Q13: Our organisation regularly studies customers' wants before developing a product/service	◯	◯	◯	◯	◯	◯
Q14: We seek continuous customer feedback	◯	◯	◯	◯	◯	◯

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	× Not Applicable
Q15:Customer feedback is of little use for the development of innovations in our organisation						
Q16:Our aim is to provide prompt service to help customers						
Q17: Our employees and managers are not at all courteous towards existing or potential customers						
Q18: Courtesy and the knowledge of employees helps to retain and attract customers						
Q19:Communication with customers is often done through online media (e.g. Online media is through emails, Facebook, twitter etc.)						
Q20: Retaining customers is one of our company's goals						

Q21: What is the highest education qualification of your CEO/owner of your firm?

- ☐ High School
- ☐ TAFE or Trade Certificate
- ☐ Technical or Natural Science degree
- ☐ Management degree or diploma
- ☐ Degree or diploma directly related to research and development (R&D) or innovation
- ☐ × Other ***(please specify in detail the nature/mode of the education and its leve*l)**

× None

× Don't Know

Q22: Approximately what percentage of "managers" in your organisation have the following as their highest education qualification?

0 % High School

0 % TAFE or Trade Certificate

0 % Technical or Natural Science degree including higher degrees

0 % Management degree or diploma

0 % Degree or diploma directly related to learning and development (L&D) and innovation

0 % Other (***Please specify in detail the nature/mode of the education and its level***)

0 % × Don't know

Q23: Approximately what percentage of "employees" in your organisation have the following as their highest education qualification?

0 % High School

0 % TAFE or Trade Certificate

0 % Technical or Natural Science degree including higher degrees

0 % Management degree or diploma

0 % Degree or diploma directly related to learning and development (L&D) and innovation

0 % Other (***Please specify in detail the nature/mode of the education and its level***)

0 % × Don't know

Q24: Does your organisation allocate budget for the development of employees through training?

Yes

No

Q25: How much does your organisation spend on each type of training activities?

	Budget Allocated				
	Less than $5000	$ 5001- 15000	$15001-50,000	50,001 - 100,000	More than 100,000
Technical	○	○	○	○	○
Marketing	○	○	○	○	○
People skills to deal with customers	○	○	○	○	○
People skills to work in a team or in a management position	○	○	○	○	○
Other; please specify	○	○	○	○	○
Don't know	○	○	○	○	○

Previous experience of members of the organisation

To what extent do you agree/disagree with the following statements?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	× Not Applicable
Q26:Previous Experience of our **"employees"** in the **same sector**is useful for our firms' growth and innovation	○	○	○	○	○	○
Q27:Previous Experience of our **"employees"** in **another sector**is useful for our firms' growth and innovation	○	○	○	○	○	○
Q28:Previous Experience of our "**managers**" in the **same sector**is useful for our firm's growth and innovation	○	○	○	○	○	○
Q29: Previous Experience of our "**managers**" in **another sector** is useful for our	○	○	○	○	○	○

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	× Not Applicable
firm's growth and innovation						

Q30: Does the CEO/owner have previous experience in innovation or creative activities?

- Yes
- No

Previous experience of the CEO/owner in innovation or creative activities

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	× Not Applicable
Q31:assists with being open to undertake innovation in the current business	○	○	○	○	○	○
Q32:creates emotional stability during innovation failures	○	○	○	○	○	○
Q33:assists with external partner collaborations for creating innovations	○	○	○	○	○	○
Q34:assists with adaptation of new technological changes	○	○	○	○	○	○
Q35:assists with creating learning opportunities for employees including managers	○	○	○	○	○	○

Motivation for innovation in your organisation

Q36:Why do the following undertake innovative activities in your organisation?

	This is the best option for their personal and professional development	In this manner they/the company earns more money than if they don't innovate	They have to innovate to stay in the market
CEO (s)	○	○	○
Managers	○	○	○

	This is the best option for their personal and professional development	In this manner they/the company earns more money than if they don't innovate	They have to innovate to stay in the market
Other Employees	◌	◌	◌

Partnership/network ties

Q37: Do you collaborate with external organisations to generate innovative activities?

◌ Yes

◌ No

Q38: How often do you work with the following on **developing** innovation activities?

	Never	Seldom	About half the time	Usually	Always
Internal partners (*"**Internal partners"** include suppliers, distributors, contract manufacturers, and logistics providers*)	◌	◌	◌	◌	◌
Customers	◌	◌	◌	◌	◌
Research Organisations (***"Research organisations"** inclu de universities, trade associations, consultants, training institutions*)	◌	◌	◌	◌	◌
Venture Capital Firms and foreign partners	◌	◌	◌	◌	◌

Government entities (***"Government entities"*** *include government enterprises and government owned subsidiaries*)	◯	◯	◯	◯	◯
Other firms either in the same or different industries	◯	◯	◯	◯	◯

Q39: How often do you work with the following on **implementing** innovation activities?

	Never	Seldom	About half the time	Usually	Always
Internal partners (***"Internal partners"*** *include suppliers, distributors, contract manufacturers, and logistics providers*)	◯	◯	◯	◯	◯
Customers	◯	◯	◯	◯	◯
Research Organisations (***"Research organisations"*** *include universities, trade associations, consultants, training institutions*)	◯	◯	◯	◯	◯
Venture Capital Firms and foreign partners	◯	◯	◯	◯	◯
Government entities (***"Government entities"*** *include government enterprises and government owned subsidiaries*)	◯	◯	◯	◯	◯
Other firms either in the same or different industries	◯	◯	◯	◯	◯

Q40: Why does your organisation enter into collaboration with outside organisations (such as research institutions, universities, venture capital firms, government enterprises or competitors)?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	× Not Applicable
Need for technical assistance	○	○	○	○	○	○
Need for marketing/organisational development assistance	○	○	○	○	○	○
Need for resource assistance	○	○	○	○	○	○
Need for government assistance (either monetary or advisory assistance) for conducting innovations	○	○	○	○	○	○
Need for knowledge and learning	○	○	○	○	○	○
The parent company acquired another company and/or wanted a project to include collaboration	○	○	○	○	○	○
Because we had no choice, but to collaborate. Please specify the reason	○	○	○	○	○	○

Q41: We learned about collaboration through

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
clients or customers	○	○	○	○	○
databases (*"**Databases**" includes government or any public or private source databases*)	○	○	○	○	○
conferences, journals or business section of newspapers (*"**Conferences**" include both academic or trade conferences. "**Journals**" includes both trade and*	○	○	○	○	○

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
academic journals. ***"Newspapers"*** *such as Financial Review and Wall Street Journal*)					
fairs, exhibitions or trade meetings	○	○	○	○	○
consultants, government/government subsidiary institutions and non-profit institutions	○	○	○	○	○
patent disclosures	○	○	○	○	○
family or personal ties	○	○	○	○	○
organisational neighbours or spatial proximity	○	○	○	○	○

To what extent do you agree/disagree with the following statements

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	× Not Applicable
Q42: Collaboration with outside organisations (**such as** *research institutions, universities, trade associations and government bodies*) creates an opportunity for future projects and growth	○	○	○	○	○	○
Q43: Collaboration with outside organisations increases our company's efficiency.	○	○	○	○	○	○
Q44: Collaboration with outside organisations does not affect knowledge and learning generated by our employees	○	○	○	○	○	○
Q45: Collaboration with outside organisations has	○	○	○	○	○	○

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	× Not Applicable
little effect on our innovations						
Q46: Collaboration with internal partners does not affect our efficiency (*"**Internal partners**" include suppliers, distributors, contract manufacturers, logistics providers, and employees*)						
Q47: Collaborative efficiency is measured through new business processes that were able to combine, recombine, or create new business						
Q48: Internal partners help to improve new ways of managing organisational structures and partnerships						
Q49: Internal partners help in online, rapid and up-to-date communication across partnerships to reduce information discrepancies						
Q50: Collaboration between workers and different departments in our organisation assists in communication of innovative ideas						
Q51: Collaboration between workers and different departments in our organisation helps in creating more innovations						

The culture and strategy of your organisation

To what extent do you agree/disagree with the following statements

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	× Not Applicable
Q52: Innovative activities undertaken in our organisation are aligned with our company's objectives. ("***Innovation activities"*** *include types of innovation such as product, process, organisational, marketing or technological innovations*)	○	○	○	○	○	○
Q53: Employees in the organisation are encouraged to innovate	○	○	○	○	○	○
Q54: Employees participate in the formation of organisational goals	○	○	○	○	○	○
Q55: Employees in the organisation are able to voice their opinions	○	○	○	○	○	○
Q56: Employees who generate new ideas are rewarded monetarily	○	○	○	○	○	○
Q57: Employees and managers in our organisation share their experiences (especially work related experiences) with each other	○	○	○	○	○	○
Q58: The new product development	○	○	○	○	○	○

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	× Not Applicable
process is reviewed frequently (at least once in a year) in our organisation						
Q59: The organisation goes to great lengths to explain to its employees why it is undertaking innovations	○	○	○	○	○	○
Q60: We have support programs in our organisation such that new ways of working and thinking are encouraged (apart from monetary benefits, programs such as training or providing access to company resources to develop new ideas)	○	○	○	○	○	○
Q61:A reflective thinking and reframing of the past experiences of failed and successful projects is undertaken as a **formal exercise** to create learning from these projects	○	○	○	○	○	○
Q62:A reflective thinking and reframing the past experiences of failed and successful projects exercises is an **informal practice**within our organisation	○	○	○	○	○	○

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	× Not Applicable
Q63: The CEO supports is committed to installing technology and IT infrastructure in the firm	◌	◌	◌	◌	◌	◌

Government Intervention/Enterprise Connect

To what extent do you agree/disagree with the following statements

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	× Not Applicable
Q64:Our organisation is supported by Enterprise Connect	◌	◌	◌	◌	◌	◌
Q65: Enterprise Connect has helped us to connect to researchers or industry associations	◌	◌	◌	◌	◌	◌
Q66: Enterprise Connect has helped our organisation to find new sources of funding	◌	◌	◌	◌	◌	◌
Q67: Enterprise Connect has provided our organisation with advice to design our overall strategy to undertake innovations	◌	◌	◌	◌	◌	◌
Q68: Enterprise Connect has provided our organisation with advice on marketing	◌	◌	◌	◌	◌	◌

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	× Not Applicable
strategies such that innovations are undertaken						
Q69: Enterprise Connect have guided us with the purchase of an Information Technology (IT) solution	◌	◌	◌	◌	◌	◌

Your organisation

Q70: Which manufacturing sub-sector does your organisation belong to?

◌ Food, beverage and tobacco products

◌ Textile, clothing

◌ Wood and paper products

◌ Printing and recorded media

◌ Petroleum, coal, chemical and rubber products

◌ Non-metallic mineral products

◌ Metal products

◌ Machinery and equipment

◌ Other (Please specify)

[ ]

Q71: How many employees do you have (approximately)?

[ ]

Q72: What was your organisation's total annual revenue or expenditure in the either the last or the preceding year (select whichever value highest in last two years):

◌ between $ 1.5 million to $ 10 million

◌ between $ 10.01 million to 25 million

- between $ 25.01 million to 50 million
- between $ 50.01 million to 100 million

Q73: In what state is your organisation's headquarters?

- New South Wales
- Queensland
- South Australia
- Tasmania
- Victoria
- Western Australia
- Northern Territory
- Australian Capital Territory

Q74: How long has your organisation being operating? (Specify the approximate number of years)

Q75: Would you be prepared to participate further in this study through telephone or face to face interview?

- Yes
- No

Q76: Please provide your name and contact details below for further participation

Name

Company's Name

Email address

Phone number

Appendix 5E: Variables of the Survey

Variables	Units Measured	Equation Classification
Number of Innovations (Product)	Number of Innovations	Dependent
Number of Innovations (Process)	Number of Innovations	Dependent
Innovations (Product)	Dichotomous, 0 or 1	Dependent
Innovations (Process)	Dichotomous, 0 or 1	Dependent
Technological change		
Observe Technological Change	Likert Scale (0-6)	External
Significant Impact of Technological Change	Likert Scale (0-6)	External
Monitor Competitors Change due to technology adoption	Likert Scale (0-6)	External
Adopt competitors technology	Likert Scale (0-6)	External
Extent to which learn about Technological Change through Employees	Likert Scale (0-6)	External
Extent to which learn about Technological Change through Customers and Suppliers	Likert Scale (0-6)	External
Extent to which learn about Technological Change through Competitors	Likert Scale (0-6)	External
Extent to which learn about Technological Change through Trade shows	Likert Scale (0-6)	External
Extent to which learn about Technological Change through Universities and Research Institutions	Likert Scale (0-6)	External
Extent to which learn about Technological Change through Government	Likert Scale (0-6)	External
Marketing Agility		
Customer wants regularly studied before new developing product/service	Likert Scale (0-6)	Internal
Customer feedback sought	Likert Scale (0-6)	Internal
Customer Feedback is little use (Reverse Coded)	Likert Scale (0-6)	Internal
Aim to provide prompt services to customers	Likert Scale (0-6)	Internal
Employees are not courteous (Reverse coded)	Likert Scale (0-6)	Internal
Courtesy of employees attract customers	Likert Scale (0-6)	Internal
Customer Communication through Online media	Likert Scale (0-6)	Internal
Retain Customers – Goal	Likert Scale (0-6)	Internal
Education and Training		
CEOS Education	Categories: HS, TAFE, Tech, Management, R&D, Other	Internal – Education
Managers General Education	Per cent of managers with degree or better	Internal – Education
Managers Management Education	Percentage	Internal – Education

Employees General Education	Per cent of employees with degree or better	Internal – Education
Employees Management Education	Percentage	Internal – Education
Training Expenditure	Dollars	Internal – Training
Previous Experience		
Value of experience of employees in Same Sector	Likert Scale (0-6)	Internal
Value of experience of employees in Another Sector	Likert Scale (0-6)	Internal
Value of experience of Managers in – Same Sector	Likert Scale (0-6)	Internal
Value of experience of Managers in – Another Sector	Likert Scale (0-6)	Internal
Value of CEO experience of innovation towards openness to innovate	Likert Scale (0-6)	Internal
Value of CEO experience of innovation towards emotional stability during failures	Likert Scale (0-6)	Internal
Value of CEO experience of innovation towards external partner collaborations	Likert Scale (0-6)	Internal
Value of CEO experience of innovation towards adaption of new technological change	Likert Scale (0-6)	Internal
Value of CEO experience of innovation towards creating learning opportunities	Likert Scale (0-6)	Internal
Motivation		
Motivation for CEO to innovate	3 options (Intrinsic, Extrinsic or Necessity)	Internal
Motivation for Managers to innovate	3 options (Intrinsic, Extrinsic or Necessity)	Internal
Motivation for Employees to innovate	3 options (Intrinsic, Extrinsic or Necessity)	Internal
Collaboration		
Collaborate with external organisations	Dichotomous (0,1)	Internal
Extent to which collaborate with internal partners to develop innovations	Likert Scale (0-5)	Internal
Extent to which collaborate with customers to develop innovations	Likert Scale (0-5)	Internal
Extent to which collaborate with research organisations to develop innovations	Likert Scale (0-5)	Internal
Extent to which collaborate with venture capitalists to develop innovations	Likert Scale (0-5)	Internal
Extent to which collaborate with government to develop innovations	Likert Scale (0-5)	Internal
Extent to which collaborate with other firms to develop innovations	Likert Scale (0-5)	Internal
Extent to which collaborate with internal partners to implement innovations	Likert Scale (0-5)	Internal
Extent to which collaborate with customers to implement innovations	Likert Scale (0-5)	Internal

Extent to which collaborate with research organisations to implement innovations	Likert Scale (0-5)	Internal
Extent to which collaborate with venture capitalists to implement innovations	Likert Scale (0-5)	Internal
Extent to which collaborate with government to implement innovations	Likert Scale (0-5)	Internal
Extent to which collaborate with other firms to implement innovations	Likert Scale (0-5)	Internal
Collaboration Need – Technical assistance	Likert Scale (0-5)	Internal
Collaboration Need – Market assistance	Likert Scale (0-5)	Internal
Collaboration Need – Resource assistance	Likert Scale (0-5)	Internal
Collaboration Need – Government assistance	Likert Scale (0-5)	Internal
Collaboration Need – Knowledge and learning	Likert Scale (0-5)	Internal
Collaboration Need – Parent company decision	Likert Scale (0-5)	Internal
Collaboration Need – No Choice	Likert Scale (0-5)	Internal
Learnt about Collaboration – customers	Likert Scale (0-5)	Internal
Learnt about Collaboration – databases	Likert Scale (0-5)	Internal
Learnt about Collaboration – conferences	Likert Scale (0-5)	Internal
Learnt about Collaboration – Fairs, Trade meetings	Likert Scale (0-5)	Internal
Learnt about Collaboration – Consultants	Likert Scale (0-5)	Internal
Learnt about Collaboration – patent disclosures	Likert Scale (0-5)	Internal
Learnt about Collaboration – family ties	Likert Scale (0-5)	Internal
Learnt about Collaboration –Spatial proximity	Likert Scale (0-5)	Internal
Collaboration with outside organisations creates growth opportunities	Likert Scale (0-6)	Internal
Collaboration with outside organisations increases efficiency	Likert Scale (0-6)	Internal
Collaboration with outside organisations does not affect knowledge (Reverse Coded)	Likert Scale (0-6)	Internal
Collaboration with outside organisations has little effect on innovations (Reverse Coded)	Likert Scale (0-6)	Internal
Collaboration with internal partners does not affect efficiency (reverse Coded)	Likert Scale (0-6)	Internal
Collaborative efficiency measured by new business processes	Likert Scale (0-6)	Internal
Internal partners improve new ways of management of organisation	Likert Scale (0-6)	Internal
Internal partners help to reduce information discrepancies	Likert Scale (0-6)	Internal
Internal collaboration assists in communication of innovative ideas	Likert Scale (0-6)	Internal
Internal collaboration assists in creating innovations	Likert Scale (0-6)	Internal
Culture		
Innovative activities aligned with organisational goals	Likert Scale (0-6)	Internal

Employees – encouraged to innovate	Likert Scale (0-6)	Internal
Employees – participate in formation of goals	Likert Scale (0-6)	Internal
Employees – voice their opinion	Likert Scale (0-6)	Internal
Employees – monetarily rewarded for new ideas	Likert Scale (0-6)	Internal
Employees and managers share experiences	Likert Scale (0-6)	Internal
New product development reviewed yearly	Likert Scale (0-6)	Internal
Explanations provided to employees for innovations	Likert Scale (0-6)	Internal
New ways of thinking are encouraged	Likert Scale (0-6)	Internal
Reflections on previous projects – Formally conducted	Likert Scale (0-6)	Internal
Reflections on previous projects – Informally conducted	Likert Scale (0-6)	Internal
CEO’s commitment towards installing technology	Likert Scale (0-6)	Internal
Government Support – Enterprise Connect		
Enterprise Connect – support provided	Likert Scale (0-6)	External
Enterprise Connect – connect with research associations	Likert Scale (0-6)	External
Enterprise Connect – Found New sources of funding	Likert Scale (0-6)	External
Enterprise Connect – Advised on overall strategy	Likert Scale (0-6)	External
Enterprise Connect – Advised on marketing strategy	Likert Scale (0-6)	External
Enterprise Connect – helped to purchase IT solutions	Likert Scale (0-6)	External
Demographic Questions		
SECTOR	Options (1-9)	Demographic
Number_Employees	Number	Demographic
Revenue	Discrete Categories	Demographic
HeadQuarter	Options (1-8)	Demographic
Age	Number	Demographic

Appendix 5F: Operationalisation of the technological change

Operationalisation of the technological construct	Items	Industry Sector	Taken from Authors
Sources of gain of technological change knowledge	Conferences, journals or media; competitors; material suppliers; equipment suppliers; customers (users of the industry's products); employees; personal inventors or designers; universities or research institutions; government programs or foreign companies including parent company (if any) will be studied.	Manufacturing	Adapted from Cohen and Levinthal (1990)
Perception gained through awareness	**Single Choice Questions** – Monitor changes in technology; Adopt a change in technology mainly because a competitor has done so		Self-developed

Appendix 5G: Operationalisation of the SME knowledge acquisition capabilities

Operationalisation of the SME knowledge acquisition construct	Items	Taken from Authors
Education	***Highest technical qualification for owners and managers*** – TAFE or trade certificate or diploma, graduate diploma, bachelor degree, master's degree, PhD, or other qualification ***Number of employees with a higher degree*** – TAFE or trade certificate or diploma, graduate diploma, bachelor degree, master's degree, PhD, or other qualification	Adapted from Leiponen (2005) and Romijn and Albaladejo (2002)
Training	Expenditure spent in gaining training activities for employees – technical, marketing, people skills to deal with customers, people skills to deal in a team or at a management position, others	Adapted from Galende and Fe Duete (2003) and Laforet and Tann (2006)
Collaboration – External and Internal Links and Mechanisms	Statement tested on the Likert scale indicating how often an organisation work with different parties to develop new products and services or delivery processes measured on a scale of never to frequently Q1) and Q2) Linkages and interactions with external partners – universities, customers, suppliers, foreign partners, consultants, public R&D centres, private research institutes, hospitals, other firms, venture capital firms (pp.242) – on a scale of never, seldom, frequently, always How do informal relations occur – family or personal ties, neighbours or spatial proximity, social occasions and professional meetings Sources of information (for ICT firms) – clients or customers; computer based information networks; conferences, meeting,	Mohannak (2007)

	journals; foreign partners; competitors; suppliers; fairs, exhibitions; consultancy firms; universities/higher education institutions; government/non-profit research institutions and patent disclosures Likert questions on 5 point scale: Partners assisted in new governance structures; increased efficiency as measured through new business processes that were able to combine, recombine, and create new business; new ways of managing organisational structures and partnerships were created; online, rapid and up-to-date communication across partnerships were able to reduce information discrepancies	Agarwal and Selen (2009)

Appendix 5H: Operationalisation of the SME implementation capabilities

Operationalisation of the SME knowledge acquisition construct	Items	Taken from Authors
Experience	Previous experience worked in the same sector before or other sectors CEOs commitment to innovation on – New product development (NPD), on new machine and equipment, on new ways of working;	Romijn and Albaladejo (2002) Laforet and Tann (2006)
Motivation	Statement tested on the basis of three choices provided Intrinsic motivation – “best option for my personal and professional development” Extrinsic motivation – “I earn more money than not to innovate.” Necessity motivation – “Had no other choice”	Adapted from Romero & Martínez-Román (2012)
Marketing Agility	Likert Questions - Appearance of the physical facilities, equipment, personnel, and communication materials. Extent to which the SME performs their services and customers can be dependent on them; Willingness to help customers and provide a prompt service; knowledge and courtesy of individuals (employees and managers) and their ability to be trustworthy and inspire confidence; and, the extent to which the organisation “cares” about its customers	Morgan (2004)
Culture	Organisation’s way of working – company’s objective Study customers wants in New products, finding out what customer thinks of the company’s products, learn from customers and study market change; Employee contribution to new ideas – shop floor, office staff, strategic manager, reward system, employees are free to act or disagree, CEO attitude to risk taking (pp.375-376)	Laforet and Tann (2006)

Appendix 5I: Operationalisation of the innovation outcomes construct

Operationalisation of the innovation outcomes construct	**Items**	**Taken from Authors**	**Measure used in this research**
Product Innovation and Process innovation	New product produced in past two years New process introduced in the business in past two years	Romero and Martínez-Román (2012)	New product produced in past two years New process introduced in the business in past two years
Open Innovation - Openness	R&D Intensity – Proportion of expenditure on R&D activities within the firm divided by the total expenditure on the development of new or changed products and processes in last two years (pp.208)	Huang and Rice (2009)	Openness - Acquisition or purchase of technology rights through licensing Customer involvement in introducing new innovations Contracting out of internal R&D to external agents, other firms or research institutions Any use of formal or informal networks (pp. 205) (adapted from the definition of the open innovation by Huang and Rice (2009))

Appendix 5J: Operationalisation of the innovation performance construct

Operationalisation of the innovation performance construct	**Items**	**Taken from Authors**
Newness to the firm	Product is new to the firm Process is new to the firm	Cooper (1979); Cooper and de Brentani (1991)
Product Uniqueness	Product is unique in the market	Cooper (1979)
Innovation Efficacy - Degree of success of innovation	Increase in the productivity of the firm	Alegre et al. (2006)
Innovation Speed	High Speed with which innovations are introduced in the market- Organisation aims to produce new/improved products or process at least once in 6 months; Adaptation to technological change is very high in the enterprise	Chandy and Tellis (2000)
Reduction in cost	The cost rate of production of goods/services has decreased than previous years	(Pavitt 2005)
Sales Increase/ Turnover Increase	Level of sales of different types of innovation Increase in the turnover – including the exports	Negassi (2004) Janz, Lööf and Peters (2003)
Profit increase	Increase in the profit	Cohen and Levinthal (1990)

Appendix 5K: Email invitation for the case studies

Dear … (Participant's name)

I am writing to ask your help with a study I am undertaking as part of my PhD in Management at the UTS Business School. At the end of last year, you very kindly responded to a survey I was conducting on innovation in small Australian manufacturing firms and you indicated that you would be happy for me to contact you about further participation in an interview. I am currently arranging interviews to further explore the process of innovation in small Australian firms, and I was hoping that you might still be available.

The interview would take about 45 minutes or so, and would help me understand how firm's like yours are responding to current challenges in Australian manufacturing. It would also be very helpful if I were able to interview three or four other members of your staff to provide a cross section of skills and approaches within the firm. These interviews would be of similar duration. I can be very flexible about the timing of the interviews so that they do not disrupt the operations of your business and all information collected would be kept anonymous and in a secure location at the University.

In return for your help, I would provide you with a short report which outlines my main results.

I would be very grateful if you were able to let me know within a week or so whether you are interested in participating, and I am very much hoping that you are.

Sincerely,
Megha Sachdeva
Ph.D. Student,
University of Technology, Sydney

Appendix 5L: Consent form for case study participants

CONSENT FORM

I ____________________ agree to participate in the doctoral research project "Innovation in manufacturing SMEs" with the UTS HREC approval reference number 2013000046 as being conducted by Megha Sachdeva, addressed to PO Box 123, Broadway 2007 and contact number as [redacted] of the University of Technology, Sydney (UTS) for her degree of doctorate of management (PhD).

I understand that the purpose of this study is to identify the process of innovation in an organization. The results of the study will benefit organizations to understand why organizations conduct innovations and what internal and external factors affect these practices within business enterprises, as well as the relationship between the factors themselves. Furthermore, the results would also be included as research thesis that will be published by UTS.

I understand that I have been asked to participate in this research because of the expertise and involvement in the innovations that are carried in my organization and that my participation in this research will involve being asked to be interviewed. I understand that if I am interviewed, it will take approximately 45 min to an hour and that by signing this form I am granting permission to be digitally recorded, but that I am able to ask to go off the record at any stage. The data will be kept confidential and would not be shared with anyone except the researcher. Once data is coded, online survey information will be destroyed. The coded data, interviews and transcripts will be kept in a password secured hard drive in a secured area.

I am aware that I can contact Megha Sachdeva (on mobile +61 [redacted] or through email megha.sachdeva@uts.edu.au) or her supervisor Dr Renu Agarwal via email renu.agarwal@uts.edu.au, if I have any concerns about the research. I also understand that I am free to withdraw my participation from this research project at any time I wish, without consequences, and without giving a reason.

I agree that Megha Sachdeva has answered all my questions fully and clearly.

I agree that the research data gathered from this project may be published in a form that does not identify me in any way.

____ ____/____/____

Signature (participant)

____ ____/____/____

Signature (researcher or delegate)

NOTE:

This study has been approved by the University of Technology, Sydney Human Research Ethics Committee. If you have any complaints or reservations about any aspect of your participation in this research which you cannot resolve with the researcher, you may contact the Ethics Committee through the Research Ethics Officer (ph: +61 2 9514 9772 Research.Ethics@uts.edu.au) and quote the UTS HREC reference number. Any complaint you make will be treated in confidence and investigated fully and you will be informed of the outcome.

Appendix 5M: Information Sheet for case study participants

INFORMATION SHEET

Innovation in Manufacturing SMEs (HREC 2013000046**)**

WHO IS DOING THE RESEARCH?

My name is Megha Sachdeva and I am a doctoral student at UTS. My supervisors are Dr Renu Agarwal, Associate Prof. Christine Burton and Associate Prof. Peter Docherty.

WHAT IS THIS RESEARCH ABOUT?

This research is to find what the process of innovation is within an Australian manufacturing organization. Further, innovative activities and the reasons why these activities are undertaken will be studied.

IF I SAY YES, WHAT WILL IT INVOLVE?

I will ask you to fill an online questionnaire that will involve 25-30 minutes of your time and an audio-recorded interview that will be between 45 minutes to an hour.

ARE THERE ANY RISKS/INCONVENIENCE?

There is minimal to low risk of participants feeling emotional or having any sort of discomfort to recall any unpleasant experiences However, the research is absolutely confidential – which means I will not reveal your name in any way. I will give both you and your organization a pseudonym – a fake name – to help keep your behaviour, actions, and verbal expressions confidential. It is possible that your time is the only factor that might cause an inconvenience for you. But this will be tried to minimise by having straight forward questions.

WHY HAVE I BEEN ASKED?

You are able to give me the information I need to find out about process and reasons of undertaking innovation and its activities within your organization.

DO I HAVE TO SAY YES?

You don't have to say yes – your participation in the research is voluntary.

WHAT WILL HAPPEN IF I SAY NO?

Nothing. I will thank you for your time so far and won't contact you about this research again.

IF I SAY YES, CAN I CHANGE MY MIND LATER?

You can change your mind at any time and you don't have to say why. You can ask me not to use any data collected about you at all, and your data will be expunged. I will thank you for your time so far and won't contact you about this research again.

WHAT IF I HAVE CONCERNS OR A COMPLAINT?

If you have concerns about the research that you think I or my supervisor can help you with, please feel free to contact Megha Sachdeva on [redacted] or Dr Renu Agarwal on 9514 3624 or via email at renu.agarwal@uts.edu.au.

If you would like to talk to someone who is not connected with the research, you may contact the Research Ethics Officer on 02 9514 9772, and quote this number HREC 2013000046

Appendix 5N: Major positions of an interviewer

Author(s)	Different position of an interviewer	Interviewer's positions discussed in the detail
Silverman (2011)	Positivism, Emotionalism, Constructivism	***Positivism*** basis its reports on external realities, where strict protocols are observed ***Emotionalism*** – interviewer should seek to overcome the presumed power imbalance with her interviewees **Constructivism** – data is presented interestingly which means that it expresses interpretative procedures or controversial practices present in the both interviewer and interviewee's actions through their talk and non-verbal actions (p.144).
Alvesson (2011)	Interactive rationalism, Romanticism, Localism, Mixed positions	**Revised neo-positivism** is also known as *interactive rationalism*. Interactive rationalism to some extent recognises social complexity and embraces soft and flexible technical measures in dealing with the problem of how to maximise reliable responses (p. 13) ***Romanticism*** – interviewers are interactive and maintain closeness with the interviewees. Romantics have an ideology on board that interviewees are guided by what researcher wants to hear and social norms of how a person presents himself or herself. (p. 14) ***Localism*** – interview statements when seen in their local, situation-specific context. Localism to some extent shares features of the poststructuralism/postmodernism whilst rejecting a mirror view on the language and humanistic view on the subject. ***Mixed positions*** – Considers both localist (partially) and romantic (mainly) aspects. Interview within this position is a source of knowledge-production, where the social process and local conditions are actively managed to accomplish valid results. Tendency to jump from one position to other varies often (p. 22).

Appendix 5O: Interview Survey

Interview Question Guide for Owners

Questions for semi-structured interview for individuals that are involved in conducting or implementing innovative practices in an organization

Thank you for agreeing to participate in this research. My name is Megha and I am a doctoral student at the University of Technology, Sydney.

I would like to assure you that any information shared by you will be kept confidential and you will be anonymous in any reporting of this research. In case you do not want to share any information on a particular question, we can remove that question from the interview. Further, if you feel uncomfortable at any time, we can stop the interview immediately with no further clarifications required by you.

Is it okay with you, if I record the interview?

Is it okay, if I might have to take notes of few things if I need to ask you so that I do not forget it later?

Is it fine for me to start the interview?

Innovation and performance

1. How would you explain to someone who does not know anything about your business, what type of business do you do?
2. Tell me about your experience in this business? Why did you start your business?
3. How many new products or services did your business introduce in the last 3 years?
    a. How did you identify these products/services as worthy of introducing?
    b. Were they successful and how did you evaluate their success?
4. How many new internal processes did your business introduce in the last 3 years to improve its operations?
    a. What were these?
    b. How did you identify these products/services as worthy of introducing?
    c. Were they successful and how did you evaluate their success?

Impact of technology

5. How do you think that changes in the technology have had an impact on your business operations?
    a. Why is that?
    b. Is there any specific changes your business introduced to cope with the changing technology?
6. How does your business monitor changes to technology in your sector/industry?
7. How likely are you to adopt a change in technology mainly because one of your competitors has done so?
    c. Well, why is that?

Competition

8. Tell me how competitive do you find the industry in which you are operating in?
    a. Do you have a recent example of the industry’s impact on your business?
    b. Once you have identified a competitor, what would you usually do after identifying them?

Education and Experience

9. In your experience of working in this business, how much do you think educational background in this has contributed you to develop new products and services?
10. What kind of education do you look for when hiring new employees?
    a. Do you focus more towards technical or business education when hiring a new employee?
    a. To what extent is on-going training important for your employees?
    b. What types of courses and programs they have done in the last 3 years or so?
11. Tell me how important do you think your previous experience has been in preparing you to manage the business?
    a. Do you have an example where your previous experience was of high value?
    b. What do you think has made you successful?
12. What previous experience do you look for in hiring new people?

Collaboration

13. Do you ever collaborate with outside businesses to develop new products, services, or delivery processes?
    a. Which type of businesses or institutions are these ones?
    b. Can you explain why did you collaborate with these businesses only?
    c. Do you seek out any government assistance when you are thinking of collaborating with other companies?
    d. Can you explain what this is and how you go about it?
    e. Was it useful in helping you develop these collaborations?
14. How important is customer feedback within your business operations?
    a. Well, Why is that?
    b. How necessary is it to spend much time with customers working out what they need?

Culture

15. Tell me something about the way you manage your business operations daily?
    a. What are your priorities in a day?
    b. Are you involved in any type of activities which relates with developing new product ideas?
16. Do your employees generate new ideas for new products or processes?
    a. How do you capture these ideas?
    b. What is the level of interaction you have with your employees on daily basis?
17. Is there anything else you would like to share with me?

Thank you for participating in this interview.

Interview Question Guide for Managers/Employees

Questions for semi-structured interview for individuals that are involved in conducting or implementing innovative practices in an organization

Thank you for agreeing to participate in this research. My name is Megha and I am a doctoral student at the University of Technology, Sydney.

I would like to assure you that any information shared by you will be kept confidential and you will be anonymous in any reporting of this research. In case you do not want to share any information on a particular question, we can remove that question from the interview. Further, if you feel uncomfortable at any time, we can stop the interview immediately with no further clarifications required by you.

Is it okay with you, if I record the interview?

Is it okay, if I might have to take notes of few things if I need to ask you so that I do not forget it later?

Is it fine for me to start the interview?

Innovation and performance

18. Tell me about your experience of working in this business? What are the reasons that you choose this organisation?
    a. Why do you think you got this job?
19. Tell me about your role in any new products or services that were introduced in the business in the last 3 years?
    a. Why do you think these products/services were worthy of introducing?
    b. What do you think about whether these products/services were successful and how do you evaluate their success?
20. Tell me about your role in introducing new internal processes in the business in the last 3 years?
    a. How do you think these internal processes affected the operations of this company?
    b. Were they successful and how did you evaluate their success?

Impact of technology

21. How do you think that the changes in the technology affect your job in particular? Why is that?
    d. Are there any specific changes you are aware of which your business introduced to cope with the changing technology?
22. Are you aware or involved in monitoring changes to technology in your sector/industry?
    e. Tell me something about the competitors businesses and how do you them this well?
    f. Well, why is that?

Competition

23. Tell me how competitive do you find the industry in which you are operating in?
    c. Do you have a recent example of the industry's impact on your business?

Education and Experience

24. In your experience of working in this business, how much do you think your educational background in this has contributed you to develop new products and services?
    a. What is your highest level of education?
    c. IS there any sort of training program that you went through?
    d. What types of courses and programs they have done in the last 3 years or so?
25. Tell me how important do you think your previous experience has been in preparing you to manage this job?
    c. Do you have an example where your previous experience was of high value?
    d. What do you think has made you successful?

Collaboration

26. Do you ever collaborate with outside people/businesses to develop new products, services, or delivery processes?
    f. Which type of people/ businesses or institutions are these ones?
    g. Can you explain why did you collaborate with these businesses only?
    h. Do you seek out any government assistance when you are thinking of collaborating with other companies?
    i. Can you explain what this is and how you go about it?
    j. Was it useful in helping you develop these collaborations?
27. How important is customer feedback within your business operations?
    c. Well, Why is that?

d. How necessary is it to spend much time with customers working out what they need?

Culture

28. Tell me something about the way you manage your operations daily?
    a. What motivates you to work for metal manufacturing?
29. As an employee what do you think about the people you work with – are they supportive of your ideas always?
30. How do you communicate your ideas with the upper management, if you do?
31. According to your perspective, tell me what do you think about potential of expansion of your business?

Thank you for participating in this interview.

Appendix 6A: Regression tables for alternative indices

On the following pages tables are shown that feature alternative indices for perceived technological change (PERC), collaboration (COL), culture (CUL). These tables replicate the regression tables included in Chapter 6 and are discussed extensively in section 6.3.2.

Table 6A1: Results of Multinominal Logistic Regressions for *Product* Innovation using *observed* Measure of Perceived Technological change (PERC).

Variable	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)
Intercept	-2.8734	0.4479	-2.2507	0.3322	-15.5384	0.1193	-14.0726	0.1156	-2.2459	0.5288	-11.8643	0.1184
PERC1	-0.0927	0.8666	-0.0342	0.9436	3.1219	0.1793	2.7858	0.1858	-0.0354	0.9656	2.2435	0.2073
ED1	-0.0160	0.9595										
ED2	0.0312	0.0886*	0.0221	0.0403**	0.0601	0.4594	0.0604	0.4483	0.0221	0.0450**	0.0190	0.0753*
ED3	0.0059	0.7949										
ED4	-0.0211	0.3587										
ED5	-0.0135	0.7178										
TRAIN	0.0000	0.9881										
COL	0.3271	0.0312**	0.3767	0.0041***	0.6836	0.4738	0.3715	0.0060***	0.3752	0.6457	0.3858	0.0043***
EXPER	0.3151	0.5213										
MOTV	0.5830	0.1711	0.6985	0.0685*	5.2826	0.0993*	5.0463	0.1028	0.6985	0.0685*	4.6376	0.1120
MAG	0.1377	0.6757										
CULT	0.0471	0.8604										
AGE	-0.0188	0.3504										
REV	-0.6572	0.3910										
STAFF	0.0117	0.4903										
PERC1* ED1												
PERC1* ED2					-0.0095	0.5977	-0.0095	0.5956				
PERC1* ED3												
PERC1* ED4												
PERC1* ED5												
PERC1* TRAIN												
PERC1* COL					-0.0714	0.7394			0.0003	0.9986		
PERC1* EXPER												
PERC1* MOTV					-1.0810	0.1444	-1.0310	0.1534			-0.9291	0.1729
PERC1* MAG												
PERC1* CULT												
PERC1* AGE												
PERC1* REV												
PERC1* STAFF												
McFadden R-squared		0.2795		0.2187		0.2539		0.2524		0.2187		0.2485
Akaike Info Citerion		1.1589		0.9228		0.9684		0.9429		0.9499		0.9199
Predicted Probabilities (%)		83.78		78.38		78.38		79.73		78.38		79.73
LR statistic (df)		20.85		16.32		18.95		18.83		16.32		18.54
p-value		0.1416		0.0026		0.0084		0.0045		0.0060		0.0023

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

Table 6A2: Results of Multinominal Logistic Regressions for *Process* Innovation using *observed* Measure of Perceived Technological change (PERC).

Variable	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)
Intercept	-16.0736	0.0049***	-13.7668	0.0027***	32.1834	0.5215	12.2948	0.2780	-22.4896	0.3029	18.2294	0.4119
PERC1	1.5599	0.0115**	1.3369	0.0117**	-11.1706	0.3431	-6.5468	0.0312**	3.2424	0.4858	-8.1413	0.1328
ED1	-0.7124	0.0546*	-0.6224	0.0469**	-13.4826	0.0200**	-12.0724	0.0069***	-0.5566	0.0844*	-11.7457	0.0060***
ED2	0.0508	0.0251**	0.0345	0.0212**	-0.0813	0.6089	-0.0881	0.4844	0.0343	0.0269**	-0.0742	0.5566
ED3	0.0028	0.8987										
ED4	-0.0240	0.2228										
ED5	0.0080	0.7886										
TRAIN	0.0001	0.0089***	0.0000	0.0120**	0.0003	0.2204	0.0002	0.2221	0.0000	0.0137**	0.0001	0.0274**
COL	0.0607	0.7471										
EXPER	-1.6408	0.0306**	-1.0971	0.0469**	-2.4008	0.5996	-2.2156	0.0182**	1.6350	0.5530	-2.0924	0.0140**
MOTV	1.0714	0.0593*	0.8681	0.0641*	0.9474	0.8401	1.7446	0.0217**	4.2405	0.2659	1.6813	0.0211**
MAG	1.1393	0.0117**	0.9685	0.0067***	2.8636	0.4199	1.8752	0.0051***	-0.6115	0.7766	1.2894	0.6514
CULT	0.6670	0.0506*	0.6369	0.0403**	-1.8434	0.7245	1.0863	0.0500**	0.5341	0.8292	1.1382	0.0384**
AGE	0.0110	0.5931										
REV	1.3546	0.2033										
STAFF	-0.0402	0.1452										
PERC1* ED1					2.9965	0.0251**	2.6565	0.0086***			2.6163	0.0073***
PERC1* ED2					0.0335	0.3991	0.0350	0.2598			0.0319	0.3185
PERC1* ED3												
PERC1* ED4												
PERC1* ED5												
PERC1* TRAIN					-0.0001	0.3015	0.0000	0.3243				
PERC1* COL												
PERC1* EXPER					-0.0123	0.9907			-0.6853	0.3262		
PERC1* MOTV					0.2199	0.8424			-0.7993	0.3760		
PERC1* MAG					-0.2229	0.7868			0.3899	0.4296	0.1337	0.8404
PERC1* CULT					0.6877	0.5738			0.0491	0.9281		
PERC1* AGE												
PERC1* REV												
PERC1* STAFF												
McFadden R-squared		0.4583		0.4102		0.6226		0.6172		0.4314		0.6050
Akaike Info Citerion		1.0646		0.9316		0.8728		0.7711		1.0150		0.7853
Predicted Probabilities (%)		82.43		81.08		89.19		87.84		82.43		89.19
LR statistic (df)		39.58		35.43		53.77		53.30		37.25		52.25
p-value		0.0005		0.0000		0.0000		0.0000		0.0002		0.0000

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

Table 6A3: Results of Multinominal Logistic Regressions for *Product* Innovation using *monitor* Measure of Perceived Technological change (PERC).

Variable	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)
Intercept	-2.9661	0.3772	-2.4600	0.2862	-4.5492	0.6338	0.4096	0.8979	0.3844	0.9029	-8.9907	0.2814
PERC2	-0.1833	0.6907	-0.2065	0.5791	0.5130	0.8330	-0.9793	0.1498	-0.9667	0.1491	1.6160	0.4381
ED1	-0.0137	0.9644										
ED2	0.0321	0.0803*	0.0327	0.0265**	-0.0105	0.8595	0.0058	0.8978	-0.0025	0.9569	0.0336	0.0280**
ED3	0.0076	0.7437										
ED4	-0.0197	0.4009	-0.0210	0.2482	0.0352	0.7234	-0.0268	0.1748			-0.0284	0.1307
ED5	-0.0151	0.6880							0.0025	0.9775		
TRAIN	0.0000	0.9355										
COL	0.3504	0.0351**	0.3763	0.0082***	-0.1212	0.8387	-0.2629	0.6255	-0.2448	0.6504	0.4008	0.0066***
EXPER	0.2611	0.5975	0.2393	0.6008	-0.2684	0.9072	0.1101	0.8323	0.1036	0.8406	0.2702	0.9007
MOTV	0.6182	0.1515	0.6650	0.0948*	3.1811	0.0861*	0.6887	0.0859*	0.6887	0.0867*	3.4180	0.0575*
MAG	0.1318	0.6898										
CULT	0.0906	0.7599										
AGE	-0.0171	0.4078										
REV	-0.6253	0.4157										
STAFF	0.0107	0.5279										
PERC2* ED1												
PERC2* ED2					0.0120	0.4108	0.0090	0.4334	0.0110	0.3643		
PERC2 * ED3												
PERC2 * ED4					-0.0157	0.4953			-0.0071	0.7332		
PERC2 * ED5												
PERC2* TRAIN												
PERC2* COL					0.1441	0.3513	0.1816	0.2033	0.1779	0.2126		
PERC2* EXPER					0.0892	0.8749					-0.0217	0.9672
PERC2* MOTV					-0.6915	0.1602					-0.7430	0.1086
PERC2* MAG												
PERC2* CULT												
PERC2* AGE												
PERC2* REV												
PERC2* STAFF												
McFadden R-squared		0.2813		0.2539		0.3153		0.2838		0.2854		0.2955
Akaike Info Citerion		1.1571		0.9415		1.0147		0.9654		0.9908		0.9536
Predicted Probabilities (%)		83.78		83.78		86.49		86.49		86.49		83.78
LR statistic (df)		20.98		18.94		23.52		21.17		21.29		22.05
p-value		0.1373		0.0043		0.0149		0.0067		0.0114		0.0048

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

Table 6A4: Results of Multinominal Logistic Regressions for *Process* Innovation using *monitor competitors* Measure of Perceived Technological change (PERC).

Variable	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)
Intercept	-9.1031	0.0354**	-8.7678	0.0059***	2.1960	0.9595	-4.3116	0.5371	-18.3415	0.3361	-22.6441	0.2810
PERC2	0.6840	0.1574	0.4578	0.2142	-3.2322	0.7548	-1.5899	0.2926	3.0506	0.4768	2.5777	0.5762
ED1	-0.6478	0.0618*	-0.5283	0.0716*	-7.4005	0.0089***	-7.0724	0.0094***	-0.5586	0.0796*	-7.0389	0.0080***
ED2	0.0399	0.0351**	0.0209	0.0614*	0.2477	0.0924*	0.2532	0.0931*	0.0333	0.0257**	0.2353	0.1041
ED3	0.0012	0.9532										
ED4	-0.0281	0.1232			-0.4670	0.1608	-0.3684	0.1157	-0.0263	0.1194	-0.3574	0.1137
ED5	0.0164	0.5737										
TRAIN	0.0000	0.0139**	0.0000	0.0234**	0.0001	0.4869	0.0002	0.2680	0.0000	0.0360**	0.0001	0.0130**
COL	-0.0326	0.8627										
EXPER	-1.0237	0.0930*			-2.8232	0.6301	-0.9208	0.1431	1.3660	0.6139	-0.8260	0.2174
MOTV	0.4566	0.3184										
MAG	0.9297	0.0219**	0.6397	0.0374**	-0.3039	0.9484	1.2933	0.0132**	1.0834	0.5469	1.3745	0.0103**
CULT	0.5148	0.1544	0.5391	0.0673*	2.9210	0.4523	0.8287	0.0638*	0.6676	0.6521	3.8442	0.1971
AGE	0.0039	0.8404										
REV	0.5866	0.5343										
STAFF	-0.0257	0.2536										
PERC2* ED1					1.6520	0.0117**	1.5808	0.0126**			1.5659	0.0100**
PERC2* ED2					-0.0484	0.1452	-0.0503	0.1432			-0.0458	0.1591
PERC2 * ED3												
PERC2 * ED4					0.1062	0.1850	0.0819	0.1308			0.0785	0.1276
PERC2 * ED5												
PERC2* TRAIN					0.0000	0.6916	0.0000	0.4147				
PERC2* COL												
PERC2* EXPER					0.4550	0.7342			-0.5216	0.4100		
PERC2* MOTV												
PERC2* MAG					0.4072	0.7263			-0.0777	0.8477	-0.7228	0.2958
PERC2* CULT					-0.51275	0.5816			0.0024	0.9947		
PERC2* AGE												
PERC2* REV												
PERC2* STAFF												
McFadden R-squared		0.3869		0.2987		0.5322		0.5268		0.3664		0.5234
Akaike Info Citerion		1.1480		1.0077		0.9784		0.9036		1.0637		0.9076
Predicted Probabilities (%)		81.08		78.38		86.49		77.03		87.84		87.84
LR statistic (df)		33.41		25.79		45.96		45.49		31.65		45.20
p-value		0.0041		0.0002		0.0001		0.0000		0.0009		0.0000

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

Table 6A5: Results of Multinominal Logistic Regressions for *Product* Innovation using *Perceived* Index Measure for Technological change (PERC) while changing Culture Index.

Variable	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	Coefficient	**Pr (> z)**	**Coefficient**	**Pr (> z)**	**Coefficient**	**Pr (> z)**	**Coefficient**	**Pr (> z)**	**Coefficient**	**Pr (> z)**	**Coefficient**	**Pr (> z)**
Intercept	-3.8313	0.2764	-2.8774	0.2167	-11.6119	0.4216	-13.7373	0.1641	-0.9420	0.7981	-11.8588	0.3737
PERC	0.1851	0.5178	0.1661	0.5362	1.3932	0.4978	1.7003	0.2316	-0.1687	0.7362	1.4493	0.4339
ED1	0.0112	0.9712			-0.0063	0.9394						
ED2	0.0302	0.0936*	0.0319	0.0323**	-0.0766	0.6052	-0.0197	0.7815	-0.0126	0.8434	0.0302	0.0432**
ED3	0.0021	0.9292			0.4290	0.6673						
ED4	-0.0239	0.2973	-0.0290	0.1231	6.0318	0.1023	-0.0259	0.1548	-0.0499	0.6965	-0.0276	0.1282
ED5	-0.0139	0.7032			-0.4569	0.8040						
TRAIN	0.0000	0.8661			-0.0224	0.2285						
COL	0.3071	0.0445**	0.3343	0.0151**			0.3494	0.0181**	0.1132	0.8881	0.3137	0.0247**
EXPER	0.3056	0.5333										
MOTV	0.5774	0.1715	0.6196	0.1169			5.6010	0.1142	0.6506	0.1104	6.4965	0.0979*
MAG	0.1138	0.7284										
CULT1	-0.0027	0.9922	0.0283	0.9088			0.0012	0.9964	0.0764	0.7668	-0.7961	0.6490
AGE	-0.0231	0.2588	-0.0203	0.2400			-0.0238	0.1985	-0.0213	0.2225	-0.0222	0.2277
REV	-0.6694	0.3897										
STAFF	0.0132	0.4631										
PERC * ED1												
PERC * ED2					0.0048	0.6556	0.0064	0.4950	0.0063	0.4676		
PERC * ED3												
PERC * ED4					0.0067	0.7320			0.0026	0.8784		
PERC * ED5												
PERC * TRAIN												
PERC * COL					-0.0123	0.9232			0.0324	0.7580		
PERC * EXPER												
PERC * MOTV					-0.7425	0.1368	-0.6804	0.1558			-0.8029	0.1289
PERC * MAG												
PERC * CULT					0.0646	0.7982					0.1073	0.6492
PERC * AGE												
PERC * REV												
PERC * STAFF												
McFadden R-squared		0.2846		0.2660		0.3240		0.3204		0.2770		0.3173
Akaike Info Citerion		1.1538		0.9563		1.0330		0.9554		1.0262		0.9586
Predicted Probabilities (%)		85.14		85.14		87.84		87.84		86.49		87.84
LR statistic (df)		21.23		19.85		24.17		23.91		20.67		23.67
p-value		0.1296		0.0059		0.0193		0.0044		0.0235		0.0048

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

Table 6A6: Results of Multinominal Logistic Regressions for *Process* Innovation using *Perceived* Index Measure for Technological change (PERC) while changing Culture Index

Variable	**Model 1**		**Model 2**		**Model 3**		**Model 4**		**Model 5**		**Model 6**	
	Coefficient	**Pr (> z)**	**Coefficient**	**Pr (> z)**	**Coefficient**	**Pr (> z)**	**Coefficient**	**Pr (> z)**	**Coefficient**	**Pr (> z)**	**Coefficient**	**Pr (> z)**
Intercept	-16.3143	0.0079***	-15.6084	0.0054***	-113.7669	0.2099	-107.1182	0.1058	4.0147	0.7448	-62.4388	0.0374**
PERC	1.1798	0.0085***	1.1290	0.0085***	11.1374	0.3340	11.7244	0.1582	-3.4001	0.0765*	6.3963	0.0718*
ED1	-0.8451	0.0440**	-0.7922	0.0412**	-19.9567	0.0879*	-12.5563	0.0283**	-12.9553	0.0400**	-1.1055	0.0271**
ED2	0.0587	0.0152**	0.0529	0.0094***	0.6746	0.1742	0.0654	0.0364**	0.2458	0.2893	0.0703	0.0078***
ED3	-0.0074	0.7414					-0.8543	0.1543				
ED4	-0.0384	0.0559*	-0.0358	0.0536*	-2.9921	0.0919*			-1.3823	0.0841*	-0.0575	0.0311**
ED5	0.0097	0.7395										
TRAIN	0.0001	0.0046***	0.0001	0.0041***	0.0003	0.4692	0.0001	0.0092***	0.0001	0.0072***	0.0001	0.0020***
COL	-0.0826	0.6842										
EXPER	-1.6656	0.0323**	-1.6176	0.0297**	7.0700	0.5712	-1.7177	0.0855*	-1.5670	0.1101	-0.8918	0.8592
MOTV	0.6311	0.2241	0.6180	0.2262	1.1804	0.2109	1.0344	0.1409	0.8056	0.2270	0.9406	0.1114
MAG	1.1734	0.0123**	1.0716	0.0098***	24.7274	0.0734*	20.0265	0.0744*	2.0480	0.0042***	11.5746	0.0096***
CULT1	0.6764	0.1196	0.6772	0.0983*	-7.4478	0.1545	1.8145	0.0283**	1.7634	0.0440**	-2.4708	0.3589
AGE	0.0089	0.6631										
REV	1.2788	0.2396	1.2553	0.2345	1.8287	0.4775			1.2063	0.4813	1.1137	0.3513
STAFF	-0.0535	0.0675*	-0.0486	0.0754*	-0.0668	0.2271	-0.0446	0.0416	-0.0421	0.2118	-0.0606	0.0589*
PERC * ED1					2.3928	0.1096	1.4891	0.0378**	1.5670	0.0501*		
PERC * ED2					-0.0769	0.2215			-0.0242	0.4046		
PERC * ED3												
PERC * ED4					0.3966	0.0968*	0.1081	0.1812	0.1813	0.0913*		
PERC * ED5												
PERC * TRAIN					0.0000	0.7036						
PERC * COL												
PERC * EXPER					-1.2574	0.4603					-0.0919	0.8826
PERC * MOTV												
PERC * MAG					-2.9445	0.0931*	-2.4126	0.0941*			-1.3579	0.0159**
PERC * CULT					1.3711	0.1032					0.5150	0.1677
PERC * AGE												
PERC * REV												
PERC * STAFF												
McFadden R-squared		0.4791		0.4738		0.7432		0.6889		0.6687		0.5715
Akaike Info Citerion		1.0404		0.9385		0.8132		0.7414		0.7920		0.9054
Predicted Probabilities (%)		86.49		85.14		93.94		93.24		93.24		86.49
LR statistic (df)		41.37		40.92		64.18		59.50		57.75		49.36
p-value		0.0003		0.0000		0.0000		0.0000		0.0000		0.0000

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

Table 6A7: Results of Multinominal Logistic Regressions for *Product* Innovation using *Perceived* Index Measure for Technological change (PERC) while changing Collaboration Index.

Variable	Model 1		Model 2		Model 3		Model 4		Model 5		Model 5	
	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)
Intercept	-3.8110	0.2777	-2.4749	0.2044	-16.6825	0.1358	-16.2587	0.1085	-0.6369	0.8618	-17.3499	0.0920*
PERC	0.2391	0.3767	0.2428	0.3231	2.1985	0.1481	2.1450	0.1198	-0.0174	0.9721	2.2864	0.1027
ED1	0.0702	0.8203										
ED2	0.0315	0.0982*	0.0321	0.0282**	0.0157	0.8589	0.0306	0.0401**	0.0098	0.8810	0.0287	0.0477
ED3	-0.0022	0.9272										
ED4	-0.0281	0.2187	-0.0304	0.0924*	-0.1078	0.4391	-0.1128	0.3628	-0.0662	0.5967	-0.0274	0.1130
ED5	-0.0035	0.9282										
TRAIN	0.0000	0.7836										
COL1	0.0951	0.3948	0.1324	0.1808	0.2750	0.6898	0.1401	0.1602	-0.0482	0.9373	0.1450	0.1472
EXPER	0.3824	0.4294										
MOTV	0.5126	0.2015	0.5571	0.1288	6.4289	0.0797*	6.3501	0.0779*	0.5571	0.1363	6.3902	0.0827*
MAG	0.1482	0.6406										
CULT	0.0004	0.9986										
AGE	-0.0279	0.1562	-0.0233	0.1597	-0.0255	0.1562	-0.0261	0.1383	-0.0239	0.1587	-0.0273	0.1231
REV	-0.8967	0.2926										
STAFF	0.0187	0.3747										
PERC * ED1												
PERC * ED2					0.0018	0.8725			0.0033	0.7051		
PERC * ED3												
PERC * ED4					0.0108	0.5539	0.0113	0.4896	0.0046	0.7845		
PERC * ED5												
PERC * TRAIN												
PERC * COL					-0.0169	0.8493			0.0248	0.7581		
PERC * EXPER							-0.7951	0.1017				
PERC * MOTV					-0.8053	0.1036					-0.7941	0.1095
PERC * MAG												
PERC * CULT												
PERC * AGE												
PERC * REV												
PERC * STAFF												
McFadden R-squared		0.2367		0.2062		0.2723		0.2714		0.2131		0.2645
Akaike Info Citerion		1.2020		0.9896		1.0310		0.9779		1.0636		0.9578
Predicted Probabilities (%)		83.78		81.08		86.49		86.49		83.78		85.14
LR statistic (df)		17.66		15.38		20.31		20.2489		15.90		19.73
p-value		0.2809		0.0175		0.0264		0.0094		0.0689		0.0062

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

Table 6A8: Results of Multinominal Logistic Regressions for *Process* Innovation using *Perceived* Index Measure for Technological change (PERC) while changing Collaboration Index

Variable	Model 1		Model 2		Model 3		Model 4		Model 4		Model 6	
	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)
Intercept	-16.0678	0.0087***	-11.8428	0.0068***	-88.8219	0.2331	-1.4211	0.9409	-43.2196	0.0765*	-41.8733	0.0653*
PERC	1.1596	0.0083***	0.9519	0.0083***	7.8336	0.3830	-2.1054	0.4011	4.4469	0.1374	4.2808	0.1235
ED1	-0.8113	0.0539*	-0.6550	0.0743*	-20.1450	0.0908*	-11.4116	0.0583*	-0.7915	0.0729*	-0.7994	0.0664*
ED2	0.0605	0.0124**	0.0448	0.0104**	0.6624	0.1827	0.3180	0.1808	0.0580	0.0125**	0.0582	0.0119
ED3	-0.0085	0.7052										
ED4	-0.0397	0.0521*	-0.0368	0.0387**	-3.2364	0.0779*	-1.2142	0.0674*	-0.0585	0.0144**	-0.0582	0.0145**
ED5	0.0107	0.7137										
TRAIN	0.0001	0.0044***	0.0001	0.0067***	0.0002	0.0212**	0.0002	0.5042	0.0001	0.0040***	0.0001	0.0036***
COL1	-0.0901	0.5492	-0.0700	0.6123	-0.3601	0.3081	-0.1845	0.5258	-0.1412	0.3815	-0.1354	0.3908
EXPER	-1.6013	0.0348**	-1.2017	0.0449**	-2.9482	0.1151	-1.2365	0.1355	-0.4948	0.9077	-1.1703	0.0877*
MOTV	0.6753	0.1914										
MAG	1.2011	0.0091***	0.9753	0.0116**	27.8166	0.0865*	1.9664	0.0088	8.7672	0.0165**	8.8461	0.0146**
CULT	0.5859	0.1765	0.6034	0.0999*	-7.4666	0.0647*	1.4897	0.0418**	-2.2577	0.3112	-2.1433	0.3099
AGE	0.0099	0.6362										
REV	1.2517	0.2439										
STAFF	-0.0537	0.0702*	-0.0250	0.1578	-0.0701	0.0632*	-0.0229	0.2705	-0.0382	0.0553*	-0.0380	0.0518*
PERC * ED1					2.4837	0.1038	1.4001	0.0687*				
PERC * ED2					-0.0730	0.2357	-0.0337	0.2496				
PERC * ED3												
PERC * ED4					0.4216	0.0821*	0.1567	0.0774*				
PERC * ED5												
PERC * TRAIN							0.0000	0.7475				
PERC * COL												
PERC * EXPER									-0.0859	0.8728		
PERC * MOTV												
PERC * MAG					-3.2573	0.1054			-1.0015	0.0300**	-1.0125	0.0262**
PERC * CULT					1.4460	0.0449			0.4490	0.1556	0.4341	0.1508
PERC * AGE												
PERC * REV												
PERC * STAFF												
McFadden R-squared		0.4718		0.4414		0.6301		0.6301		0.5186		0.5183
Akaike Info Citerion		1.0489		0.9492		0.8371		0.8371		0.9402		0.9135
Predicted Probabilities (%)		86.49		81.08		89.19		89.19		86.49		86.49
LR statistic (df)		40.75		38.12		54.42		54.42		44.79		44.76
p-value		0.0004		0.0000		0.0000		0.0000		0.0000		0.0000

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

Table 6A9: Results of Multinominal Logistic Regressions for *Process* Innovation using *Perceived* Index Measure for Technological change (PERC) while changing Collaboration and Culture Index

Variable	Model 1		Model 2		Model 3		Model 4		Model 5		Model 5	
	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)	Coefficient	Pr (> z)
Intercept	-16.2560	0.0081***	-12.0877	0.0067***	-255.6865	0.2217	-65.5012	0.2157	-7.2344	0.7214	-56.9926	0.0435**
PERC	1.1752	0.0083***	0.9690	0.0076***	28.2808	0.2688	6.6318	0.3389	-1.7275	0.4805	6.1165	0.0683*
ED1	-0.8021	0.0586*	-0.6307	0.0880*	-27.1610	0.1377	-10.5433	0.0532*	-10.7765	0.0591*	-0.8234	0.0694*
ED2	0.0588	0.0144**	0.0437	0.0119**	1.8945	0.1622	0.0554	0.0427**	0.2990	0.2094	0.0585	0.0127**
ED3	-0.0074	0.7419										
ED4	-0.0394	0.0556*	-0.0368	0.0406**	-6.6461	0.1409	-0.9271	0.0987*	-1.3790	0.0561**	-0.0619	0.0122***
ED5	0.0098	0.7371										
TRAIN	0.0001	0.0045***	0.0001	0.0069***	0.0011	0.1618	0.0001	0.0108**	0.0002	0.3725	0.0001	0.0032***
COL1	-0.0717	0.6385	-0.0588	0.6706	-0.9226	0.2070	-0.0323	0.8861	-0.2405	0.4321	-0.1338	0.4135
EXPER	-1.6784	0.0319**	-1.2806	0.0387**	23.3029	0.2932	-1.5574	0.0855*	-1.2565	0.1633	-0.9140	0.8393
MOTV	0.6351	0.2244										
MAG	1.1736	0.0117**	0.9509	0.0154***	44.2006	0.1489	12.8739	0.1503	2.1063	0.0100**	10.6792	0.0097***
CULT1	0.6670	0.1290	0.6846	0.0707*	-18.4509	0.1553	1.7791	0.0205**	1.8757	0.0300**	-1.8982	0.5300
AGE	0.0098	0.6345										
REV	1.3093	0.2283										
STAFF	-0.0546	0.0649*	-0.0252	0.1605	-0.0640	0.1698	-0.0402	0.0716*	-0.0274	0.2033	-0.0430	0.0369**
PERC * ED1					3.2662	0.1531	1.2563	0.0665*	1.3231	0.0693*		
PERC * ED2					-0.2270	0.1741			-0.0311	0.2866		
PERC * ED3									0.1788	0.0639*		
PERC * ED4					0.8798	0.1428	0.1180	0.1204	0.0000	0.5799		
PERC * ED5												
PERC * TRAIN					-0.0001	0.2068						
PERC * COL												
PERC * EXPER					-3.6125	0.2653					-0.0677	0.9033
PERC * MOTV					-5.2218	0.1608						
PERC * MAG					3.0831	0.1409	-1.4893	0.2069			-1.2470	0.0162**
PERC * CULT											0.4431	0.2680
PERC * AGE												
PERC * REV												
PERC * STAFF												
McFadden R-squared		0.4797		0.4517		0.7652		0.6585		0.6578		0.5467
Akaike Info Citerion		1.0396		0.9372		0.7065		0.7769		0.8048		0.9075
Predicted Probabilities (%)		86.49		83.78		94.59		91.89		90.54		87.84
LR statistic (df)		41.43		39.01		66.08		56.87		56.81		47.21
p-value		0.0003		0.0000		0.0000		0.0000		0.0000		0.0000

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.