Operationalising Ambidexterity through Better Management Practices: The Case of High-Variety, Low-Volume Manufacturing

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A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

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Australia

2020

Certificate of Original Authorship

I declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the Faculty of Engineering and IT at the University of Technology Sydney. This thesis is wholly my own work unless otherwise reference or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis. This document has not been submitted for qualifications at any other academic institution. This research is supported by the Australian Government Research Training Program.

Signature: Production Note: Signature removed prior to publication.

Date: 23rd January 2020

Acknowledgements

First and foremost, I would like to thank my principle supervisor Assoc. Prof. Dilek Cetindamar Kozanoglu who's boundless guidance and endless support was not only instrumental to the completion of this thesis, but also to my development as a researcher. This thesis would not have been possible without her encouragement, suggestions and support.

I would also like to express my deepest gratitude to Assoc. Prof. Renu Agarwal who's been my co-supervisor, mentor and friend. Her belief in me and the opportunities that stemmed from that belief helped make me who I am today.

I am also indebted to the constant support from my colleagues and friends at the School of Information, Systems and Modelling at the University of Technology Sydney. In particular, I would like to thank Mr. Ravindra Bagia and Dr. Nathalie Sick for their continual encouragement and guidance throughout this journey.

To my family and friends that have had to endure the four tumultuous years, just as much as I have. Without your inspiration, kindness and constant support, this project would not have been possible. In particular, I would like to thank my parents, Mr. Mile Katic and Mrs. Stoja Katic, as well as my sister Tanja, for fuelling my motivation to succeed and for standing by me at every step of the way.

Lastly, I would like to extend many thanks to Dr. Hasan Akpolat for opening the opportunity for me to undertake this research project in the first place. His continuous support throughout this journey cannot be understated.

Mile Katic

January 2020

Abstract

Despite increased research interest concerning organisational ambidexterity - the ability to increase operational efficiency and simultaneously leverage assets for change and innovation – the question of how this is actually operationalised in organisations remains elusive. This thesis aims to address this gap based on the context of small to medium sized manufacturers that produce a high variety of customised products at low volumes (HVLV). For these HVLV manufacturers, ambidexterity appears in all parts of their daily operations. However, the reality seems far more challenging as the flexibility so ingrained in their organisational design can actually be to their detriment.

Taking on the routines-based view of organisation, this thesis aims to uncover the mechanisms that enable ambidextrous capabilities to impact organisational performance in HVLV manufacturers. In particular, this thesis is concerned with the role better management practices (BMP), in the form of production planning and control (PPC) and human resource management (HRM), play in facilitating the deployment of ambidextrous capabilities towards organisational performance outcomes.

A literature review and theory building exercise led to the development of a conceptual model grounded on the hypothesised links between ambidextrous capabilities, BMP and HVLV manufacturer performance. An Australia-wide survey of HVLV manufacturers was subsequently undertaken and the results analysed through the use of partial least squares structural equation modelling.

The outcomes of this research reveal that both PPC and HRM mediate the relationship between ambidextrous capabilities and HVLV manufacturer performance by way of operational flexibility and process innovation. Though providing evidence that BMP form the conduit from which ambidextrous capabilities incur performance outcomes, their impacts prove varied. PPC, whilst effective in facilitating operational flexibility, does not have an impact on process innovation and HRM, whilst useful in inducing process innovation, does not appear to have an impact on operational flexibility.

This thesis adds to the growing body of literature on ambidexterity where BMP are uncovered as a missing link between ambidextrous capabilities and organisational performance outcomes. In addressing the HVLV manufacturing dilemma, this research reveals that merely holding ambidextrous capabilities is not enough. In order to capitalise on these capabilities, HVLV manufacturers need to make effective use of management practices that actually help to get work done in the first place. This thesis ends with a discussion on theoretical and empirical implications as well as suggestions for further research.

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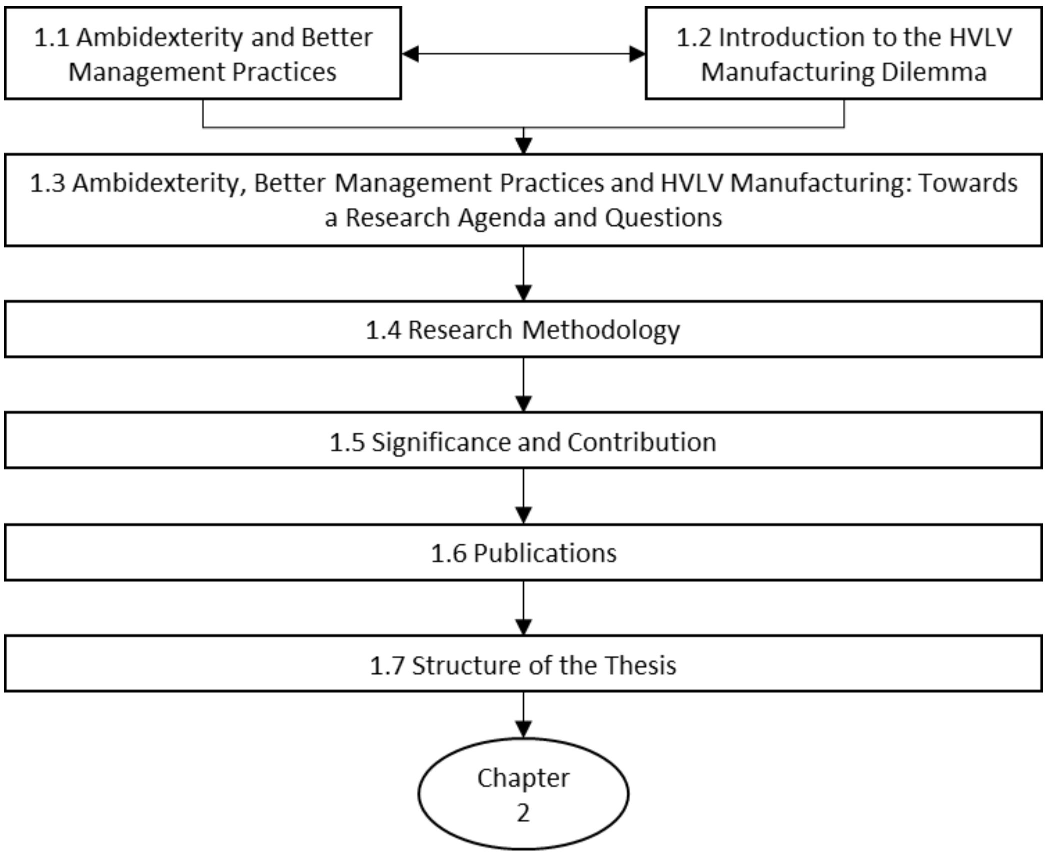
Chapter 1 Introduction

This chapter sets the scene for the research undertaken in this thesis. It begins by outlining the topic being investigated in two parts. Firstly, to establish the research paradigm in organisational ambidexterity and better management practices, and secondly to articulate the HVLV manufacturing dilemma as the context in which this thesis is grounded. A consolidation of the themes investigated in this thesis is also provided, which lends itself toward a cohesive research question and research agenda. The significance and contributions of this research effort are then set forth and an overview of the publications associated with this thesis and the chapters in which portions of the publications appear is provided. This chapter ends with an overview of the thesis structure. An outline of this chapter is shown in Figure 1-1.

Figure 1-1 Outline of Chapter 1



1.1 Ambidexterity and Better Management Practices

Organisations today are facing increasingly volatile and uncertain times. Those fortunate enough to succeed through the ages have managed to make sense of their surroundings, recognise opportunities for growth and at the same time make critical capability and asset decisions that may well jeopardise everything they have worked so hard to build (O'Reilly III & Tushman 2016) – if only to exist for another few years. This innate ability to exploit existing assets and capabilities whilst simultaneously exploring new opportunities has since become a corner stone of organisational competitive advantage (Eisenhardt, Furr & Bingham 2010). However, this so-called organisational ambidexterity is also notoriously challenging to achieve, let alone leverage towards better organisational outcomes.

Traditional thinking in ambidexterity literature would suggest two over-arching methodologies in achieving this elusive capability in 1) separating out exploration and exploitation in both time and space; or 2) building an organisational context to support it (Gibson & Birkinshaw 2004; O'Reilly & Tushman 2008). Literature has since moved beyond this into understanding the mechanisms that lie beneath the surface in the activities that members of an organisation actually do to make it ambidextrous in the first place (Andriopoulos et al. 2018). Here, we are introduced to the notion of ambidexterity as a dynamic capability (O'Reilly & Tushman 2008) – helping organisations to sense new opportunities, seize them in the hopes of creating value and transform their resource base and asset positions when markets become less favourable (Birkinshaw, Zimmermann & Raisch 2016). Ambidexterity, then, helps organisations adapt to changing circumstances and ensure their continual survival. However, despite its importance to the well-being of organisations and only increasing research attention, we still have a long way to go before making sense of the inner workings of such a capability (Wilden et al. 2018).

This thesis takes on the challenge of understanding how organisations operationalise ambidexterity. In adopting a routines-based lens, this research extends existing theory in dynamic capabilities and ambidexterity by demonstrating that holding ambidextrous capabilities alone is not enough. In order for organisations to capitalise on these capabilities, so as to leverage the contradictions between exploitation and exploration towards better performance outcomes, they also need to make effective use of management practices (or routines) that actually help to get work done in the first place.

This research adopts the notion of better management practices (BMP) as routinised patterns of behaviour (Schatzki 2012) that can offer some helpful insights in this space. Emerging evidence from mass-scale survey research has proven the existence of so-called structured management practices that appear "better" than others in achieving greater organisational performance outcomes in both productivity (Bloom et al. 2017; Bloom & Van Reenen 2006) and innovation (Agarwal, Brown, et al. 2014) that also sustain over time (Bloom et al. 2018).

Though presenting itself as an appealing avenue for investigating the nature of ambidextrous capability deployment, BMP only make sense in context (Jarzabkowski et al. 2016b), and to avoid oversimplification from universalistic assumptions, this research will place focus on an organisational context known as high-variety, low-volume (HVLV) manufacturing.

1.2 Introduction to the HVLV Manufacturing Context

HVLV manufacturers present themselves as highly flexible small to medium sized manufacturing enterprises (SMEs) that specialise in making a high variety of customised products at low volumes. Their manufacturing strategy is designed to facilitate maximum adaptation as they give their customers the ultimate power to dictate what products get produced, when and even at what cost (Fox et al. 2009). Hence, agility, flexibility and problem solving are all key terms analogous to HVLV manufacturing (Katic & Agarwal 2018). They are also often considered the problem solvers of the manufacturing world, making anything and everything they have the capability and know-how to do (Konijnendijk 1994). To the subjective observer, HVLV manufacturers would then present themselves as inherently ambidextrous organisations – indeed they have to be if exploring solutions and exploiting opportunities is their business. The reality is, however, a different story.

HVLV manufacturers are characterised by high environmental uncertainty (from the demand side) and high internal uncertainty (from the type of products produced). The degree of customisation can vary considerably between products as well – ranging from standard products, to pure customisation where the customer order infiltrates the entire manufacturing value-chain (Hendry 2010). What's more, this is happening at the same time and using the same resources and equipment (Kingsman et al. 1993). Significant efforts in managing various functions (including marketing, engineering and production) and sub-functions is required in order to successfully undertake this manufacturing strategy (Aslan, Stevenson & Hendry 2012). The result is often poor organisational performance, where overruns in cost and lead-time budgets are commonplace (Land & Gaalman 2009).

Literature on the subject would then focus much attention on being able to economise the production process towards more predictable and efficient operations (Katic & Agarwal 2018). To an extent, this is necessary in ensuring some level of capability in meeting due-date and cost goals (Land & Gaalman 2009). Holding exploitative capabilities such as these is certainly helpful in increasing customer satisfaction levels (Zhang, Chen & Ma 2007), profitability (Silva, Stevenson & Thurer 2015) and competitive advantage (Amaro, Hendry & Kingsman 1999), but too much emphasis on this can cause an organisation to stagnate in the face of change by creating an inertia which is significantly difficult to break (March 1991). In this instance, the manufacturer also needs to be able to explore new opportunities for growth, leveraging their existing capabilities towards the creation of new products, processes and capabilities, thus ensuring the manufacturer does not becomes obsolete in the face of change. This means embracing variation in customisation, breaking the mould with existing business practices and developing new and innovative ways of capturing and delivering value for their customers. However, the ability to create something new is also nested on the organisational practices and routines that enable the manufacturer to compete in the first place (Andriopoulos & Lewis 2009). Thus, an apparent trade-off ensues.

In order to simultaneously undertake exploration and exploitation, the HVLV manufacturer must commit resources between the two activities (Gupta, Smith & Shalley 2006). Given their stature as SMEs, as well as perceiving themselves as manufacturing service providers (Konijnendijk 1994), making resource allocation decisions are increasingly difficult as, in some instances, they are selling their own capabilities and resources. In addition, despite being flexible organisations, they still tend to err on the side of efficiency and short-term gains. Thus, justifying expenses for longer-term endeavours that may or may not eventuate proves problematic.

This was also observed to be the case in similar organisational contexts (project-based organisations) where they tend to place more focus on the adoption of efficiency enhancing mechanisms and only commit resources to exploratory means when it becomes absolutely essential (Keegan & Turner 2002). Divulging an ad-hoc approach to organisational slack like this will often place the manufacturer at risk because by the time they realise they have to change, it is too late to balance the contradictory demands of exploration and exploitation. In this case, the flexibility so ingrained in the essence of HVLV manufacturing operations is the same flexibility that is stopping them from achieving ambidexterity. Something has to give.

1.3 Ambidexterity, Better Management Practices and HVLV Manufacturing – Towards a Research Agenda

The problem domain targeted in this thesis is the lack of understanding in how organisations operationalise ambidexterity. Through taking the routines-based view, we narrow our focus on a specific subset of management routines known as better management practices and apply them to an organisational context known as HVLV manufacturing. Given the gap in research in 1) the operationalisation of ambidexterity, 2) the role of routines in translating ambidextrous capabilities to organisational outcomes and 3) the HVLV manufacturing dilemma in leveraging their flexibility towards ambidextrous outcomes, we formulate the following overarching research question:

How do better management practices (as routinised patterns of behaviour) impact the operationalisation of ambidexterity in HVLV manufacturing?

In order to investigate this question, we also derived three research objectives:

1. Investigate the impact of ambidextrous capabilities on the adoption of better management practices;
2. Investigate the impact of better management practice adoption on HVLV manufacturer performance outcomes; and
3. Investigate the combined impact of ambidextrous capabilities and better management practice adoption on HVLV manufacturer performance outcomes.

1.4 Research Methodology

This thesis presumes the hypothetico-deductive method of scientific enquiry (Sekaran & Bougie 2013) in uncovering the role of BMP in the relationship between ambidexterity and HVLV manufacturer performance. To this end, a conceptual model is developed based on an extended routines-based view of organisation and coupled with the complementary literature on BMP, ambidexterity and HVLV manufacturing. This model subsequently guides the dissemination of research hypotheses. A cross-sectional questionnaire was then developed for the purpose of data collection and sent to key decision makers in HVLV manufacturing organisations operating within Australia. Hypothesis testing was ultimately conducted using partial least squares (PLS) structural equation modelling (SEM) through SmartPLS 3 software (Ringle, Wende & Becker 2015).

1.5 Significance and Contributions

The context within which this thesis is centred is amongst the most volatile in the world. The Australian manufacturing industry typically experiences an average output that is 20% above trend during economic upswings, though also experiences 20% below trend in average output during downturns[1] (AMGC, 2018). Combine this with increasingly competitive global markets, the demand for highly customised products and the high-

[1] To put this into perspective, the UK experiences fluctuations around the 14% mark and Germany at approximately 8% (AMGC, 2018).

cost economy, there is also little surprise in finding that this equates to significantly heightened firm mortality rates.

Indeed, this does not necessarily affect Australia alone. The need to achieve ambidexterity has come centre stage globally as all organisations are starting to feel the pressures of competing in a world characterised as volatile, uncertain, complex and ambiguous (Schoemaker, Heaton & Teece 2018). For smaller HVLV manufacturers, this would mean less reliance on economies of scale through repeat business as markets become more fragmented and demanding. As important as giving their customers what they want and when they want it once was, nowadays as industry trends in information and communication technology start taking hold, they will also have to start supplying their customised solutions at a cost more resembling that of a standard product. To be clear, this is moving beyond mass-customisation as this is only a middle-ground and is actually laying waste to the unique production capabilities HVLV manufacturers hold (Hendry 2010). The challenges equate to everything from design to specification and production – the entire manufacturing value chain is affected.

This thesis also provides the following broad contributions to knowledge in both ambidexterity and HVLV manufacturing literature:

1. By extending our understanding of how ambidexterity is operationalised through routines, in that this research demonstrates the explanatory power of specific BMP in capability deployment. In addition, BMP as both *explanans* and *explananda* are brought forth as the missing link between ambidextrous capabilities and organisational performance.
2. By extending HVLV manufacturing literature through explicating the dual purpose of BMP in unlocking the potential of HVLV manufacturing capabilities without compromising their core capabilities in flexibility and customisation.

With regards to managerial contributions, this thesis offers the following:

1. A research framework which highlights the inherent tensions and contradictions that need to be leveraged, synthesised and expressed through routine adoption of BMP. Helping managers build a credible foundation for translating the ambidextrous capabilities they already have, into observable performance outcomes.
2. Highlight the significant implications (both positive and negative) of two often taken for granted BMP (human resource management and production planning and control) and work towards strategies that enable better translation of ambidextrous capabilities.

1.6 Publications

Portions of this thesis were presented at various conferences and subsequently published in a Journal article. Reference to each chapter are shown in Table 1-1.

Table 1-1 List of Publications and Corresponding Chapters

Chapter	Reference to Publication
1	• Katic, M. & Agarwal, R. 2018, 'The Flexibility Paradox: Achieving Ambidexterity in High-Variety, Low-Volume Manufacturing', Global Journal of Flexible Systems Management, vol. 19, no. 1, pp. 69-86
2	• Katic, M. & Agarwal, R. 2018, 'The Flexibility Paradox: Achieving Ambidexterity in High-Variety, Low-Volume Manufacturing', Global Journal of Flexible Systems Management, vol. 19, no. 1, pp. 69-86 • Katic, M., Agarwal, R. and Al-Kilidar, H. 2017, 'Exploring the effect of customisation on management practices in High-Variety, Low-Volume Manufacturing', paper presented to the 24th EurOMA Conference, Edinburgh, Scotland.

Table 1-1 List of Publications and Corresponding Chapters (Continued)

Chapter	Reference to Publication
3	• Katic, M. & Agarwal, R. 2018, 'The Flexibility Paradox: Achieving Ambidexterity in High-Variety, Low-Volume Manufacturing', Global Journal of Flexible Systems Management, vol. 19, no. 1, pp. 69-86 • Katic, M., Agarwal, R. and Al-Kilidar, H. 2017, 'Exploring the effect of customisation on management practices in High-Variety, Low-Volume Manufacturing', paper presented to the 24th EurOMA Conference, Edinburgh, Scotland.

1.7 Structure of the Thesis

Following on from this introductory chapter, this thesis is structured as follows:

Chapter 2 begins this research journey through a review of ambidexterity and BMP in HVLV manufacturing. It highlights the deficiencies associated with our understanding of how organisations operationalise ambidexterity and present BMP as a potential source for achieving the same. An extensive conceptualisation of HVLV manufacturers is then undertaken, followed by a review of BMP in this unique organisational environment. This chapter ends with a review of ambidexterity in a HVLV manufacturing context which summarises the relationship between the main themes in this chapter.

Chapter 3 provides the theoretical basis for this research project. Starting with an in-depth introduction to the routines-based view, this chapter lays the foundations for a conceptual model by tracing the roots of the routines-based view back to the notion of competitive advantage through the resource-based view. This is followed by a theory building exercise that articulates the transition from (ambidextrous) capabilities to routines and finally towards organisational performance outcomes by building a high-level schematic through the routines-based lens. Finally, a conceptual model that forms the basis of this thesis is presented, which also outlines the hypothesised relationships between ambidexterity, BMP and HVLV manufacturing performance examined in this research.

Chapter 4 introduces the research methodology. An overview of the philosophical perspective(s) adopted throughout this research project is provided as well as a discussion surrounding the choice of research design and the subsequent theoretical foundations that form the basis of this design process. The questionnaire tool is introduced as well as an overview of the development of measures for constructs used within it. Finally, the questionnaire design and implementation process are also discussed in depth, alongside an overview of the data analysis and evaluation methods.

Chapter 5 presents the results of the data collection and analysis process. It begins with a data cleansing exercise where missing values, outliers and data distribution are placed under scrutiny. Descriptive statistics concerning the respondents and organisational characteristics of HVLV manufacturers is then provided, followed by an evaluation of both measurement and structural models towards the assessment of research hypotheses. Finally, common method bias is examined, and a summary of the results is provided.

Chapter 6 provides a discussion of the results. The research question is revisited here, and a discussion of the results takes place under each of the research objectives. This chapter ends with an overarching discussion on the role of BMP in operationalising ambidexterity in HVLV manufacturing.

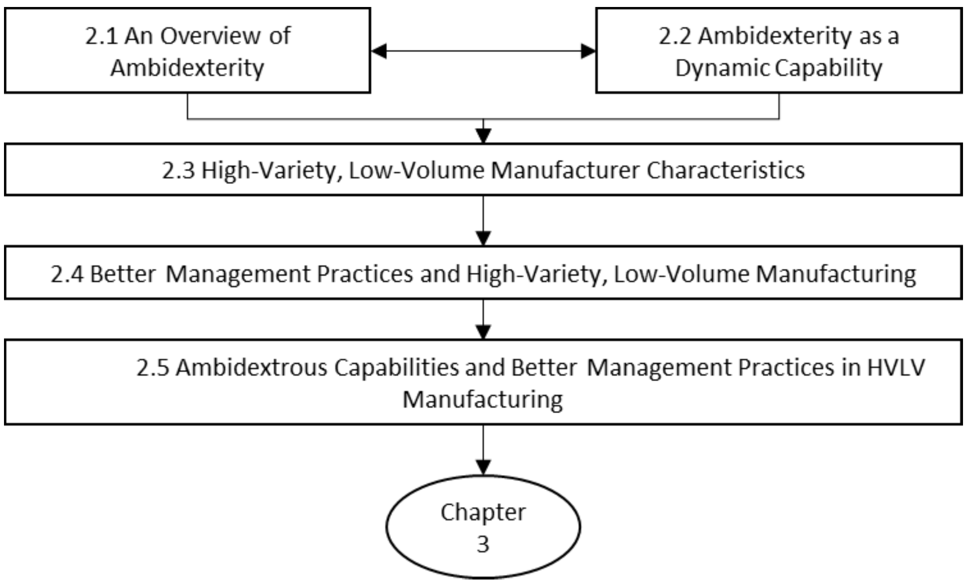
Chapter 7 rounds up this thesis with a conclusion and implications. A summary of the research project and findings is provided. This is followed by an outline of the theoretical and managerial implications associated with this research. Finally, the limitations and directions for future research are provided.

Chapter 2 Ambidexterity and Better Management Practices in HVLV Manufacturing: A Review

The literature review presented in this chapter encompasses three themes. Firstly, an overview of ambidexterity is provided. This leads to a review concerning the operationalisation of ambidexterity, given its conceptualisation as a dynamic capability. Secondly, the HVLV manufacturing context and the notion of better management practices is introduced. Finally, a review concerning the interplay between ambidexterity, better management practices and HVLV manufacturing is conducted.

Given the multiple themes, this literature review takes a more narrative approach whereby the "conventional" approach of consolidating prior works towards the identification of gaps is combined with a critical review process throughout (c.f. Grant & Booth 2009). The primary reason guiding this approach was to allow for the synthesis and convergence of disparate concepts and theories – given the inclusion of better management practices and the HVLV manufacturing context. A literature review will also occur continuously throughout this thesis as new concepts are introduced, disseminated and critically evaluated. An outline of this chapter is provided in Figure 2-1.

Figure 2-1 Outline of Chapter 2



2.1 An Overview of Ambidexterity

Ambidexterity typically refers to an organisations' ability to undertake both exploratory and exploitative activities at the same time (Cantarello, Martini & Nosella 2012; O'Reilly & Tushman 2008). This, of course, is based on the presumption that the exploration of new opportunities and exploitation of existing capabilities and resources are a fundamental component of sustainable competitive advantage (Eisenhardt, Furr & Bingham 2010). The tensions that ensue as part of an organisations' pursuit of operational excellence for today and innovation and change for tomorrow have been (and continue to be) key areas of concern for academics and practitioners alike - particularly because one does not play well with the other, at least in the short-term.

Undertaking exploration requires fundamentally different structures, processes and culture than exploitation (O'Reilly & Tushman 2013). The difficulty for decision makers, in this instance, concerns building/buying or renting resources to undertake both. Investing in exploitation, for example, emphasises short-term gain, present-time survival and stability over long-term gain, survival for the future and change (Lavie, Stettner & Tushman 2010). In his seminal article, March (1991), although not explicitly referring to ambidexterity, recognised these inherent organisational tensions and broke-free from traditional thinking at the time to suggest that organisations can (and should) undertake both. Based on these perhaps more behavioural roots, two now well-established means to achieve ambidexterity emerged: structural and contextual ambidexterity.

The structural school of thought would emphasise an organisational design where different business units would undertake either exploratory or exploitative activities. In this instance, the key to achieving ambidexterity would rest on the ability of the top management team to maintain strategic alignment between the two seemingly disparate groups – some mechanisms of which can include effective dissemination of an organisational identity and value systems (O'Reilly & Tushman 2013). The contextual school, on the other hand, would suggests the ability of an organisation to achieve ambidexterity rests at the individual/team level where the key is to build an organisational context that promotes a behavioural orientation towards a combined capacity for both exploitation and exploration (Gibson & Birkinshaw 2004). Though, both approaches come with respective critique.

From a practical perspective, achieving structural ambidexterity seems difficult for organisations with severe resource constraints (Gupta, Smith & Shalley 2006) and even when undertaken, having one part of the organisation working as a flexible entity responding to changes in market conditions and the other focussed on creating internal efficiencies proves to be difficult to manage (Schreyögg & Sydow 2010). The alternative method (which focuses more on individual and team behaviour) has also been criticized for being too unrealistic in the goals it is trying to achieve and the manner in which it proposes to achieve them (Schreyögg & Sydow 2010). According to Schreyögg & Sydow (2010), this is directed primarily on the notion that an individual can effortlessly switch between behaviours that facilitate exploration and exploitation on an on-going basis. There are other social, institutional and cognitive factors that pay a toll on the ability of an individual to do this (Smith & Lewis 2011).

It would seem, in this instance, that structural ambidexterity and contextual ambidexterity are actually linked in that one can have an effect on the other. More recent thinking on ambidexterity has also focussed on making the most out of both approaches (Eisenhardt, Furr & Bingham 2010; Gibson & Birkinshaw 2004). Typical amongst this perspective is the relative agreement on the importance of "paradox thinking" which embraces the organisational tensions between exploration and exploitation (Martini et al. 2013; Schreyögg & Sydow 2010). In this approach, authors attempt to "make sense" of seemingly incompatible yet highly interdependent phenomena (Schad et al. 2016) by explicitly taking into consideration the dynamic and cyclical nature of the exploration/exploitation paradox as well as the emphasis on interdependence between the two activities (Lewis 2000). By adopting such a theoretical lens, authors have been able to take into consideration the tensions between exploitation and exploration at a wide variety of organisational levels, thus avoiding over-simplification at the expense of rich theoretical understanding (Smith & Lewis 2011).

Other recent approaches in ambidexterity research recognise that the concept is still very much a function of strategic choice, and that whilst it is indeed important to help managers “deal with” internal contradictions in relation to exploitation and exploration, choices still have to be made and those choices need to be in line with market requirements (D’Souza, Sigdyal & Struckell 2017; Lavie, Stettner & Tushman 2010; Turner, Swart & Maylor 2013). D’Souza, Sigdyal & Struckell (2017), for example, proposed a “relative ambidexterity framework” which explicitly takes into consideration market forces in the decision to build either exploration or exploitation capabilities. In their work, they recognise the importance of undertaking both exploration and exploitation activities to the long-term success of organisations, though they also recognise that the two are still very different capabilities and not always complimentary. The authors also place concern over the fact that certain industries don’t have to be as “ambidextrous” as others – based on the findings of Junni et al. (2013). Some organisations may also benefit more from maximising either exploitative or exploratory capabilities than they are in necessarily balancing them (Cao, Gedajlovic & Zhang 2009). This also depends on the characteristics of their external market environment at a particular point in time (Luger, Raisch & Schimmer 2018).

Internally to the firm, however, the characteristics of an organisations’ resource pool[2] from which the outcome of capability investments in exploration and/or exploitation are realised also holds significant bearing over the efficacy of a particular ambidextrous orientation for different organisations (Cao, Gedajlovic & Zhang 2009). Hence, an organisations’ capacity to realise benefits from ambidexterity appears driven by their ability to formulate a viable strategic trajectory in markets that complement their existing resource base and eventually reconfigure this if and when it becomes necessary, through certain capability investments (c.f. Pisano 2017). It would appear that ambidexterity isn’t necessarily a source of competitive advantage in itself, it is the resource reconfigurations stemming from this capability that seem to facilitate this (O’Reilly & Tushman 2008). Such capabilities in continuously adapting resource (and other asset) positions towards more favourable outcomes in different markets are broadly defined as dynamic capabilities (Teece, Pisano & Shuen 1997), discussed in more detail next.

[2] Resources, in this sense, refer to an organisations’ intangible assets including, for example, skills, capabilities and routines (Pisano, 2017)

2.2 Ambidexterity as a Dynamic Capability

The simultaneous pursuit of exploration and exploitation is no easy feat. Organisations must hold the capability to induce often radical change whilst retaining effective operations to compete in existing markets (Eisenhardt, Furr & Bingham 2010). The discussion in section 2.1 elaborated on the manner in which ambidexterity can be achieved and the "types" of ambidexterity organisations can strive for. What this section did not quite address, is that achieving ambidexterity isn't always possible. It depends on a host of factors, some of which relate to the configuration of exploratory and exploitative activities and others in relation to the composition of the activities themselves.

2.2.1 Capabilities-Based Understanding of Ambidexterity

Apart from the difficulty in managerial cognition and skills mentioned earlier, organisations face more fundamental challenges. Organisations are not a bottomless pit of resources, they are a function of precedence, history and path dependence (Nelson & Winter 1982). To change involves significant effort in understanding the current state of asset positions and subsequently developing a strategy to either build, buy and/or rent certain competencies and skills when markets become less favourable (Teece 2017). The efficacy of this strategy rests on leaderships' abilities in recognising emerging opportunities for growth, capturing value from these opportunities and transforming the organisation accordingly (Helfat & Peteraf 2015). In this instance, "sensing" opportunities relates to exploratory capabilities, "seizing" or capturing value from those opportunities relates to exploitative capabilities and "reconfiguring" or transforming the organisation to match are regarded as ambidextrous capabilities (Birkinshaw, Zimmermann & Raisch 2016; O'Reilly & Tushman 2008; Teece 2017). These ambidextrous capabilities dictate the nature of resource investments as well as the strategic trajectory of the firm to ensure the exploitative and exploratory capabilities complement each other, given the markets within which it wishes to operate (Jansen, Simsek & Cao 2012; O'Reilly & Tushman 2008). Without such capabilities, the chances of long-term competitive success are slim (Eisenhardt, Furr & Bingham 2010) - particularly in the case of organisations operating in volatile and uncertain environments (Teece, Peteraf & Leih 2016).

From this brief description, one can assume that ambidexterity acts as a higher-order capability that enables organisational adaptation (or strategic change) by influencing the composition of lower-order capabilities in exploration and exploitation (Zimmermann & Birkinshaw 2016). Here, lower-order (or operational) capabilities help the business maintain its current position and optimise its current offering whilst higher-order (or dynamic) capabilities help organisations change to earn a living in the future (Helfat & Winter 2011). Such a multi-level "configurational" approach to ambidexterity as a dynamic capability is becoming increasingly popular in ambidexterity literature.

Zimmermann & Birkinshaw (2016), for instance, recognise that different modes of ambidexterity are more appropriate than others in different organisational contexts. To demonstrate this, they distinguish between lower-level ordinary capabilities and higher-level dynamic capabilities in a framework based on levels of analysis (groups/teams and organisational level) as well as the level of environmental dynamism experienced by organisations in lieu of their market. Here, organisations operating in more stable markets would benefit from continuous improvement at the group level (achieved through contextual ambidexterity) and cross-functional integration at the organisational level (achieved through structural ambidexterity). Whilst those operating in more dynamic environments would benefit from sensing and seizing at the group level and reconfiguring at the organisational level (achieved through temporal or structural ambidexterity). A similar line of reasoning was also adopted by Birkinshaw, Zimmermann & Raisch (2016) as well as in Cantarello, Martini & Nosella (2012) where they investigated how operational processes contribute to ambidexterity outcomes in the search phase of an innovation venture.

Continuing from this, Maijanen & Virta (2017) proposed a capabilities-based ambidexterity framework where exploitation was related to ordinary capabilities, exploration to dynamic capabilities and both juxtaposed with the sensing and seizing activities of dynamic capabilities described earlier – though they also stress the importance of both types of capabilities in relation to exploration and exploitation and their roles in dynamic adaptation in a media context. In this framework, they seem to go back to the roots of dynamic capability theory by drawing on the role of strategic choice in capability investments (Pisano 2017). Here, they refer to the choices of entering new markets vs. staying in old as well as long-term vs. short term thinking (where the former of each refers to exploration and the latter to exploitation). Vahlne & Jonsson (2017) similarly differentiate between operational and dynamic capabilities and make comparable connections with exploratory and exploitative activities in the context of organisational globalisation activities.

Though some authors portray a seemingly clear-cut distinction between operational and dynamic capabilities, there are some latent characteristics of capabilities that can impact their interactions. Capabilities don’t operate in a vacuum i.e., they are a part of the organisational tissue that links individual actions to macro organisational outcomes (Felin et al. 2012). As such, they are prone to influence from endogenous and exogenous change as well as the learning processes that transcend the capability building process itself (Pentland et al. 2012). Indeed, operationalising ambidexterity as a dynamic capability is as much a function of peoples’ actions and daily activities as it is a function of strategic choice.

2.2.2 Composition of Ambidextrous Capabilities: The Role of Routines

As brought forward in section 2.2.1, ambidexterity is a dynamic capability consisting of other lower-level capabilities. What is also the case, however, is that those capabilities only come into being through routines characterised by “repetitive, recognisable pattern[s] of interdependent actions, involving multiple actors” (Feldman & Pentland 2003, p. 95). There is also a commonly held belief that routines exist in a hierarchy where one routine (or set of routines) can be used to influence other lower-level routines (Helfat & Winter 2011; Winter 2003). This seems to underpin the existence of (dynamic) capabilities, where, from a more evolutionary perspective, capabilities can be characterised as “high-level routine[s]… that, together with its implementing input flows, confers upon an organization’s management a set of decision options for producing significant outputs of a particular type” (Winter 2003, p. 991). A key learning from this conceptualisation is the nature of actions and the role agency plays in these interactions between (and among) individuals, processes and structures (Feldman & Pentland 2003; Felin et al. 2012). Thus, adding more granularity to the configurational understanding of ambidexterity mentioned in the previous section.

According to Pentland et al. (2012), a routine is recognisable in the observed sequence of actions as they are bound by interdependencies – if one action follows (or is dependent on another). On the other hand, a routine is repetitive in the observed outcomes of a sequence of actions in lieu of an external stimulus – if a certain pattern of actions is observed based on a particular stimulus, it is reasonable to assume a similar pattern will occur in response to a similar stimulus, whereby a stimulus could be actor-related or from the external environment (another routine, for instance)(Becker 2004). In other words, for a routine to be repetitive, the recognisable patterns must be the same every time. Routines can also merge with each other to form new routines – some more flexible than others (Felin et al. 2012; Schatzki 2012). This suggests the routines that underlie ambidextrous capabilities are also undergoing constant change as the outcomes are quite often unpredictable. This also reinforces the difficulty in balancing structure/control and change/uncertainty that underlies the basis of ambidextrous capabilities – routines are as much forces for variation as they are stability (Pentland et al. 2012).

In this respect, it would also seem that just holding good ambidextrous capabilities is not enough (Wilden, Devinney & Dowling 2016). Routines are often said to be the "genes" of an organisation, playing a key role in how organisations are able to legitimise themselves, learn and evolve over time (Nelson & Winter 1982). Thus, they provide the foundation for all those "mechanisms" (to be discussed in the proceeding section) that seem to support effective ambidexterity. Nonetheless, counter to some of the studies mentioned in section 2.2.1, routines also play a key role in both lower-order operational capabilities in exploration and exploitation as well as higher-order ambidextrous capabilities. Hence, insufficient emphasis on routines will likely result in an incomplete picture of ambidextrous capabilities (Wilden et al. 2018).

In light of this, routines have also seen increased popularity in understanding the mechanics of organisations and their reason for being (Feldman et al. 2016) as well as becoming key explanans in theories of competitive advantage (Ketokivi & Schroeder 2004) (to be discussed further in Chapter 3).

2.2.3 Operationalising Ambidexterity

Recent times have observed considerable attention to understanding exactly *how* organisations can be ambidextrous. Such a movement has typically been associated with the study of so-called “micro-foundations” (Andriopoulos et al. 2018) or “mechanisms” (Turner, Swart & Maylor 2013) enabling the execution of ambidexterity in practice. For instance, in their review of mechanisms that enable organisational ambidexterity, Turner, Swart & Maylor (2013) underline the importance of individual, group (team) and organisational levels of analysis and their respective mechanisms categorised based on human, social and organisational capital - given empirical substance later on (Turner, Maylor & Swart 2015). They bring forth an important point in the danger of understanding ambidexterity at one level of analysis and the assumptions associated with this myopic understanding. More recent reviews and commentaries by seminal authors also point to the importance of a multi-level and lateral understanding of the mechanisms enabling (or hindering) ambidexterity (Benner & Tushman 2015; Birkinshaw & Gupta 2013). In fact, there have been special forums directed at this very problem (Andriopoulos et al. 2018). The result is a rich literature on various micro-level phenomena that are said to have an important role in understanding how ambidexterity is operationalised by organisations. Though, as we demonstrate here, our understanding seems to have departed somewhat from its original conceptualisation in terms of dynamic capabilities.

To start with, Benner & Tushman (2003) present one of the seminal and well-cited works in this domain where they took aim at process management practices as highly routinised behaviour and their perceived impact on the ability of organisations to reconcile the contradictory demands of incremental and radical innovations. The authors argued that process management initiatives are best suited towards incremental innovation and will likely have a negative impact on more radical forms of innovation and, in effect, stifle creativity. A commentary piece by Adler et al. (2009)

provides a similar argument. In this paper, the authors return to the issue of process management practices and their impact on exploratory and exploitative learning. Based on their experience, the authors reiterate that whilst process management (or best-practices) can be a source of innovation in the short term, once codified in the organisations' memory in the form of standards, procedures, documentation and other artefacts, the ability of an organisation to respond to major changes in the marketplace (or indeed, create them) diminishes significantly.

Whilst there is quite an extensive and convincing argument against the adoption of process management (or efficiency driven and variation reducing management practices) today (Benner & Tushman 2015), recent works have also begun to investigate how well defined management practices that once belonged to the "best practice" paradigm in operations research (elaborated in section 2.4) can actually have a positive impact on both exploitative and exploratory initiatives in organisations.

Matthews, Tan & Marzec (2015), for instance, investigated the impact of process improvement initiatives on organisational ambidexterity in project-based organisations. They found that a particular organisations' competitive priorities actually guide the direction of focus on what the authors label as exploratory and/or exploitative learning. Taking it one step further, Tamayo-Torres et al. (2017) demonstrated that ambidexterity is a pre-curser for, and enabler of, manufacturing performance improvements as they pertain to quality, speed, flexibility and cost. Based on their study of Spanish manufacturing companies, they also found that higher environmental dynamism strengthened this effect and thus echoing the results of Frank, Güttel & Kessler (2017) where higher environmental dynamism increased the importance of ambidextrous capabilities. Others including Herzallah, Gutierrez-Gutierrez & Munoz Rosas (2017) linked what they labelled as "quality ambidexterity" to strategic intent – concluding that ambidextrous capabilities had a positive relationship on adopting different organisational strategies centred on cost leadership, differentiation and focus (though focus had a negative relationship on manufacturing performance). This perspective is observing considerable growth and popularity in ambidexterity literature in general (Snehvrat et al. 2018).

It is also important to keep in mind that process or routines-based perspectives, as described here, are by definition time-based and (in the simplest sense) rely on a sequence of events. In addition, they only ever come into being through the action of individuals operating within tightly coupled organisational constraints in the form of structure and design. Some authors have made the leap between these perspectives in operationalising ambidexterity (Adler, Goldoftas & Levine 1999; Andriopoulos & Lewis 2009, 2010; Chandrasekaran, Linderman & Schroeder 2012 are well-cited examples) though the approaches, perspectives and the role of underlying foundations of ambidextrous capabilities remain fragmented and incohesive (Turner, Swart & Maylor 2013).

This need was in fact the intended target of O'Reilly & Tushman (2008) in their popular piece characterising ambidexterity as a dynamic capability. At that time, they were critical of the lack of substance in articulating capabilities and practices that help operationalise ambidexterity. Since then, attempts have been made to identify and understand the underlying mechanisms that make ambidextrous organisations so capable of reconciling the inherently conflicting objectives of exploration and exploitation.

Turner, Swart & Maylor (2013), as mentioned in an example earlier, took on this task by juxtaposing the individual, group/team and organisational levels of analysis so synonymous with ambidexterity research (Zimmermann & Birkinshaw 2016) with the intellectual capital perspective. Through a literature review, they went beyond the "traditional" paradigms of ambidexterity towards an understanding of the role intellectual capital resources (organisational, social and human) play in operationalising ambidexterity. This understanding was demonstrated in a later empirical study where the authors exemplified how social, organisational and human capital prove valuable in understanding how ambidexterity is operationalised in organisations (though some appeared more important than others)(Turner, Maylor & Swart 2015). Carter (2015), on the other hand, opted for a hierarchical approach based on the dynamic capabilities framework of Winter (2003) and discussed, through a literature review, how ambidexterity can be operationalised at the zero order, higher order and top management team levels. They theorised that ambidexterity occurs at all three levels, though again, some appear more critical than others.

2.2.4 Routines, Context and Ambidextrous Capabilities

We began this section with an overview of ambidexterity, where ambidexterity is conceptualised in the simultaneous pursuit of contradictory organisational goals (which, in our case, reflect exploratory and exploitative activities). The characterisation and treatment of these tensions appears to be the differentiating factor, whereby more "traditional" approaches would assume a dichotomous stance based on either/or decisions whilst others would adopt a paradox-like view where competing tensions are somewhat reconciled through a cyclical process of differentiation and integration (Smith & Lewis 2011) at varying levels of organisation (Jarzabkowski, Lê & Van de Ven 2013). Whilst recent times have observed an increased interest in this so-called paradox thinking in dealing with organisational tensions, the manner in which an organisation can pursue both exploratory and exploitative activities simultaneously remains a pressing concern (Schad et al. 2016).

Each organisation holds its own idiosyncrasies in design, management model and processes that, suspended in their past experience, affects their capacity and desire to explore new opportunities and exploit existing assets (Levinthal & March 1993). By simplifying the need for adaptation and balance, we also seem to simplify the impact of this balancing act on organisational outcomes (Wilden et al. 2018). Capabilities matter, and while we seem to recognise the need for ambidextrous capabilities in facilitating long-term competitive advantage, we still have a long way to go before fully understanding the role they play in actually operationalising ambidexterity; including how they emerge and how they become embedded in organisational routines (Wilden et al. 2018). This also links to the concerns over the paucity of research on how exactly ambidexterity is achieved in organisations (Turner, Maylor & Swart 2015; Turner, Swart & Maylor 2013) and the underlying role of operations, routines and lower level "mechanisms" in this pursuit (Patel, Terjesen & Li 2012).

This has provided credence in that some authors have recognised that different operational capabilities exist, all with a different area of focus (for instance, customisation, cooperation, innovation, improvement and so on)(Wu, Melnyk & Flynn 2010). In this respect, operational capabilities can also potentially conflict with each other and ambidextrous capabilities can help facilitate their productive complementarity (Patel, Terjesen & Li 2012). Indeed, there exists evidence that certain routines can help build exploratory and exploitative organisational capabilities, though evidence that they impact both, and how they actually aid in achieving ambidexterity remains unsettled (Wilden et al. 2018).

In addition, much of the work on achieving ambidexterity is internally centred without a clear focus on external market/industry factors that can have an influence on the way in which ambidexterity is achieved and, indeed, if ambidexterity is even required in the first place (D'Souza, Sigdyal & Struckell 2017). The importance of strategic choice and competitive priorities (by virtue of industry affiliation) does not appear to be a central theme in ambidexterity research, even though the evidence of industry/contextual effects as potential moderators has been quite well established (D'Souza, Sigdyal & Struckell 2017; Junni et al. 2013).

As Pisano (2017) and Teece (2017) reiterated, the decision to build/buy/rent capabilities should be founded upon a particular organisations strategic intent and the markets in which it competes (or wishes to compete). Organisations which are more market-driven tend to build operational capabilities based on efficiency and optimisation (exploitative strategies) whilst those which are market-leading tend to build capabilities that help mitigate against risk and build new business models (exploratory strategies)(Wilden, Devinney & Dowling 2016). This also echoes some complimentary work on stable vs. dynamic environments and the choice to build ambidextrous capabilities (Junni et al. 2013).

In light of the concerns in ambidexterity literature regarding context, processes and the role of routines, we now narrow the research focus on organisations characterised as high-variety, low-volume (HVLV) manufacturers and draw upon the notion of better management practices (BMP) as routinised patterns of behaviour in the effort to illustrate a more refined research agenda.

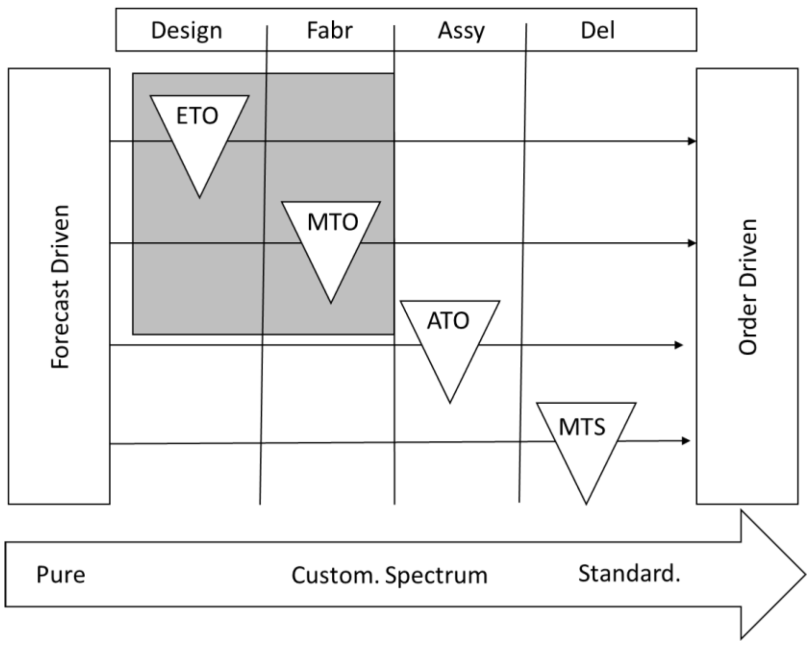
2.3 High-Variety, Low-Volume Manufacturers as Ambidextrous Organisations

This section departs from the broader theoretical underpinnings of ambidexterity towards a conceptualisation of high-variety, low-volume (HVLV) manufacturers as the context for this research. Here, HVLV manufacturer typologies are reviewed, followed by an overview of key operational and strategic peculiarities towards an in-depth characterisation of HVLV manufacturing.

2.3.1 HVLV Manufacturer Typologies

HVLV Manufacturers are typically characterised as SMEs that produce a wide variety of customised products (Amaro et al., 1999). The level of product (and service) customisation offered by HVLV manufacturers can vary significantly – ranging from standard products to pure customisation where the customer order infiltrates the entire manufacturing value-chain (Katic et al., 2017, Amaro et al., 1999, Hendry, 2010). Figure 2-2 depicts these characteristics using the Customer Order Decoupling Point (Wikner and Rudberg, 2005, Giesberts and Tang, 1992).

Figure 2-2 Characterisation of a HVLV Manufacturer using the Customer Order Decoupling Point



Source: adapted from Rudberg and Wikner (2004) and Portioli-Staudacher and Tantardini (2012)

Manufacturing systems are typically categorised as engineer-to-order (ETO), make-to-order (MTO), assemble-to-order (ATO) and make-to-stock (MTS) according to where the customer order infiltrates the manufacturing value-chain (Wikner and Rudberg, 2005). HVLV manufacturers can exhibit both ETO and MTO characteristics, depending on the degree of customisation offered and the types of activities the manufacturer is willing to do (design, fabrication, assembly and so on) (Amaro et al., 1999). For instance, HVLV manufacturers that offer fully customised solutions requiring comprehensive design activities can be characterised as ETO. Other HVLV organisations may only offer fabrication services with limited customisation capabilities. In this case they can be classified as MTO (an example can be a typical job-shop where the product is “produced to print” i.e., the customer would provide a drawing to manufacture from and the HVLV manufacturer may provide limited design solutions to increase the manufacturability of the product – more often to fit their own machine requirements).

As one can imagine from this rather generic characterisation of HVLV manufacturing, coming up with an all-encompassing definition or typology proves to be quite a difficult exercise. For this reason, and in line with other studies concerning HVLV manufacturing (Amaro, Hendry & Kingsman 1999; Portioli-Staudacher & Tantardini 2012b), we take into consideration SMEs[3] that exhibit both MTO and ETO characteristics. From this perspective, there are peculiarities that can be considered unique to HVLV manufacturers, particularly when it comes to strategic and operational characteristics (Portioli-Staudacher & Tantardini 2012b). The following briefly summarises some of these.

2.3.2 Operational and Strategic Organisational Characteristics

From an operational perspective, and stemming from the adoption of a customisation-based manufacturing strategy (and the many uncertainties associated with this), HVLV manufacturers are observed to have significant difficulty in developing plans (including sales, production and procurement plans) (Adrodegari et al. 2015). Based off the

[3] In HVLV manufacturing literature, SMEs typically refer to organisations that carry less than 250 employees, given a simplified definition based on that by the European Commission (2003) is often cited. Because this research is undertaken in the Australian context, we take a less conservative approach by adopting the definition of SME by the Australian Bureau of Statistics (2001) as an organisation having less than 200 employees.

characterisation provided by Adrodegari et al. (2015), Persona, Regattieri & Romano (2004), Amaro, Hendry & Kingsman (1999) and Little et al. (2000), forecasting is almost impossible, and the supplier relationships are practically non-existent due to the nature of the demand driven manufacturing approach. In addition, the production system is designed specifically to cater for a high variety of products where the job-shop style of production is typically adopted. This means work routings are complex, general purpose machinery is implemented and setup times as well as WIP (work in process) are also high.

From a strategic perspective, the competitive priorities and criteria are also unique to HVLV manufacturers. The order-winners and order-qualifiers framework brought forward by Hill (2000), also adopted by Hendry (2010) and Amaro, Hendry & Kingsman (1999), suggests HVLV manufacturers typically compete on the basis of price, delivery time, delivery reliability, conformance to quality, “specialist” know-how and some unique production capabilities. However, these have been known to change depending on the external market conditions of the time and the decision makers’ perception of who their competitors are (Hendry 2010).

For example, a study by Amaro, Hendry & Kingsman (1999) suggests firms which perceive their direct competitors as very similar organisations which adopt the same manufacturing strategy and production process would assume they compete on the basis of price, delivery time, capability and know-how. However, the same study also suggests firms who perceive their main competition to be mass-producers (or those which operate under a completely different manufacturing strategy) would also claim customisation to be a key area of competitive advantage (not evident in the previous example). Whilst one can identify the various mechanisms used by HVLV manufacturers to gain competitive advantage, the importance (or the priority rank) of these mechanisms is debatable and remains to be an open discussion in HVLV manufacturing literature. A particular driver for this is the notion that HVLV manufacturers who perceive price to be the most important criteria for winning an order seem to attach significant strategic importance to achieving repeat business (Amaro, Hendry & Kingsman 1999). This occurs from the difficulty of reducing costs based on a high-variety oriented manufacturing system. In this case, the degree to which repeat business presents a key strategic decision also seems to influence the weighting or precedence of competitive priorities (Hendry 2010).The type of customer relationship pursued by HVLV manufacturers is also altered depending on the competitive priorities of these firms (Kingsman, Hendry, Mercer & De Souza 1996).

Though it might appear difficult to discern the strategic orientation of such firms, a foundational understanding can be obtained by investigating HVLV manufacturers based on their strategic intent and what came to be known as "core characteristics". Core characteristics are said to be the "soul" or "essence" of an organisation (Ashforth & Mael 1996), guiding management decisions as they endure throughout the lifetime of an organisation (Gioia et al. 2013). When viewed in this light, two core characteristics (and by virtue, their strategic intent and competitive priorities) can be identified: 1) the strategic choice to emphasise customisation; and 2) the flexibility necessary to facilitate this customisation.

For instance, in a review of ETO supply chain strategies, Gosling & Naim (2009) suggest flexibility and customisation (albeit using different terminology) can both be core characteristics and part of key improvement strategies of ETO organisations. Similarly Salvador et al. (2007) in their study of strategic trade-offs within a Build to Order (BTO) organisation focussed on both volume flexibility and mix flexibility, proclaiming both to be core to BTO organisation success. In addition, earlier studies on HVLV organisational improvement focussed on leveraging their core capabilities to produce customised products through various order-control and release mechanisms (Hendry, Kingsman & Cheung 1998; Kingsman 1997) as well as strategies to reduce the chasm between sales and engineering (Kingsman et al. 1993). In such studies, flexibility appeared to be a given characteristic of HVLV organisations. The key, then, was in managing the relationship between customers (both external and internal to the manufacturer) to ensure due dates are set correctly and adhered to.

In addition, manufacturers were also urged to ensure the correct job was released at the correct time to facilitate maximum resource utilisation whilst allowing room for problem solving. Following on from this stream, Zorzini, Stevenson & Hendry (2012) identify customisation and flexibility (labelled as the location of the customer order penetration point and system flexibility, respectively) as key contingency factors in the success of customer enquiry management - ultimately resulting in improved organisational performance of HVLV manufacturers (labelled as non-make-to-stock).

2.4 Better Management Practices and HVLV Manufacturing

Having provided an in-depth conceptualisation of HVLV manufacturing organisations including their typologies and key characteristics, this section now delves into the notion of better management practices (BMP) as the conduit from which ambidextrous capabilities in HVLV manufacturers emerge. A brief overview of BMP research is provided, outlining some key theoretical contingencies which need to be taken into account. Finally, a thorough literature review of BMP in HVLV manufacturing is conducted. This includes the impetus behind their adoption as well as their relationship with operationalising ambidexterity.

2.4.1 Overview of Better Management Practice Research

Recent times have observed a deluge of large-scale empirical studies suggesting the existence of management practices that appear universally "better" than others. These studies claim the adoption of so-called "structured" management practices is a key force in explaining differences in performance at the firm level (Bloom et al. 2012) as well as explaining the differences in performance between entire economies (Agarwal et al. 2015; Bloom & Van Reenen 2006) and different industrial contexts as well (Agarwal, Bajada, et al. 2014; Bloom & Van Reenen 2010). In addition to all of this - and perhaps even inspired by the results of these large-scale empirical studies on BMP – some have even articulated a "practice-based" theory of the firm (discussed in more detail in Chapter 3) seeking to explain the competitive advantage of organisations via the adoption of BMP (Bromiley & Rau 2014, 2016b). This line of theorising, stems from the tradition of best practice research – of which operations management literature has a rich history in advocating (Voss 1995). Though, this is not to say there are not any important considerations in this line of reasoning.

The definitions found in literature (as shown in Table 2-1) suggest the existence of one significant and perhaps fundamental assumption - that there exists a set of management practices which can be characterised as “better” than others and the adoption of such practices by underperforming firms will increase their chances of organisational success. Whilst this assumption does, in fact, hold merit in the overwhelming amount of evidence already mentioned; when one dives deeper into the discourse within which the assumption holds true, the foundation once assumed to be stable is actually hiding some caveats which require further discussion.

Firstly, contingency theory plays a key role in the age-old argument where certain management practices are only effective in improving business performance within specific contexts (Skinner 1974; Sousa & Voss 2008). Common examples of this include the use of Lean manufacturing and other World Class Manufacturing techniques within organisations producing highly customised products at low volumes (Hendry 1998; Slomp, Bokhorst & Germs 2009). In this instance, there is a clear mismatch between marketing, manufacturing strategy and production processes if the management practices are adopted in their entirety – that is to say, these particular practices must be adapted to suit different operating environments.

Table 2-1 Definitions of Best Practices

Author	Definition of best practice
Bretschneider, Marc-Aurele & Wu (2005)	The term “best practice” implies that it is best when compared to any alternative course of action and that it is a practice designed to achieve some deliberative end.
Overman & Boyd (1994)	The most precise definition of Best Practice Research is the selective observation of a set of exemplars across different contexts in order to derive more generalizable principles and theories of management
Laugen et al. (2005)	The basic principle of the best practice thinking is that operations philosophies, concepts and techniques should be driven by competitive benchmarks and business excellence models to improve an organisations’ competitiveness through the development of people, processes and technology
Oxford English Dictionary (2017)	Commercial or professional procedures that are accepted or prescribed as being correct or most effective
Ungan (2005)	A manufacturing best practice is an approach that provides a significant improvement in measurable factors such as cost, quality, and time

Source: adapted from Veselý (2011)

Secondly, and perhaps a more recent argument, stems from the idea of "best" or "better" management practices as fashions or fads making their way into mainstream industries. The temporal nature of management practices as well as the relative immaturity of the management discipline (compared to other social sciences) often gives rise to questions concerning their credibility and validity (Bloom et al. 2012; Mi Dahlgaard-Park et al. 2006). Again, evidence of poor organisational performance from the rapid adoption and diffusion of what seem to be "best practices" within a plethora of different industries seem to be a major driver of these concerns (Abrahamson & Fairchild 1999). Nonetheless, Alexopoulos & Tombe (2012) quantified the effects of managerial innovations on various US macro-economic performance measures and found a significant correlation between the rise in managerial innovations - including management by objectives and quality circles where both of which are considered to be fads (Gibson & Tesone 2001) - and increase in macro-economic performance. In fact, Alexopoulos & Tombe (2012) and Bloom, Sadun & Van Reenen (2016) also suggest that managerial innovations are just as important (if not more so) as non-managerial innovation in explaining changes in output to measures including productivity. Other seminal benchmarking studies across various countries also suggest the existence of management practices which appear "better" at improving organisational performance than others (Schonberger 1987; Womack, Jones & Roos 1990).

Taking the above into consideration, the next section proceeds to review BMP as they pertain to the HVLV manufacturing context.

2.4.2 A Review of Better Management Practices in HVLV Manufacturing

Table 2-2 shows some of the key activities typically undertaken in HVLV Manufacturing. Here, the activities are often labelled physical, non-physical and support activities (Hicks, Earl & McGovern 2000). In this instance, the support activities present themselves as "general purpose" in their applicability across a wide range of industrial markets, whilst those activities associated with pre-production and production activities tend to be more domain specific and are associated with a commitment to a certain industrial application (c.f. Pisano 2017). Though appearing quite ordinary in the sense that these activities resemble how the HVLV manufacturer competes in its established market (as well as the fact that one can easily benchmark their adoption) they do, in fact, hold a considerable degree of merit in propelling the manufacturer to a new strategic trajectory as well. As we will demonstrate in Chapter 3, just because they are ordinary does not mean they are generic.

Much of the literature associated with BMP in HVLV manufacturing revolves around the world class manufacturing (WCM) concept. A world class manufacturer was once described as being able to compete amongst the best in the world (Hayes & Wheelwright 1984). First coined by Hayes & Wheelwright (1984) and later popularised by Schonberger (1996), WCM was seen as a driver of helping US companies in the late 1980's to bring back their competitiveness from threats emerging out of foreign countries. The target was a complete restructure of the role of manufacturing in driving competitive advantage for US manufacturers. This was achieved using a holistic approach to continuous improvement which involved every conceivable aspect of the manufacturing organisation.

Table 2-2 Description of Key Activities for HVLV Manufacturing

Physical Activities	
Manufacturing/Assembly	Physical manufacture and assembly of finished components
Service/Refurbishment	Maintenance and after-sales service
Non-Physical Activities	
Sales and Estimation	Quotation management and acceptance Inter-functional collaboration between marketing/sales and engineering Cost and lead-time estimation and negotiation
Design	Engineering design activities Design for manufacture (minor changes to original specifications to fit machine requirements if applicable)
Procurement	Supplier selection (if applicable), negotiation and purchasing
Production Planning and Control	Order acceptance and release to the shopfloor Resource allocation, production levelling

Table 2-2 Description of Key Activities for HVLV Manufacturing (Continued)

Support Activities	
Project Management	Order progress monitoring, bottleneck detection, budgeting, customer/supplier liaison, corrective action
Quality Management	Quality Control and Assurance
Human Resource Management	Recruitment, training, motivation and incentive systems.
Maintenance Management	Preventive and predictive maintenance, development of proprietary processes/equipment

Source: adapted from Adrodegari et al. (2015), Muda & Hendry (2003) and Hicks, Earl & McGovern (2000)

Borrowing from other best-practice paradigms of the time including total quality management (TQM), just in time (JIT) and the Toyota production system (TPS), the underlying assumption of WCM is that the adoption and continuous improvement of best-practices will lead to better organisational performance, otherwise the manufacturer will lose its competitive edge to others that do (Schonberger 1996). WCM has evolved since the early works to accommodate different changes to the manufacturing environment, though the main areas of concern remain relatively consistent. These inevitably found their way into HVLV manufacturing.

Hendry (1998), in an early investigation of the applicability of WCM principles and measures to the HVLV manufacturing environment, presented one such study. Here, she breaks down the 16 WCM principles posited by Schonberger (1996) into seven core themes namely: 1) workforce empowerment; 2) design for products, processes and improved supplier relationships; 3) simplifying the shopfloor; 4) capacity related problems; 5) improvements in quality and value for money; 6) up-to-date and appropriate planning and control systems; and finally 7) performance measurement, benchmarking and continuous improvement. Whilst this list seems to fit a universally applicable model to suit all manufacturers, the underlying suggestions within some of the main themes do not fare well within specific contexts including HVLV manufacturing.

In the same study, Hendry (1998) also found that companies explicitly choosing to retain a job-shop style layout (as HVLV manufacturers are inclined to do) typically rank poorly in existing WCM assessments as the cellular layout is the preferred "world-class" standard. Other principles including a major reduction in time to market was also found to conflict with basic HVLV manufacturing characteristics. For instance, as mentioned in a previous section, many HVLV manufacturers are primarily involved in build-to-print operations where the customer has already done most of the design work and sometimes supplementing this with their own product range to take advantage of repeat business. The main argument in this case is that the WCM paradigm is important, though not to hold the measures of effectiveness at face-value for different manufacturing environments.

Stemming from this argument, Shaladdin Muda and Linda Hendry subsequently developed the SHEN Model (derived from their names "SH"aladdin and "HEN"dry) (Muda & Hendry 2003; Muda & Hendry 2002; Muda, Rahman & Hasan 2013). This model is one of very few which incorporates best-practice principles from the traditional WCM paradigm into the context of HVLV manufacturing. Literature reviews and personal author experiences were used in this case to modify the original WCM framework by Schonberger (1996). Case-study evidence using various HVLV manufacturing firms was used to validate the literature-based model which ultimately consisted of 12 principles (see Table 2-3). Much like the original WCM concept, each principle contains a set of five capabilities, all ranked according to a score (a score of five being of "world-class" standard). Akin to the broad studies on management practices by Bloom et al. (2012) and MacDuffie (1995), the scores are cumulative and an organisation can potentially exhibit a capability score of five whilst not necessarily exhibiting all of the required capabilities.

Table 2-3 The SHEN Model of World Class Manufacturing in HVLV Environments

Theme	Practices
Generate Enquiries and Sales	Design for products, processes and improved supplier relations Collaborate with customers
Operations and Capacity	Simplify the shop floor Improve scheduling and workload control to cut flow times Cut the start-up/Changeover time and improve preventive maintenance Improve information flow
Human Resources	Make essential improvements in skills and flexibility Everybody is involved in change and strategic planning – to achieve a unified purpose
General Continuous Improvement	Improve quality and implement appropriate performance measures Gather customer feedback and benchmarking Promote/market/sell every improvement

Source: adapted from Muda (2003)

In a similar vein, Petroni, Zammori & Marolla (2017) conduct a study of Italian HVLV manufacturers (or batch production, make-to-order SMEs as they are referred to here) in order to isolate and validate WCM practices. As in prior studies, Petroni, Zammori & Marolla (2017) accomplish this by first utilising a literature review of WCM practices as they related to their specific context, though instead of case-studies, as in Muda & Hendry (2003), they used a three-phase Delphi study as a preliminary validation tool followed by a survey of 1,638 North Italian SMEs spread almost evenly amongst a sample consisting of textile/fashion, furniture and precision engineering firms. The argument posed by Petroni, Zammori & Marolla (2017) was of a similar nature to Muda & Hendry (2003) in that the universalistic and generalised nature of the WCM study by Schonberger (1996) was not sufficient, nor practical, in the HVLV context. In this sense, the themes were adopted from Schonberger (1996) though the principles within the themes were adapted to suit a HVLV manufacturing environment. The practices adopted in this study are outlined in Table 2-4.

They found the best performing sample of batch production SMEs (adopting almost, if not all, WCM practices) were actually observed to produce almost commoditised products with very little customisation. They also found a cluster of firms with good organisational performance, though with very little adoption of WCM practices. These organisations best resembled HVLV manufacturers as they had high degrees of customisation (though, this would appear to be more "personalisation") of a standard product (wedding dresses and furniture fit into this category). Here, such manufacturers were labelled as "artisan quality seekers" owing to their lack of regard towards price and high emphasis on quality. In this instance, very little operational improvement initiatives are undertaken as they were not seen as necessary. Indeed, as Petroni, Zammori & Marolla (2017) mentioned, given the nature of todays' manufacturing competitive environment, it is not known how long such a strategy will last.

Table 2-4 WCM Model based on Batch Production SMEs

Theme	Practices
Strategy, Communication and Top Management Support	Sharing of corporate strategy and objectives Competitive benchmarking HRM control system Accountability system Culture diffusion
Human Resource Management	Employee empowerment Working conditions Labour flexibility Employee training Management of teamwork Motivational and incentive Systems Use of single point lessons
Production Planning and Control	Production planning/scheduling Capacity control Production levelling Bottleneck detection Set up reduction plan Pre-shop pull management
Internal Logistics and Supply Chain	Traceability of purchases and input materials Layout optimisation Packaging standardisation Routing optimisation Analysis of idle and transportation time Data sharing Suppliers involvement in design Customer knowledge base Customer involvement in product development

Table 2-4 WCM Model based on Batch Production SMEs (Continued)

Quality Management	Supplier evaluation Post sell service Customer feedback Quality certification Statistical quality control Determination of quality costs
Maintenance Management	ICT for maintenance Statistical analysis for maintenance Priority assessment and risk analysis Integrated maintenance policies Integration of workers and maintenance teams Assessment of machine variability

Source: adapted from Petroni, Zammori & Marolla (2017)

From a similar perspective, there has also been a plethora of research examining the applicability of the Lean concept to HVLV manufacturing environments. Whilst much has been done in terms of applying Lean (or just in time) principles with the aim of improving production planning and control (Bokhorst & Slomp 2010; Slomp, Bokhorst & Germs 2009; Thurer et al. 2013; Thurer et al. 2014) and value stream mapping in general (Chaple & Narkhede 2017; Gurumurthy & Kodali 2011; Koch & Lodding 2014; Seth, Seth & Dhariwal 2017), this review places focus on more holistic studies exhibiting (at the very least) the application of Lean practice bundles (e.g. Furlan, Vinelli & Dal Pont 2011) to the HVLV manufacturing environment.

One such study is by Birkie & Trucco (2016) (following on from Azadegan et al. 2013) where they aimed at investigating the contextual effects of dynamism and complexity on Lean implementation in ETO organisations. They found that complexity can be a precursor for Lean practice adoption, though dynamism (both internal and external to the organisation) poses some challenges for Lean implementation. They also found that complexity and dynamism, at the same time, can positively moderate the link between the implementation of Lean practice bundles and its associated performance effects. The indicators they used for Lean practice bundles in their case-based research are shown in Table 2-5. The same indicators were also used in a subsequent study where Birkie, Trucco & Kaulio (2017) found that Lean can be applied to ETO organisations (with some modifications) and these practices have a positive impact on organisational performance which was measured through sustained operational performance.

Other studies based on a smaller subset of Lean practices have investigated the impact of customisation and demand variability on what they deem a non-repetitive context. Bortolotti, Danese & Romano (2013) found customisation has negligible effects on the impact of JIT management practices on performance. However, they also found that demand variability did have a significant negative impact on this link. The authors conducted a survey of customisers where just in time (JIT) was operationalised using pull production systems, cellular layout, lot size reduction, set-up time reduction and daily scheduled adherence as well as JIT delivery by suppliers. Performance was measured based on operational efficiency and responsiveness.

Following on from product-related contingencies, Qudrat-Ullah, Seong & Mills (2012) found that Lean manufacturing and Lean product development are compatible in that both can be used to improve HVLV manufacturer operations. They developed a theoretical model through case-based evidence suggesting that the inclusion of various Lean product development tools associated with people, process and tools can help HVLV manufactures boost performance. The list of elements associated with these three dimensions is shown in Table 2-6.

Table 2-5 Lean Management Practices used in Engineer-to-Order Organisations

Themes	**Practices**
TQM and Visual Management	Quality management programs Formal continuous improvement programs Process capability measurement Use of proper visual tools
JIT/Flow	Cellular layout Bottleneck identification and removal Cycle time reduction Reengineering processes Quick changeover techniques
Human Resource Management	Job rotation, design and enrichment Formal cross training programs Problem solving groups and employee involvement Flexible and cross functional workforce
Lean Purchasing	Reduced purchase order size Short order placement processes Reduced need for incoming material inspection
Customer Involvement and Development	Customer direct engagement in product offerings Customers feedback on different performances

Table 2-5 Lean Management Practices used in Engineer-to-Order Organisations (Continued)

Themes	Practices
Supplier Involvement and Development	Close contact and long-term partnership Supplier development and certification Improvement commitments from suppliers
Standardisation	Standardising processes and procedures
Total Productive Maintenance	Maintenance optimization techniques Preventive and predictive maintenance techniques New process technology acquisition

Source: adapted from Birkie & Trucco (2016)

Table 2-6 Recommended Lean Practices for HVLV Manufacturers

Themes	Practices	
People	Customer value Multiple solutions	Development flow Standardised design
Process	Tailored technology Visual communication Written reports	Standard tools Design standard improvements
Tools	Leadership of chief engineer Matrix organization Technical knowledge	Supplier involvement Stride to learning Continuous improvement

Source: adapted from Qudrat-Ullah, Seong & Mills (2012)

Olhager & Prajogo (2012), on the other hand, suggest that Lean practices don't quite have the same effects on organisational performance for MTO firms as they do for MTS firms. Instead, they find that supplier integration has a more significant effect on performance, rather than Lean management practices for MTO firms. They operationalised Lean using both internal and external Lean practices. The authors also included the effects of internal logistic integration and supplier rationalisation as "supply chain and manufacturing improvement initiatives". Performance, in this instance, is measured based on subjective responses concerning sales, return on investment and market share.

Adding to this, Jayaram et al. (2012) found comparable results in their study of TQM adoption in MTS and MTO manufacturers. They found supplier quality management, benchmarking on design management and process management as well as training on process quality to have a more significant impact on MTO firm quality performance than MTS firms. Godinho Filho et al. (2017) in their comprehensive study of quick response manufacturing (QRM) practices, found that adoption of management practices specifically associated with the reduction in lead-time (the key element of QRM) was the least adopted among their sample of organisations. Despite a considerably low sample (20 organisations), they also found evidence that adoption varied among the firms, suggesting that organisations follow their own path when it comes to QRM adoption and adapt/modify QRM practices to fit their needs (discussed further in Chapter 3).

Another stream of research associated with the design of enterprise resource planning (ERP) systems for HVLV manufacturing environments provides further insight into HVLV manufacturing management practice adoption. In the generation of a reference model for production planning and control in what they label as "versatile manufacturing" organisations, Persona, Regattieri & Romano (2004) found, through multi-case research, that customer requirements definition and commercial configuration of customer orders, supply and production planning as well as project evaluation and control mechanisms are key areas for improvement in HVLV environments. Key processes they recommend should be included in an integrated solution for production planning and control (PPC) are shown in Table 2-7 (on the next page).

Following on from this, Adrodegari et al. (2015) found that different processes were more critical than others in their case research of ETO production planning and control in an Italian context. They found support processes such as cost control, planning and project management to be critical software functionalities for ERP in a HVLV manufacturing environment. They also found quotation and order management as well as design and commissioning activities to be of comparable criticality. Their process reference framework encompasses the best-practices they deduced in lieu of the operational difficulties HVLV manufacturers were facing in their context. Keeping with this theme, Aslan, Stevenson & Hendry (2012) studied the applicability of ERP systems in a HVLV manufacturing environment. They took customer enquiry management, design and engineering, job entry, job release and dispatching, supply chain and customer relationships to be key defining characteristics of HVLV manufacturing operations – all with a heavy influence on the functionality requirements of ERP software in this context. Their work was further validated in an empirical study later on (Aslan, Stevenson & Hendry 2015).

Table 2-7 Key Production Planning and Control Processes for HVLV Manufacturing

Prod. Phase	Improvement Mechanisms
Pre-Production	• Customer requirements definition including rough-cut feasibility analysis, price delivery date estimation and negotiation before order confirmation • Commercial configuration of the customer order, translation of customer requirements into rough-cut technical requirements • Feasibility analysis, cost and delivery date estimation • Offer drawing up negotiation and order confirmation • Order placement, referring to the generation and release of an internal customer order according to each individual project.
Production	• Technical configuration of customer order including design of new functional groups, parts, components and generation of bill of materials and work routing • Customer order modelling for a multi-project environment including definition and codification of links between customer orders, line items and work orders splitting into macro-activities (WBS, OBS, PBS), milestone definition • Detailed master production planning capacity planning in a multi project environment referring to both the customer order as a whole and to the work orders it generates • Project requirements planning, including material and capacity requirements planning, production and purchasing order release
Post-Production	• Real-time supply and shop floor cost monitoring • Intermediate and final project performance evaluation

Source: adapted from Persona, Regattieri & Romano (2004)

Indeed, from this review one can quite easily grasp the variability and efficacy in adopting better management practices in HVLV manufacturing, given the often-conflicting evidence. The vast majority of studies would assume a stance on HVLV manufacturing performance as that synonymous with operational efficiency. Bar a few notable exceptions (the SHEN model and the associated workload control concept), most studies would also suggest that BMP do not seem applicable the higher along the customisation continuum you go. In fact, one study found that firms with higher levels of customisation simply did not adopt the majority of recommended BMP (Petroni, Zammori & Marolla 2017). Here, classic notions of ad-hoc problem solving and firefighting to “get the job done” appear to take centre stage as they did decades ago (c.f. Clegg & Fitter 1981).

Similarly, innovation (in the most general sense) does not appear to be explicitly considered as part of BMP either. This seems to be an interesting case, given workers in HVLV manufacturing firms often pride themselves in coming up with novel solutions (Clegg & Fitter 1981). In fact, innovation based on their specialist know-how is a clear competitive criterion for HVLV manufacturing (as mentioned in section 2.3.2). This, however, does not appear to be an isolated case in HVLV literature.

For example, Hicks, Earl & McGovern (2000) in a study of UK capital goods manufacturers, suggests that innovation in terms of the technical features within a particular product is not a crucial area of concern. The same study also suggests that a focus on reducing direct and overhead costs in the product design over technical (or high-tech) solutions is required in order for the manufacturer to compete on a global scale. The lack of focus on innovation can also be attributed to the fact that some HVLV manufacturers primarily focus on producing products based on customer's designs (Amaro, Hendry & Kingsman 1999; Konijnendijk 1994). Though, as was established in previous sections, managerial innovation is just as (if not more) important than technical innovation when it comes to improving competitiveness.

As discussed in the next section of this chapter, part of this discrepancy in efficiency driven operations and their capabilities in exploration can be accounted for by the drivers surrounding the adoption of BMP for HVLV manufacturing firms. Though, there still remain gaps which hinder our understanding of ambidextrous capabilities in HVLV manufacturing environments.

2.4.3 Drivers of Better Management Practices

When referring to better management practices, it is almost intuitive to assume these practices should lead to some sort of organisational improvement. But what does organisational improvement mean for HVLV manufacturers? This question, whilst fundamental in understanding the identification of BMP, brings forth some latent contradictions that require further discussion.

As discussed in depth by the extensive literature review conducted by Katic & Agarwal (2018) and in this chapter, some HVLV manufacturing authors would advocate to improve efficiencies in the operations and allow for a more predictable environment within which further efficiency-based capabilities can be developed, whilst others would take the opposite route and advocate for increasing flexibility in order to effectively "deal with" the high variety of products and, of course, there are a multitude of ways in which this can be achieved. It is quite interesting to note that whilst one would fairly easily assume they present two very different logics (one focussed on efficiency, the other on flexibility), the goal appears to remain the same i.e., to improve the ability of the HVLV manufacturer in nullifying the effects of uncertainties in relation to external demand for customised products. Although, this shouldn't come as a surprise given authors of HVLV manufacturing research would often base their research rationale on the operational difficulties associated with the complex and dynamic nature associated with adopting a customisation-based manufacturing strategy. These complexity and dynamism factors have been a driving force in contingency research related to management practices in HVLV manufacturing and are often depicted as the *sine qua non* of poor organisational performance.

Returning to Birkie & Trucco (2016) in their study of the impact of complexity and dynamism in implementing Lean in an engineer-to-order context, they summarised the contextual factors that relate to various areas of dynamism and complexity – these are shown in Table 2-8 (on the next page). In their action research project, Birkie & Trucco (2016) highlighted the main impetus behind the adoption of Lean practices in one of their case organisations was to improve the ability of the manufacturer to respond to rapidly changing customer requirements. This, along with the need to reduce costs to be on-par with market requirements, formed the basis of adoption. Petroni, Zammori & Marolla (2017) alluded to the fact that the ability to customise is only half the problem and is no longer sufficient in today's manufacturing environment. The use of WCM practices (of which Lean forms a large part) is said to help manufacturers both increase operational efficiencies and retain competitive parity through innovative management practices. Similar arguments arise in the more general studies on BMP (Bloom et al. 2017).

Some authors, on the other hand, take a more pragmatic approach and recognise that, yes, while these practices can be adapted to a certain context, that doesn't necessarily mean they should. That is to say, whilst the motivation remains relatively clear in the improvement of HVLV manufacturing operations and at the same time retaining/gaining competitive advantage, there are some tools which are more effective than others.

Hendry (1998), for instance, call these big impact and small impact changes. Big impact changes include improving visibility, exploiting capacity, improving information flow, improving planning and continual improvement efforts. Small impact changes, on the other hand, revolve around engineering and design activities. Despite this, it is interesting to note that improving engineering and design activities seems to be a major focus on HVLV manufacturing research in recent times (Cannas et al. 2018).

Table 2-8 Complexity and Dynamism Factors Influencing Engineer-to-Order Operations

Factors	**Sub factors**
Internal Complexity	• Product diversity and novelty
	• Production process interdependencies
	• Variety of interactions (i.e., decision making)
	• Composition of skills and competence necessary in the business
	• Organisational goals and objectives (inconsistencies of)
	• Short average product lifecycle
External Complexity	• Diversity of inputs
	• Diversity and number of customer segments for major products/services
	• Suppliers and subcontractor's involvement
	• Regulatory requirements
	• Extent of technological requirements to meet
Internal Dynamism	• Internal performance issues (technology workforce)
	• Rate of innovation
	• Changes in modes of production

Table 2-8 Complexity and Dynamism Factors Influencing Engineer-to-Order Operations (Continued)

Factors	**Sub factors**
External Dynamism	• Change in customer demographics
	• R&D expenditure changes
	• Demand unpredictability and instability
	• Suppliers and subcontractor's performance predictability
	• Predictability of competitors actions/pressure
	• Changes in regulatory requirements

Source: adapted from Birkie & Trucco (2016)

Such a pragmatic approach to BMP adoption also holds weight in comprehensive systems-based studies investigating the foundation of HVLV manufacturing hardship. Fox et al. (2009), for example, also wished to investigate the impact of dynamism and complexity on what they called project-based manufacturing operations. In their study, they found rework to be a function of the high potential for human error, limited potential for application of technologies, unpredictability in pre-production processes, little to no repetition of post-production design uncertainty and ultimately allowing the individual customer authority over design and production activities. It is also interesting to note that overtime - a strategy commonly employed by HVLV manufacturers to achieve a form of flexibility (Zorzini et al. 2008) - was found to be a function of rapid rescheduling of work, changes to product components, changes to product functionality, changes in market trends reported to the brand holders and ultimately the changes in priorities of the end users, potentially extending HVLV manufacturing problems to beyond their direct customer.

Another recent study by Mello, Strandhagen & Alfnes (2015) which investigated the factors affecting coordination in ETO supply chains found the integration of engineering and production, size of the manufacturing job, extent of concurrent engineering and production, maturity of the design and technology, collaboration between project partners, customer order changes and production capabilities have an effect on an ETO manufacturers ' coordination efforts. In addition, Land & Gaalman (2009) investigate the difficulties associated with production planning and control (PPC) in MTO SMEs and found that, for the most part, poor performance can actually be predicted well before an order even hits the manufacturing floor. They found that decisions made after the order has actually been released to the shop floor are made only to deal with problems in scheduling that occurred much earlier. Apart from the more company specific issues affecting PPC performance in the organisations studied in this case-based research, Land & Gaalman (2009) found that inadequate planning overviews for sales decisions and uncontrolled delays at the pre-production stage (stemming from the engineering and design departments) were common to all seven organisations studied. Little et al. (2000) also found issues associated with insufficient product specification and configuration at the enquiry stage, poor master production scheduling, lack of design planning and monitoring, use of incorrect planning mechanisms (the use of MRPII when project requirements planning is enough), poor assembly planning, poor shop-floor scheduling, high rework, later deliveries and a lack of an integrated approach to the management of all processes to be major deficiencies in their analysis of 13 ETO manufacturing cases.

2.5 Ambidextrous Capabilities and Better Management Practices in HVLV Manufacturing

Whilst there does not appear to be too much emphasis in literature regarding ambidexterity, BMP and HVLV manufacturing (Katic & Agarwal 2018), there is certainly an implicit emphasis that stems from the need to effectively combine coordination, control and flexibility. In this case, literature points to the interplay between efficiency-driven, variation reducing management practices and those related to flexibility, innovation and exploration.

Some of the earlier work in this domain concerned the difficulty of coordination at the project, program/portfolio and organisational level. For example, Caron & Fiore (1995) focus on the tensions that exist between innovation and manufacturing and how such tensions can be minimised through a systematic approach to ETO project coordination. They cite organisational design as a major factor contributing to poor integration of innovation activities and manufacturing – referring primarily to the poor use of information between functions and the pitfalls associated with a sequential approach to product development. Caron & Fiore (1995), in developing a holistic project management approach that attempts to integrate innovation and manufacturing activities, provide five guidelines for ETO organisations in helping them enact their model. From an organisational point of view, they suggest the creation of a dedicated project-based office for the integration of non-standard and standard subsystems (the former, they suggest, should be leveraged to gain efficiencies using “traditional” production planning and control mechanisms). As such, at the project-level they suggest separating standard and non-standard products and developing a manufacturing-based work breakdown structure and a development-based work breakdown structure. They also recommend designing products based on modularisation and standardisation as much as practicable.

Such an approach as that described in the preceding paragraph also seems to resemble a focus on structural ambidexterity with its emphasis on segregating exploitative and exploratory activities – using project management to effectively link the two. This is also apparent in a related work where Konijnendijk (1994) focusses on the divide between marketing (sales) and manufacturing functions and the coordination mechanisms that can help integrate the two. When referring to this functional divide and its impact on innovation the author mentions:

“A good fit with production capabilities does not mean that the product cannot be innovative, innovativeness can be a major strength of an ET0 company because of the high capabilities of engineers. Typically, when the number of orders is high, there will be a drive for standardization, not accepting innovative customer orders and produce as efficient as possible, when the number of orders is low the company will accept almost anything. When sales is very much pressured for sales turnover by management, it will be more focused on market fit than on technology fit. The impact of a customer order may be large enough to have top-management involved in order acceptance. This means that top-management engages in operational tasks or stated differently …

“The use of rules for coordination in the form of design standards is very limited. Standardization may seem attractive because it provides people with something to hold on to, to gain experience and increase efficiency, but standardization fails to balance innovativeness and efficiency or market requirements and production capabilities.

Standardization can be used only where variation is predictable. Standardization easily leads to a focus on efficiency alone" (Konijnendijk 1994, p. 24)

This echo's the concerns of Keegan & Turner (2002), where – in a study of innovation in project-based organisations – they found that the project-based nature of work did not accommodate an environment that fostered innovation. Innovation was not seen as important as it 1) was too costly and required strict management, 2) it disrupted existing positions and relationships and 3) was only ever useful if the customer explicitly asked for it. It is also reminiscent of the early works on ambidexterity where scholars including March (1991) and Levinthal & March (1993) exemplify how organisations naturally like to err on the side of efficiency rather than exploration.

Interestingly, literature that appears to tackle the HVLV manufacturing dilemma presented here seems to focus on increasing the certainty associated with the customisation-based manufacturing strategy. The logic, as will be discussed in the proceeding paragraphs, is that there are greater opportunities for growth and profitability if the HVLV manufacturer begins to standardise some of its operations. This standardisation procedure is said to improve lead-times and result in achieving budget goals as well as eradicating the dichotomy that exists between flexibility and efficiency in this domain – albeit by removing some of the flexibility from the equation. Indeed, this logic stems from the notion of mass customisation.

Mass customisation, in general terms, involves producing a customised product at a price resembling that of a standard product (Ahstrom & Westbrook 1999). This concept has only just started to emerge in environments resembling HVLV manufacturing, given the increasing pressures to perform in todays' competitive markets (Thomassen & Alfnes 2017). Here, HVLV manufacturers are being urged to consider adopting modular designs, creating a solution space for these designs and become more streamlined by way of customisation processes (Haug, Ladeby & Edwards 2009). However, whilst certainly effective, this approach has significant implications for HVLV manufacturers.

Firstly, being SMEs such firms (particularly in times of economic hardship) also cannot afford to turn away jobs which may require far less (or far more) engineering or design work (Lorentz et al. 2016). It is also not uncommon for these types of firms to offer a standard product range which can be “personalised” to suit specific customer requirements (Adrodegari et al. 2015). Therefore, within the same firm at a particular point in time, there can be any number of different products (with varying degrees of customisation) on the same production floor. Hence, a unique situation occurs where standard products and highly customised products are being produced using the same production infrastructure.

Now, according to literature on order-winners and competitive priorities the manufacturer will both be competing on the basis of customisation on one product, and on the basis of price and lead-time on the other – somewhat going against the central rules of manufacturing strategy (Skinner 1974). This not only poses challenges in relation to the production function of the firm but also poses a key strategic issue, discussed next.

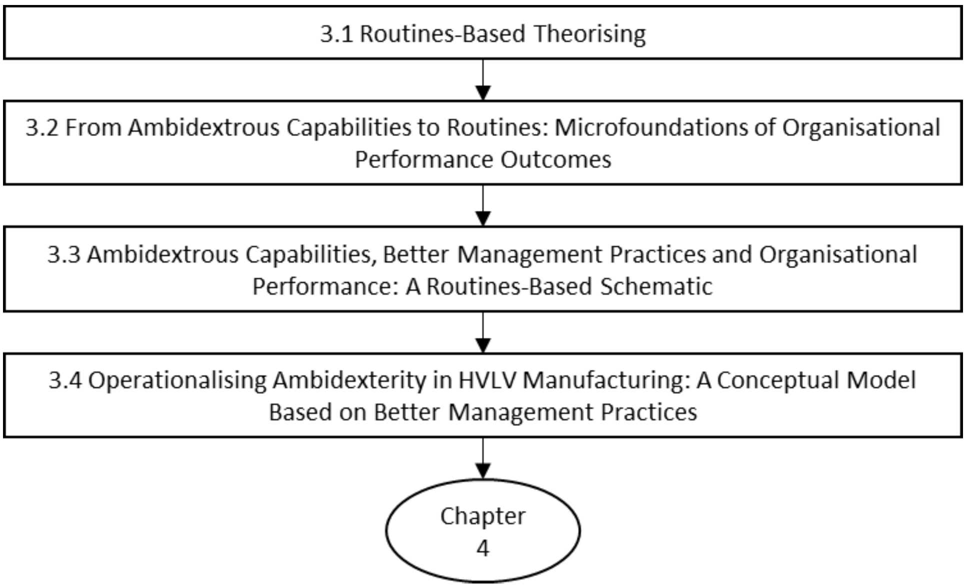
If the manufacturer chooses to “manage” the variety of products being produced (such as that by mass customisation) they will profit from increased efficiencies in the production function brought about by various standardisation measures, though at the same time also have to fundamentally change their business model to suit and risk losing the competitive edge brought about by their customisation abilities - effectively underutilising the resources that make this possible. On the other hand, if they maintain the HVLV manufacturing strategy and produce anything they have the operational capability and know-how to do; the manufacturer will maintain high levels of customer satisfaction (Zhang, Vonderembse & Lim 2003) and innovation capabilities (Haug, Ladeby & Edwards 2009), though encounter problems with long lead-times and cost-overruns (Land & Gaalman 2009). If the previous scenario was adopted, the firm will no longer be identified as a HVLV manufacturer, as such the question becomes not how to better manage the variety of products - as is commonly asked in mass-customisation literature (Saad et al. 2006; Thomassen & Alfnes 2017) - the question should be how you better manage the organisation to take advantage of these unique capabilities.

This is where the literature on better management practices appears to earn its keep. The literature review revealed the main impetus behind their adoption was in somehow leveraging the environmental dynamism that surrounds HVLV manufacturing in general. However, the results are mixed, and their recommendations appear fragmented according to differences in firms undertaking highly customised work and those that do not. In addition, whilst an implicit emphasis on the role of balancing variation inducing and variation reducing activities is apparent in the goals of HVLV manufacturing, their impact in leveraging these contradictory objectives appears uncertain as well. Given the relevance in today’s markets, an understanding of how HVLV manufacturers actually leverage their contradictory demands in exploration and exploitation through better management appears a timely and worthwhile endeavour. Building off this need, the next chapter now undertakes a theory building exercise in explaining such a phenomenon.

Chapter 3 Theoretical Foundations

This chapter starts by elaborating on the routines-based view of organisation as the bedrock upon which the argumentation in this thesis is founded. Because it is so intuitive to understand and versatile in application, the theoretical boundaries in this perspective are quite blurred. Thus, this chapter begins by tracing its roots back to the notion of competitive advantage through the resource-based view. The transition from resources to routines and finally towards organisational performance outcomes is articulated by building a high-level schematic grounded on the routines-based view. This schematic outlines the mechanisms driving the relationships hypothesised in this research. Finally, this chapter ends by developing a conceptual model forming the basis of the research efforts and outlining the hypothesised links between ambidextrous capabilities, better management practice routines and HVLV manufacturer performance. An outline of this chapter is provided in Figure 3-1.

Figure 3-1 Outline of Chapter 3



3.1 Routines-Based Theorising

This section elaborates on the routines-based view of organisation adopted in this thesis - tracing its roots through various theories of competitive advantage, starting with the resource-based view.

3.1.1 From Resources to Routines

The resource-based view (RBV) of competitive advantage - though originally brought forward by the likes of Penrose (1959), Wernerfelt (1984) and Rumelt & Lamb (1984) - is often attributed to two seminal works by Prahalad & Hamel (1990) and Barney (1991) (Newbert 2007). By taking an “inside-out” view of strategic management, Prahalad & Hamel (1990), though presented in a practitioner-led manner, were able to draw mainstream attention to the importance of internal capabilities in shaping competitive advantage for organisations. In their work, they demonstrated the importance of not relying purely on the attractiveness of markets towards competitive advantage, rather cultivating and effectively combining core competencies through suitable structural arrangements and management mindset in developing highly innovative products and services that help differentiate an organisation from its competition.

Barney (1991), whilst demonstrating the effects of the perfect market assumption in industrial organisation economics, put forward the notion that in order for resources to be a source of competitive advantage they need to be valuable, rare, imperfectly imitable and not substitutable. He argued, based on the assumption that organisational resources are heterogenous and imperfectly mobile, that whilst holding valuable and rare resources may be a source of competitive advantage in the short-term, organisations should seek to build resources that are hard to duplicate and can’t be gained through other means in order to sustain competitive advantage in the long term (Dierickx & Cool 1989). Upon further work which explicitly separated resources from competencies (the latter making use of the former in order to gain competitive advantage), this framework was later extended to include organisational factors which helped leverage resources in building capabilities that actually provided value for the organisation (it’s one thing to build capabilities, it’s quite another to make the most out of them). Subsequently, the VRIO framework ("O" for organisation) has since become a core concept in organisation strategy practice and research.

In a similar vein, other researchers who also recognised the fact that resources and capabilities need to be built, sustained and leveraged over time took a more evolutionary approach in an attempt to explain the process in which competitive advantage can be sustained (Teece, Pisano & Shuen 1997). The dynamic capabilities approach is one such theory which takes into consideration the dynamic nature of markets and the fact that capabilities are not static - they need to be constantly adapted, integrated and reconfigured according to those market dynamics (Teece 2017). Whilst the roots of the RBV described in the previous paragraphs appear Ricardian in that they focus on what Makadok (2001) label as "resource picking", the dynamic capabilities perspectives on the other hand takes on a more Schumpeterian approach in that they focus on the process of "capability building" where capabilities refer to a firm's ability to deploy resources[4] (Amit & Schoemaker 1993). Here, it is in the process of doing that gives rise to sources of competitive advantage (Ketokivi & Schroeder 2004). In addition, whilst it seems reasonable to assume dynamic capabilities are those related to change, it is not so clear-cut in that change is also a normal part of everyday operations – there is always something changing at some point in time. Indeed, if you take a Neo-Darwinian view of organisational strategy, there is never actually any time that an organisation is not in a state of change (Stacey & Mowles 2016).

Besides the definitional issues associated with what actually constitutes dynamic capabilities, what is important to remember at this point is that it is still fundamentally a theory a strategic choice (Stacey & Mowles 2016). In a recent article by one of the original proponents of dynamic capability theory, Pisano (2017) goes back to the original premise of dynamic capabilities as helping make sense of how capabilities contribute to competitive advantage in dynamic markets. In his article, Pisano (2017) places focus on the capability investment decisions organisations make in order to gain competitive advantage. Here, he outlines the importance of discerning between general-purpose capabilities (such as human resource management, performance management and so forth) and market-specific capabilities (such as car design) in developing what he labels

[4] Note this is a more generalised conceptualisation of capabilities than that typically referred throughout this thesis.

a "capability strategy" – moving away from the dominant research on dynamic capabilities as key to adapting to different market conditions, and back to the fundamental strategic question of which capabilities are going to contribute towards competitive advantage and what are the implications of these decisions.

3.1.2 Conceptual Considerations in Resource-Based Theorising

As is evident from the discussions above, the resource-based view of competitive advantage is inherently an efficiency-driven theory designed to explain differences in organisational performance between firms by looking inside the organisation (Peteraf & Barney 2003). This means everything happening outside the firm is essentially kept constant – customer/supplier dyads, collaboration or collusion amongst firms, differences in policy arrangements that effect industry as well as other external phenomena are effectively ignored. Whilst, this can also be seen as a good thing (Peteraf & Barney 2003), as a standalone theory it does leave a lot to be desired.

Besides the fact that the RBV can be considered a natural extension of the market-based view (Barney 2001b) - or vice versa (Mahoney & Pandian 1992) - and that spin-off's from the RBV including dynamic capabilities (Teece, Pisano & Shuen 1997), knowledge-based view (Eisenhardt & Santos 2002) and network-based view (Lavie 2006) all require (in some way or another) some consideration of market-based forces, recent developments in the RBV field have also been met with significant insights when juxtaposed with other research fields such as ambidexterity (O'Reilly & Tushman 2008) as well as management practice research (Ketokivi & Schroeder 2004) (both of which form the basis of this thesis). Though, like most theories that have reached a critical stage in their maturity, the RBV isn't without its critics.

Early debates about the efficacy of the RBV surrounded its validity as a theory – targeting the seemingly tautological nature of its core arguments, underdeveloped definitional issues and, indeed, its usefulness to practice (Barney 2001a; Priem & Butler 2001). A more recent review on the critiques associated with the RBV suggests most of these concerns are now effectively null, though others still remain an area of interest (Kraaijenbrink, Spender & Groen 2010). This article suggests, for instance, the questions of managerial usefulness, limited application in different environments and the validity of sustainable competitive advantage as a strategic tool are essentially well accounted for (though they do mention issues pertaining to the efficacy of the RBV in SME environments where owners may not seek to gain competitive advantage or grow, in this instance the usefulness of the approach comes into question when owners are happy with the way things are). The definitional problems associated with the use of the VRIN/O framework, in particular the core concept of "value" still appear problematic (Peteraf & Barney 2003). In light of the research presented in this thesis, there are two important implications of these potential downfalls.

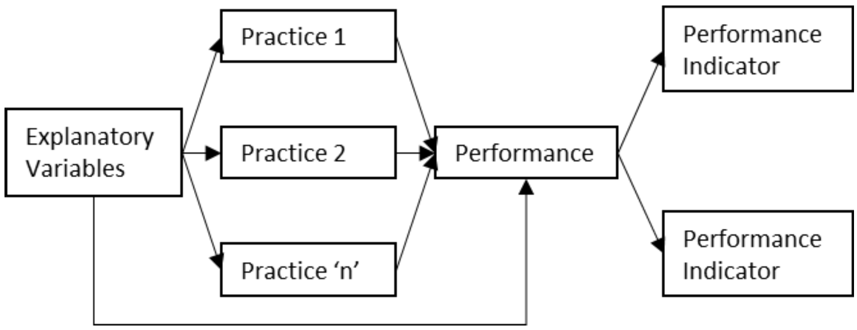
The first is surrounding the factors that actually aid organisational performance outcomes where questions have been raised about whether the VRIN/O framework is sufficient and/or necessary. One of the main issues is that most studies seemed to focus on the adoption and adaptation of a particular resource and thus essentially implying "cherry picking" of certain resources is enough to sustain competitive advantage. Whilst, this is certainly not true given the importance of actually deploying resources (as mentioned earlier), it is still very much being analysed at the deployment of individual resources rather than its interaction with others. As many researchers have asserted, it is not necessarily the value of any one resource that matters, rather it is the synergistic effects of multiple resources that really makes the difference in sustained competitive advantage (Teece 2017) – something we return to in Section 3.2.5.

In addition to this, and following on from the concerns surrounding the identification of resources, the RBV does not seem to take into consideration the effect of resources that are very well imitable and yet have a significant positive impact on firm performance (Bromiley & Rau 2014). Well known management philosophies including Lean and TQM as exemplars of "best-practice" are not necessarily considered resources that aid in achieving competitive advantage (violating the rule of inimitability and perhaps non-substitution under some circumstances), yet nonetheless are quite well known to improve organisational performance. However, there are also instances of firm performance variation within organisations that have implemented such philosophies – this comes down to *how well* these practices have been adopted (going back to the RBV).

The second issue is surrounding the people actually using these resources – people with agency, individuality and creativity. It has been argued the RBV doesn't quite take into consideration the characteristics of individuals and, in particular, the effects of cognition, judgement and mental models of key decision makers. Indeed, this has spawned some research into the micro-foundations of RBV (Barney, Ketchen Jr & Wright 2011) though as we've noticed by the continued calls for research into these areas, this is still in dire need for further investigation.

In operations management (OM) literature, these seemingly fundamental problems prompted discussions about the efficacy of the RBV. Whilst a recent review of the RBV in operations management literature by Hitt, Xu & Carnes (2016) found that the RBV – when combined with other theories such as network theory, institutional theory, transaction cost economics and the relational view - helped extend OM theory in disciplines such as supply chain management, operations strategy, innovation and performance management, they also concede that authors adopting the RBV should be mindful of its limitations (particularly with regards to theoretical ambiguity). Arming themselves with these limitations, Bromiley & Rau (2016b) proposed the adoption of the practice-based view (PBV) which, as shown Figure 3-2, they claim is a " simpler and better alternative for operations management where scholars attempt to explain the entire range of firm and unit performance based on transferable practices" (Bromiley & Rau 2016b, p. 95). In their words, the RBV seeks to explain sustained competitive advantage based on things that are hard or impossible to imitate, whilst the PBV attempts to explain performance based on things that are imitable (Bromiley & Rau 2014, 2016a). The differences are quite clear, rather than referring to sustained competitive advantage (something notoriously difficult to measure) they adopt organisational performance as well as including what they proclaim to be essentially any practice (whether it be imitable or not). In addition, though not evident in this distinction, the PBV also takes into consideration the adoption of practices which can be both beneficial and detrimental to firm performance. The PBV also leans quite heavily on the behavioural theory of the firm (c.f. Franco & Hamalainen 2015) as well as in evolutionary economics by taking into consideration path dependence and other human related factors that have some influence on the (successful) adoption of certain practices (Bromiley & Rau 2016b).

Figure 3-2 The Practice-Based View of Organisation



Source: adapted from Bromiley & Rau (2014)

Whilst the PBV seems to plug some of the gaps of the RBV where Hitt, Carnes & Xu (2016) have even suggested the two can be complimentary (rather than necessarily opposing, as Bromiley & Rau (2014) would suggest), there are concerns over its credibility as a theory as well.

Jarzabkowski et al. (2016a) and Jarzabkowski et al. (2016b) in particular draw on the vast tradition of strategy as practice (SaP) research in highlighting an apparent oversimplification of "practices" as a concept. They claim the manner in which management practices are conceptualised does not pay enough attention to complexities in their adoption and diffusion throughout organisations. Management practices are part of a highly interconnected "management system" consisting of individuals enacting such practices - individuals with inherently different mental models and experiences are using different practices simultaneously in order to achieve a certain outcome within a particular organisational context. Here, the what (practices), who (individuals) and how (processes and context) are so intertwined that the variable-based reasoning of Bromiley & Rau (2014) can lead to serious misattribution of outcomes and even misleading advice for managers. It is here that a routines-based view comes into play.

3.1.3 A Routines-Based View

From the brief characterisation of routines in section 2.2.2 of the previous chapter, one gets the impression that we certainly are not just talking about rules of thumb, policies or standard operating procedures. Sure, this is one way of characterising routines (c.f. Eisenhardt & Martin 2000), but it isn't the only way. As "repetitive, recognisable pattern[s] of interdependent actions, involving multiple actors" (Feldman & Pentland 2003, p. 95), you start to paint the picture of routines as almost "living" entities, interacting with its environment and fellow routines. This also seems to portray a sense of rigidity, stability and certainty as they are adopted by human actors to undertake tasks within which the outcome should be the same every time. However, todays' routine theorists would beg to differ.

Routines aren't just mindless, autonomous activities that occur without much conscious thought (Cohen et al. 1996). They also hold generative qualities in the emergence of new and oftentimes unexpected outcomes (Feldman et al. 2016). In fact, inertia and rigidity as central to the study of routines can actually be a significant source of variation (Yi, Knudsen & Becker 2016). Part of this reasoning can be explained in the emerging field of routine dynamics where continuous interactions between routines, practices and process are not only critical, but inseparable (Howard-Grenville & Rerup 2016). Here, routines are not just things that can necessarily be engaged, but something that individuals actually do. Thus, they are a process which, like any other process, contain various parts and emerge through activities happening in time and space as individuals connect with other individuals and artefacts to perform certain tasks. These "processes" happen in context, thus at a certain place, in a certain time and in a certain way. Because they occur in situated action, there's no guarantee that the same process is going to have the same outcome at a different time. People matter, and their skills, knowledge and personal intentions all have an impact on the outcome of a particular process (or in our case, a management practice).

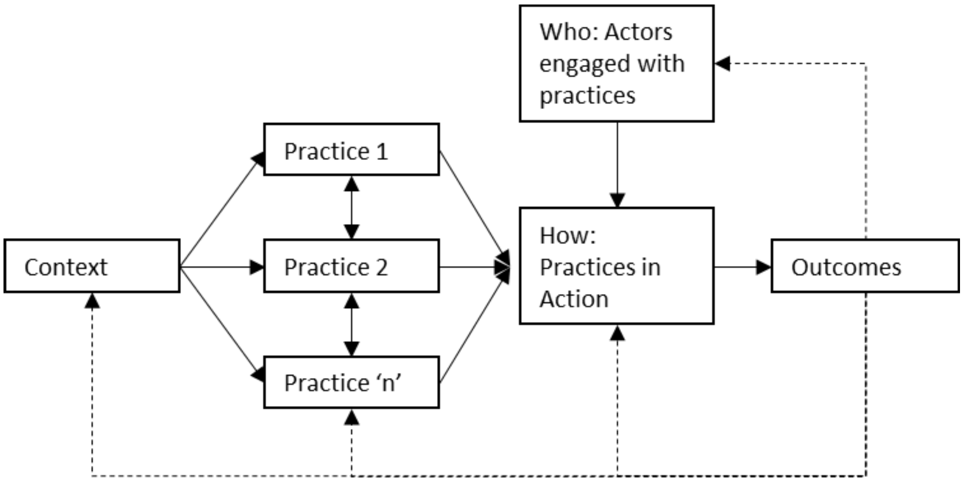
This line of reasoning paved the way for a routines-based perspective of organisational performance to emerge. In this perspective, it is the management practices organisations adopted as well as the manner in which they are adopted that move front and centre in explaining firm-level performance heterogeneity (Ketokivi & Schroeder 2004). As Ketokivi & Schroeder (2004, pp. 173-4) mention:

"[when] we walk into a manufacturing plant we see people and machines, but above all, we see people and machines executing certain routines. Machines and even people may appear similar going from one electronics assembly plant to another, however, the routines may appear quite different, with respect to their existence, content and intensity."

In this study, Ketokivi & Schroeder (2004) draw complementarities between the RBV and routines-based thinking by outlining the fact that both place a focus on value creation processes, and that routines have contingent value in the manner they are adopted, when they are adopted, why they are adopted and where they are adopted (similar to the phenomena described in the preceding paragraph). However, the authors still seem to adhere to the notions of competitive advantage in their reference to routines as being difficult to imitate in the short term, given they are a function of process and bound by path-dependence and inertia.

This thesis adopts a more liberal approach in the perspective on organisational performance and the role of routines. We don't necessarily constrain ourselves to notions of competitive advantage (indeed this is not the impetus of this research), rather we intend to investigate the operationalisation of ambidexterity, given the HVLV manufacturing context. Thus, extending the theorising by Ketokivi & Schroeder (2004), we include all possible means of adoption, selection and outcomes of management practices, given organisational performance is a function of the core characteristics in HVLV manufacturing (more on this later in this chapter). Thus, returning to the contemporary understanding of routines, we centre our theorising on the integrative model of strategy practice illustrated by Jarzabkowski et al. (2016b) and shown in Figure 3-3.

Figure 3-3 Integrative Model of Strategy Practice



Source: adopted from Jarzabkowski et al. (2016b)

Here, Jarzabkowski et al. (2016b) adopt a complementary practice-based lens that pays particular attention to what, who and how certain management practices are adopted. The practices, in this instance, represent the "what". These can include the typical management practices specified in Ketokivi & Schroeder (2004), those by Bromiley & Rau (2014) and indeed those in the extensive mass-scale management practice studies of Bloom et al. (2017). The "who" and the "how" represent the people enacting the management practices and the manner in which they do this (clearly, someone with more skill at a certain task will perform it better than someone who doesn't necessarily have the same skill – more on this in Section 3.2.6). The outcomes are quite unique in this model, as in the routines-based perspective, the outcomes can range from an understanding of organisation-wide performance all the way to the emergence of new practices. The key in their model, however, is not necessarily the "what", but the "who" and the "how".

In a practice-perspective, as in the routines-based view, the practices adopted are so intertwined with the people adopting them and the manner in which they are adopted that trying to pull them apart makes little sense[5] (Jarzabkowski & Paul Spee 2009).

[5] In the model shown in Figure 3-3, the "how" and the "who" are shown as separate boxes. This is only to demonstrate their interdependencies. This is also part of the reason why Jarzabkowski et al. (2016b) also referred to this as a "schematic" rather than a full-fledged model.

Management practices are selected, adopted and enacted under certain circumstances, motivations and may even be used for different purposes (Jarzabkowski & Kaplan 2015). Management practices don't just happen automatically, they are embedded in context as well as in the minds and actions of individuals whom, for one reason or another, may not even know they are doing them (Schatzki 2012). As Jarzabkowski & Paul Spee (2009) stress, management practices are "less something that is employed by an actor and more something that is constitutive of acting within the world" (p. 19). This, of course, includes their role in the overall management model of the firm where they interact with other practices, some more effectively than others (Birkinshaw & Ansari 2015).

This brings us to an important conclusion in this rather high-level overview of the routines-based view. Whilst we can now appreciate the importance of routines in understanding the mechanics of organisations by way of practices, context and potential outcomes, we still don't have a complete picture of how routines (or practices) and capabilities interact to form organisational performance outcomes, For this, we now turn to the micro-foundations of the capability, routine and performance relationships.

3.2 From Ambidextrous Capabilities to Routines: Microfoundations of Organisational Performance Outcomes

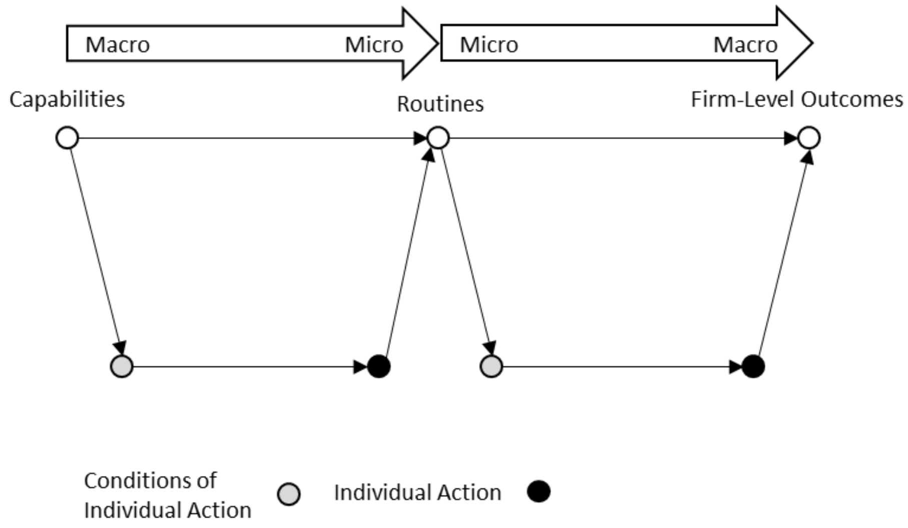
The microfoundations "movement" has recently gained traction in helping explain key organisational phenomena in capability building (Felin et al. 2012; Gavetti 2005), resolution of organisational paradox (Andriopoulos et al. 2018; Miron-Spektor et al. 2017) and many others in strategic management (Felin, Foss & Ployhart 2015). The popularity of this approach is also recognisable in the various forums and special issues on the subject (Felin, Foss & Ployhart 2015). Thus, it also comes as no surprise to see the ideology making its way into explaining heterogeneity in organisational-level performance outcomes, particularly by way of the link between capabilities and routines (Abell, Felin & Foss 2008).

Microfoundations typically aim towards "locating (theoretically and empirically) the proximate causes of a phenomenon (or explanations of an outcome) at a level of analysis lower than that of the phenomenon itself" (Felin, Foss & Ployhart 2015, p. 586). This involves investigating the core effects of "lower-level" phenomena on "higher-level" outcomes – whether they be individuals, routines, structures or otherwise (Teece 2007). The selection of each phenomena under consideration is usually driven by the nature of the research, as attempting to cover all possible factors that may pose as microfoundations of a particular organisational phenomenon may not be practicable (Felin, Foss & Ployhart 2015).

In the case of identifying the microfoundations that link routines and capabilities to organisational performance outcomes, the approaches and perspectives are manifold. As is evident from the literature review in section 2.2, a hierarchical perspective between capabilities and routines (where the later are microfoundations for the former) is often adopted. There are also evolutionary (Nelson & Winter 1982) as well as behavioural and cognitive (Gavetti 2005) approaches to this. Though a great deal of research has been undertaken in this department, establishing a link between routines and capabilities remains, in actual fact, a significantly challenging exercise (Felin, Foss & Ployhart 2015).

In explaining the link between capabilities, routines and organisational outcomes, we adapt the Coleman & Coleman (1994) "bathtub" model used to elicit these links in Abell, Felin & Foss (2008) as well as Felin, Foss & Ployhart (2015). As shown in Figure 3-4, the links between macro-level capabilities, micro-level routines and macro-level firm outcomes are split into two "bathtubs". The direct links between them are shown on the top arrows whilst the indirect links (sometimes referred to individual "microfoundations") are shown on the bottom half of the diagram. The sections to follow are split between the capabilities and routines link (on the left) and the routines and firm outcomes link (on the right). As will become evident, explaining the direct links without reference to individual action and practices could result in incomplete theory.

Figure 3-4 Explaining Routines and Explaining by Means of Routines



Source: adapted from Abell, Felin & Foss (2008)

3.2.1 Connecting Macro-Level Ambidextrous Capabilities to the Adoption of Micro-Level Routines

We defined capabilities as “high-level routine[s]… that, together with its implementing input flows, confers upon an organization’s management a set of decision options for producing significant outputs of a particular type” (Winter 2003, p. 991). This has important implications as:

1) It suggests that capabilities exist on a higher-level than routines (i.e., is formed by lower-level routines)
2) Routines are not the only “inputs” – competencies also draw on skill, knowledge and governance mechanisms, for instance(Teece 2007).
3) Is an effectively managerial construct involving actual decision-making, thus is not purely a function of environment or context (Pisano 2017) – drawing it squarely in the realm of strategic management (Felin, Foss & Ployhart 2015).

Thus, ambidextrous capabilities are a function of “lower-level” routines that, together with other “inputs”, including structure and governance mechanisms, enable an organisation to carry out exploration and exploitation simultaneously through effective leadership and decision-making.

In addition, because it is a dynamic capability involving notions of change and adaptation to meet different market requirements, ambidextrous capabilities also require a keen understanding of existing core-competencies to enable appropriate selection, integration or removal of exploitation and exploration routines. Thus, ambidextrous capabilities are seen to influence lower-level exploratory and exploitative routines and effective changes lead to better organisational outcomes. This, however, may be too simplistic an assumption.

Drawing a direct link between more macro-level phenomena in capabilities and the adoption of micro-level phenomena such as routines risks oversimplifying the emergent properties of both, and worse still, risks misattribution of effects given other organisational phenomena may also be at play. Some level of "black boxing" activities such as this is indeed acceptable to such an extent as the boundary surrounding the adoption of routines and the reduction towards microfoundations isn't necessarily required (Felin, Foss & Ployhart 2015). Nevertheless, in the context of this present research (as was evident in the literature review) we uncovered multiple contingencies that need to be addressed, both in the interest of theory building as well as in clarifying the role of routines as both *explananda* and *explanans* for capability formation and organisational performance outcomes (Abell, Felin & Foss 2008) – given also the continued scarcity on the subject in extant literature (Felin, Foss & Ployhart 2015).

3.2.2 Characteristics of Routines and Capabilities – Salient Tensions

The first of these contingencies relates to the characteristics of routines and capabilities themselves. Routines, for instance, can be considered highly rigid in environments where precision and hard guidelines are the norm (aerospace and pharmaceuticals). In other circumstances, the routines have room to move and we begin to see differences between the performative and ostensive aspects of routines (i.e., what you think the routine should be vs. what it really is). In terms of capabilities, there remains a grey area as to the identification of operational and dynamic capabilities where there are instances of operational capabilities holding dynamic qualities and the ongoing discussions concerning improvisation and problem solving as “capabilities”(Winter 2003).

In HVLV manufacturing, exploitative and exploratory routines are subject to the same inconsistencies. Given the project-based nature of operations, HVLV manufacturers may require both strict control mechanisms with regards to meeting quality targets in safety-critical projects whilst simultaneously allowing for flexibility in both the production system and in the design of the product. This is required given rework by way of customer demands occurs frequently for long-range projects spanning multiples months to years. This interplay between control and flexibility is rampant in HVLV manufacturing literature as a main area of poor organisational performance. It is here that HVLV manufacturers are urged to reduce variation towards more predictable operations where themes including mass customisation have been brought forward (Thomassen & Alfnes 2017) as well as modular designs and the predictive forward design processes that has only just begun to emerge (Cannas et al. 2018). However, where the manufacturer is by definition a manufacturing-service provider, the context is completely different and mass customisation and pre-design work are quite often not be feasible (Haug, Ladeby & Edwards 2009).

3.2.3 Characteristics of Routines and Capabilities – Latent Tensions

The second contingency relates to the design of the HVLV manufacturer as an inherently flexible organisation. As suggested in the previous Chapter, the fact that the HVLV manufacturer is built as a flexible organisation can actually preclude it from developing and utilising its ambidextrous capabilities. Above the more salient and high-level understanding of governance mechanisms and organisational structure on both the adoption of management practices and on organisational performance outcomes, there are also those more latent contradictions involved concerning microfoundations and the unintended consequences of organising in such an environment. Take the following case study by Clegg and Fitter (1981) as an example.

The case company was a manufacturer of highly customised capital equipment and was operating during periods of variable demand which had an influence on the performance of the organisation. The manufacturer has a proud history of producing high quality products and prides itself on the technical abilities of its employees. It was bought-out by a larger corporation who put pressure on the manufacturer to increase the performance of the manufacturing function whilst presumably increasing sales of these highly customised products. These “pressures” were seen to contribute to far-reaching organisational problems where interpersonal conflict, heightened stress levels and defensiveness resulted in poor organisational performance. The managers had no time to plan given they were too busy fighting fires as they were experiencing these changes as a result of the tensions.

Whilst there could be many reasons for this - including perhaps the organisation fell into a “simplicity trap” (Clegg et al., 2002) whereby good organisational performance was seen to come from giving the customer what they asked for when they asked for it. This could create an inertia leading the organisation to continue exploiting resources and get better at it – the logic will seem to be, better delivery equals more business. We contend, however, that the role of unintended consequences of individual behaviour is not taken seriously here. This has resulted in the organisation not being able to cope with the constant tensions that were perceived and materialised in the form of poor organisational practices – including falling into simplicity traps.

In the case study described earlier, the parent organisation was so concerned for the performance of the manufacturer that they held the senior managers personally responsible for different performance criteria. This led to the senior managers “tightening control” over their respective business units. In addition, bonus schemes were set-up to help motivate employees. Both of these had unintended consequences whereby tightening control led to all the people down the hierarchy to come under more pressure to perform and at the same time given less responsibility – leading to decreased quality of communication, alienation and rogue functions (creating their own rules). Bonus schemes also led to further organisational deterioration through increased fragmentation between and within functions – as Clegg and Fitter (1981) say “making someone personally responsible for something makes him even more protective, defensive and increases parochialism”.

Whilst observing or foreseeing unintended consequences is quite a difficult task given the complex nature of organisations in general and the many interdependencies of their constituent elements – it does not change the fact that tensions are in-fact embedded in the interdependencies between seemingly contradictory elements and that efforts to manage these tensions can bring about unintended consequences during synthesis (Hargrave and Van de Ven, 2017). According to Lewis (2000), responses to tensions can lead to positive or negative reinforcing cycles. In their dynamic equilibrium model of organising, Smith and Lewis (2011) suggest that environmental factors including plurality, change and resource scarcity (all observed in the case study example) make latent tensions salient and when individuals are too focussed on consistency, experience anxiety, defensiveness as well as forces for inertia in organisations (as described in the cases by Keegan and Turner, 2002) can lead to these negative reinforcing cycles of poor management practices – driving unintended consequences. This leads us to the final, and perhaps more critical contingency – that related to synthesis.

3.2.4 Connecting Ambidextrous Capabilities to Micro-Level Routines Through Synthesis

Though clarifying the link between capabilities in routines still leaves much to be desired in literature, there is an emerging argument that an organisation has the capability to enact routines in so far as it can "repeatedly internalise such externalities (i.e., realise synergies)" (Abell, Felin & Foss 2008, p. 490). This is also the case for ambidextrous capabilities.

Traditionally, ambidexterity literature would suggest to separate the routines of exploration and exploitation either through time, space or both (Gibson & Birkinshaw 2004; O'Reilly & Tushman 2008). More recent approaches aim to find synergies in both seemingly incompatible states of organising. In this view, the tensions only exist in so-far as the boundaries drawn around them are at the local level. It is in the interaction between the "opposing" elements that synergies start to emerge (Lewis and Smith, 2014). However, such synergies are short lived as new contradictory elements emerge over time that replace the old synergies, though still carrying the remnants of their previous interactions – as Clegg et al. (2002), citing Benson (1977), mentions "thesis follows antithesis in a never-ending succession, where a given dynamic is followed by its opposite, only to emerge again" (p. 485). As we demonstrated, these interactions are not necessarily predictable in that unintended consequences can emerge as a result of communication between individuals (Stacey and Mowles, 2016). As such, the relationship between seemingly contradictory elements is complex insofar as the interactions can continuously affect each element in any number of ways. Synthesis occurs when the relationship between elements is said to be symmetrical (i.e., mutually advantageous) (Hargrave and Van de Ven, 2017) and not "obscured by everyday practices" (Clegg et al., 2002) through uncertainty, conflict and politics (Andriopoulos and Lewis, 2009).

Take, for instance, a HVLV manufacturer of highly customised capital equipment as a hypothetical scenario. As already mentioned, this manufacturer needs to accommodate both control and freedom when managing at the project level. Strict planning and scheduling is necessary to ensure that the customer receives the product on-time as well as facilitating seamless entry of other projects in the "product mix" on the factory floor. At the same time, the manufacturer experiences significant uncertainty from the external environment as customers constantly change the requirements and demand fluctuates to the point where one day the machines on the shop floor are at a comfortable level of resource utilisation and the next day the manufacturing system is pushed to its limit as other jobs with higher-priorities are pushed through. In this instance, the project manager would need to have the freedom to improvise and quickly come to a solution to ensure the project progresses in a timely manner.

This scenario is also reminiscent of various cases of organisational paradox including the planning vs acting paradox exemplified in Clegg et al. (2002), control vs autonomy paradox (Langfred and Rockmann, 2016) as well stability vs flexibility paradox (Adler et al., 1999). In either case the former can act a catalyst for the latter as well as the other way around. As an example, going back to the previous scenario and juxtaposing the example provided by Clegg et al. (2002), improvisation requires a certain level of creativity whereby the project manager must now make a decision given the current state of the project and using the existing resources at hand. Action follows reaction as the project manager continually refers back to the plan and makes adjustments as necessary. Here, the management practices conducive to exploitation help aid in the creation of exploration – the combination of both in this instance gives rise to synergy in the form of creativity and improvisation. This is also akin to the process of problem solving where convergent and divergent thinking take place on a constant basis (Runco, 2014, Runco and Acar, 2012) and when combined with right environment and certain individual characteristics gives rise to creative thought (McShane et al., 2013). The interactions of exploration and exploitation result in similar outcomes as exploitation helps facilitate exploration and vice versa (Birkinshaw and Gupta, 2013, Andriopoulos and Lewis, 2009, Gupta et al., 2006).

That said, the ability of an organisation to "exploit" the tensions involving exploration and exploitation on an ongoing basis also rests on the individuals experiencing it. The higher the level of uncertainty with projects, the more important individual characteristics become in dealing with abnormality (Turner et al., 2016).

3.2.5 Connecting the Adoption of Micro-Level Routines to Macro-Level Performance Outcomes

From the characterisation of routines in this thesis, it becomes clearer that on the surface they consist of repetitive, observable actions that rely on (or even relay) tacit knowledge. Digging deeper, however, they are saturated in variation and, somewhat contra to what Eisenhardt & Martin (2000) suggest in their seminal piece on dynamic capabilities, can often result in unpredictable outcomes. Taking on the espoused philosophy of the resource-based view, routines often show inimitability as they are enacted by individuals who demonstrate a particular "skill" in enacting them, indicating some level of competitive advantage can be obtained. Indeed, as Nelson & Winter (1982) proclaim, the behaviour and outcomes of an organisation can be reduced to the actions of individuals within them. In another sense, routines, by definition, are often codified in processes and procedures and logged into an organisation's knowledge bank in the form of tacit knowledge for use whenever it is necessary (Nelson & Winter 1982). This is in close association with proponents of knowledge-based theories of organisation in that tacit knowledge appears "deeply rooted in action, commitment, and involvement in a specific context" (Nonaka 1994, p. 16). Indeed, even tacit knowledge has seen links with overall organisational performance (e.g. see the review by Venkitachalam & Busch 2012) spurring on the direct link between routines and firm-level organisational performance (Abell, Felin & Foss 2008). However, it is also in these notions of individual skill and (organisational) knowledge that the connection between routines and overall organisational performance can be complicated.

3.2.6 Skill in Routine Deployment and Organisational Performance Outcomes

Skill can be characterised as "a smooth sequence of coordinated behaviour that is ordinarily effective relative to its objectives, given the context in which it normally occurs" (Nelson & Winter 1982, p. 73). This is also linked to the concept of personal mastery (Stacey & Mowles 2016) where, for instance, an individual that is a highly skilled project manager of a certain style of pre-fabricated home will have a fairly easy time managing the same style of home again – it is, according to the classic view of routines, almost automatic in that the individual would then retrieve a certain mental model and enact the routine accordingly. If the project manager encounters a similar style of pre-fabricated home with comparable complexity, the job becomes easier. This, of course, is based on the understanding of mental models as "simplifications of reality" taking on a cognitivist stance on human psychology (Stacey & Mowles 2016).

Translating this into highly dynamic environments and to the organisational level, however, tells a rather different story. Take our expert project manager, they have received the same job, however the customer has changed their preference in material – a material the project manager has never come across before. In this instance, adopting the same mental model will yield poor results given a different mental model is required under this circumstance. To protect their own reputation, the project manager begins to politicise the situation by covering-up their lack of knowledge and not sharing the fact they don't possess the necessary skill or knowledge to undertake this job. This forms a spiral of counter-productive behaviour that can span towards anyone involved in the functioning of the project or indeed the organisation. Routines can then be to the detriment of the organisation.

This is also evident in HVLV manufacturing literature in a recent longitudinal action-based research project by Stevenson & Vanharanta (2015). They investigated the decision-making behaviour of managers in HVLV manufacturers in the hopes of investigating the adoption (or lack thereof) of systematised production planning and control (PPC). They found that managers would typically undertake what's known as recognition-primed decision making (RPD) to quickly inform PPC related activities. Even with the high variety of products, managers were seen to perform quite well based on this approach, though as soon as the order book started to fill up, the RPD model was no longer sufficient as managers couldn't keep up with the constant changes in the environment – there was little situational awareness. In this instance, those managers that embraced a systematised production planning and control method in times of increased workload seemed to be better-off than those that did not.

Adopting a learning-based lens in the understanding of routines does have its limitations though. Achieving knew knowledge appears predicated on the transfer between tacit and explicit knowledge among individuals (Nonaka 1994). Effective knowledge sharing thus requires open and transparent communication. However, even with this, attempting to make sense of and codify tacit knowledge is extremely difficult given it resides in skill (Nelson & Winter 1982). In addition, in an organisational setting, there are other group and social related factors that play a role in the transfer of knowledge and enactment of skill (Stacey & Mowles 2016). Hence, such phenomena can also be a precursor for poor organisational performance.

3.2.7 Management Practice Adoption and Organisational Performance Outcomes

Another related factor that has remerged as critical in understanding the role of routines in firm-level performance outcomes is related to the notion of X-inefficiency by Leibenstein (1966). X-inefficiency relates to the "failure of a productive unit to fully utilize the resources it commands and hence attain its efficiency frontier - the maximum level of output possible under the prevailing resources and circumstances" (Leibenstein & Maital 1994, p. 252). Thus, in the most general terms, it relates to the ability of an organisation to make the most out of what it has. Teece (2017) referred to the notion of X-inefficiency in a bid to demonstrate the importance of better management practices in achieving, at the least, operational parity (given his conceptualisation of routines as those that reflect operational/ordinary capabilities). He also cites the work of Bloom et al. (2013), where they conducted a field experiment on management practice adoption and performance impact in Indian textile plants. Bloom et al. (2013) found that firms that had adopted 38 key management practices[6] as part of their intervention observed a 17% increase in productivity after the first year of adoption. Factors explaining poor adoption included the likes of lack of management knowledge in the part of managers and scepticism in relation to their importance. Interestingly, in a validation study years later, Bloom et al. (2018) revisited the same firms and found that the majority of management practices had been retained, in fact some had even spread within firms. They also found, however, that once key managers who were driving the management practice adoption left firms, so did the management practice adoption rate. In addition, lack of director time was also attributed to drops in adoption rates – suggesting the importance of individuals (and knowledge) in driving performance outcomes from the adoption of better management practices.

It is also interesting to note that in the seminal study by March (1991), where he adopts a behavioural perspective on what came to be known as ambidexterity today, he pays particular attention to those often less visible decisions that organisations (or their leadership team) make with regards to incentive systems, production processes and other management practices in order to essentially pick which side of the exploration/exploitation paradox they want to pay attention to. Choices such as these are further complicated by the very nature of exploration and exploitation, given the former is more long-term and the respective performance results are realised much less later than those concerning the latter. In terms of knowledge and skills, March (1991) also recognised that the difficulty in achieving change in one area and efficiency in another is analogous to improving skills and developing knowledge as opposed to creating new skills and creating new knowledge. The impact of these exploratory and exploitative activities on organisational performance depends on an in individuals'

[6] These management practices were specifically tailored for the Indian textile plants in this study. The management practices included factory operations, quality control, inventory management, human resource management and sales and order management.

propensity to adopt a management practice given their degree of know-how in that practice (awareness and adoption) and attitude regarding effort. Unfortunately, ambidexterity literature departed quite quickly from these more behavioural roots, though authors are being urged to return to this based on its importance in explaining firm level ambidexterity outcomes (Wilden et al. 2018).

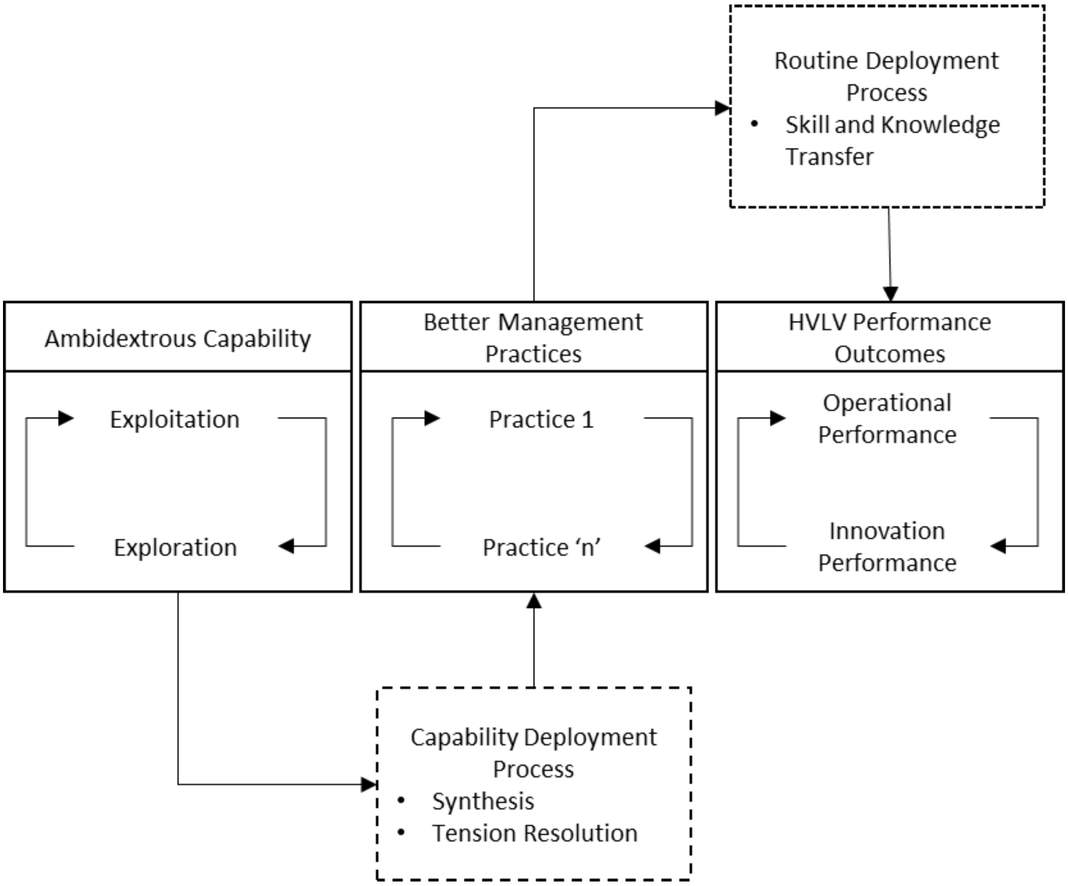
3.3 Ambidextrous Capabilities, Better Management Practices and Organisational Performance: A Routines-Based Schematic

A routines-based lens postulates that organisational performance is not only a function of routine adoption, but also in the processes and implicit choices that come with the adoption. A critical theme in this perspective is the internal dynamics of routines that manifest themselves in both capabilities and organisational outcomes as they continually interact with themselves and the greater organisational system.

Literature has highlighted three primary drivers that facilitate the links between capability deployment, adoption of routines (such as better management practices) and deployment of these routines, namely: synthesis by way of complementarities in exploration and exploitation, resolution of tensions stemming from this synthesis and the transfer of skills and knowledge amongst individuals and groups. Based on the literature review performed in Chapter 2 and the theory building exercise in this Chapter, a simplified schematic of these relationships in the context of HVLV manufacturing is shown in Figure 3-5 (note here the constructs within the capabilities, routines and organisational performance building blocks are explained in Section 3.4 next).

Here, ambidextrous capabilities allow for the effective balancing or integration of exploratory and exploitative activities. The interactions between them give rise to tensions and it is in the recognition and leveraging of these tensions that facilitate the usefulness of ambidextrous capabilities. Organisations can only make use of ambidextrous capabilities if they are able to “internalise their externalities”, hence the breakdown towards the adoption of routines by way better management practices can only occur if the organisation is able to: 1) recognise the constraints and opportunities of its existing resource pool and other assets as well as in effectively identifying threats and opportunities emerging from the external environments, 2) leverage the value stemming from complementarities in existing resources and assets, 3) make decisive and effective leadership and strategic decisions in resource allocation and organisational design decisions to facilitate ongoing ambidexterity. The adoption of management practices has the opportunity to add to greater organisational performance outcomes through the routine deployment process involving the transfer of skill and tacit knowledge. The links demonstrated in this high-level schematic now enable the formation of a more defined research model, presented in the next section.

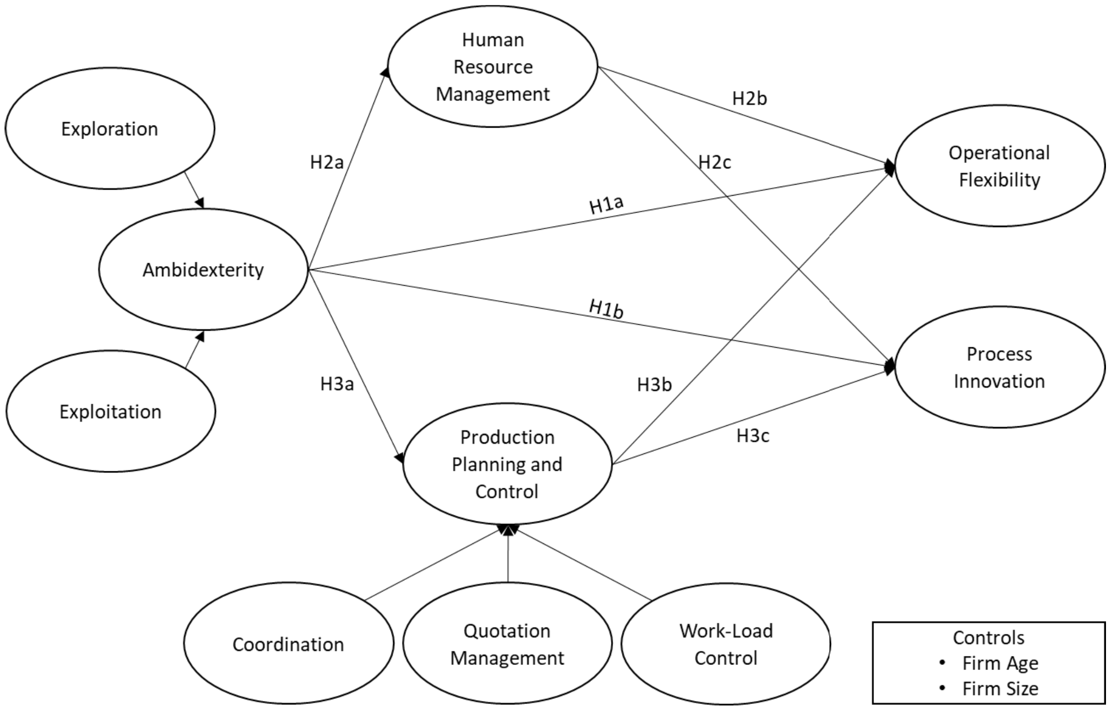
Figure 3-5 Routines-Based View of Ambidextrous Capabilities, Better Management Practice Adoption and Organisational Performance Outcomes



3.4 Operationalising Ambidexterity in HVLV Manufacturing: A Conceptual Model Based on Better Management Practices

Figure 3-6 illustrates the research model used in this thesis. This section outlines the main building blocks of this model and describes the hypothesised relationships between them.

Figure 3-6 Conceptual Model of Operationalising Ambidexterity in HVLV Manufacturing through BMP



3.4.1 Flexibility and Process Innovation Performance as Dependant Variables

Studies on better management practices often appear to have an implicit bias towards their intended impacts on organisational performance. This can be attributed to the argument of not taking the notion of practices seriously (Jarzabkowski et al. 2016b) in the failure to explicitly consider manufacturing goals, practices and multi-dimensional performance outcomes (Ketokivi & Schroeder 2004).

In this study, the manufacturing goals are embedded in the performance outcomes. This is to reflect the fact that better performance in HVLV manufacturing relates to the capability in producing a wide variety of products at a cost and lead time to reflect the market in which they operate – as we've demonstrated throughout this review, anything less would fall out of the jurisdiction of HVLV manufacturing. It is also important to keep in mind that dynamism does not just impact HVLV manufacturers from the inside by way of the uncertainty associated with the production of many different customised goods at the same time, but also from outside as a function of the volatile and uncertain market conditions plaguing manufacturers in general. Thus, merely having to contend with the constant flux associated with variations in customer and product specifications is not enough. HVLV manufacturers must also keep up with increasingly stringent customer demands and improve their operational capability in undertaking a HVLV manufacturing strategy. For the sake reducing potential bias in grouping performance outcomes into a single construct and reflecting the organisational goals in HVLV manufacturing, we have opted to select operational flexibility and process innovation as separate dependant variables in this thesis.

3.4.1.1 Operational Flexibility as a HVLV Manufacturing Performance Outcome

Flexibility, though a pervasive concept appearing in many different fields of enquiry, does not have a generally accepted conceptualisation (Brozovic 2016). Motivated by this lack of understanding, Golden & Powell (2000) went in search of this "holy-grail" of definitions and describe flexibility as what is essentially "a capacity to adapt". Much like the recent reviews of flexibility by Roberts & Stockport (2009), De Haan et al. (2011) and Brozovic (2016), Golden and Powell (2000) concluded that flexibility cannot be understood as a singular phenomenon – rather it consists of varying dimensions which affects the capacity of an organisation to adapt to changing circumstances. Such dimensions are typically in relation to (as labelled by Golden and Powell, 2000) time, range, intention and focus[7]. Even still, delineating the dimensions of flexibility relevant to a particular context is only half the battle – arranging them in such an order to facilitate a cohesive analysis and then effectively operationalising each still proves to be

[7]Time refers to the time it takes to adapt; range is the ability to adapt to foreseeable and unforeseeable changes; intention is whether the organisation takes an "offensive" or "defensive" position in the face of change and finally focus refers to where the flexibility is being created and in what context (typically characterised as internal or external contexts).

an arduous task (Jain et al. 2013; Pérez Pérez, Serrano Bedia & López Fernández 2016; Upton 1994).

Because there is such ambiguity with the term flexibility and the varying conceptualisations of its constituent dimensions, we begin by understanding what needs to be flexible in the first place. Given “change” is a central tenet of flexibility (Brozovic, 2016), to understand the role of flexibility in HVLV manufacturing performance we ask what needs to change and why. This is reflected in their HVLV manufacturing strategy.

A core competence of HVLV manufacturing is the ability to design, engineer, assemble and manage manufacturing projects (Adrodegari et al., 2015). Clearly, the ability to provide customised solutions presents itself as a key factor to the success of these firms. However, from a strategic perspective, this is not necessarily a key competitive criterion. According to the literature on HVLV manufacturers and competitive advantage, their strategic orientation is typically centred on the access to and retention of repeat business (Hendry, 2010). As we’ve demonstrated in our characterisation of HVLV manufacturers in Chapter 2, the extent to which this holds true is dependent on their perception of their competitors and (potential) customers. Thus in order to operationalise flexibility as a core construct in HVLV manufacturing performance, the discussion needs to take into account those HVLV manufacturers that seem to place a focus on achieving repeat business (known as repeat business companies) and those that do not (known as versatile manufacturing companies) (Hendry 2010).

Starting with the latter, HVLV manufacturers that primarily operate in a market characterised by the competitive bidding for single “one-off” projects on a consistent basis are known as versatile manufacturing companies (Amaro et al., 1999, Kingsman and de Souza, 1997). From the customers point of view this means each buying decision is made on a project-by-project basis i.e., every project is put out for tender regardless of which organisation has done the job before. As one would expect in such environments, HVLV manufacturers operating under these conditions would have to cope with constantly varying product types with different amounts of processing as well as workflow requirements. In this instance, the changes occurring in the organisational context are centred around the product being produced with flexibility required to facilitate as much range in the product as possible. The time focus is very much in the operational space as the manufacturer must “adapt” to each new project won on a relatively short-term basis. Here, inter-functional collaboration between sales, engineering and production is key to ensure seamless integration of projects into the production system accompanied by a formal method of production planning and control under periods of high-workload and resource utilisation (Hendry et al., 2013, Stevenson and Vanharanta, 2015). Flexibility is achieved by (for example) the use of highly-trained cross functional staff, overtime, shift-work and most commonly the allocation and constant reshuffling of resources (Zorzini, Stevenson & Hendry 2012). During peak periods flexibility is also achieved by outsourcing, hiring temp workers and similar external means (Kingsman et al. 1993; Zorzini, Corti & Pozzetti 2008). It becomes evident that resource availability and capacity to facilitate major differences in project requirements is key here.

On the other hand, repeat business companies focus the majority of their efforts to stabilise demand and increase efficiencies through repeat business (Amaro et al., 1999). The first customer order will typically present itself as a one-off highly customised solution though the contract will include subsequent orders of the same (or similar) product. Here, they are still competing based on lead-time and cost against other HVLV manufacturers, however it is not uncommon for the organisation to intentionally lose money on the first order knowing it will make up for it on subsequent orders so long as the project is delivered on time (Kingsman et al., 1996). Flexibility here is more centred on the type of customer, with the time focus being tactical (seasonal) rather than operational. Increased predictability and reduced uncertainty from the type of products being produced means greater opportunity to plan and less integration required between sales and production – essentially freeing the manufacturer up to focus on more longer-term objectives. Even if the manufacturer does not precisely know when they will be receiving orders for more products, they can still plan with relative certainty (Hendry, 2010). Flexibility can thus be achieved by hiring seasonal workers as well as facilitating effective customer and supplier relationships.

What this discussion so far tends to demonstrate is that as the demand for customised products becomes more predictable, the focus of efforts in flexibility tends to change from short-term production related flexibility to longer-term customer focused flexibility. However, as exemplified in more detail by Katic & Agarwal (2018), it still appears the goal in HVLV manufacturing remains the same – to improve the ability of the organisation to nullify the effects of uncertainties in relation to external demand for customised products. This is achieved through building operational capabilities: whether the manufacturer makes a strategic decision to buy capabilities through capital or business investments, increasing focus on supplier/customer relationships; or increasing inter-functional collaboration. The aim is still on stabilising the organisational performance and incrementally improving efficiency.

3.4.1.2 Process-Based Innovation as a HVLV Manufacturing Performance Outcome

Process-based innovations refer to "new or significantly improved production or delivery methods [including] significant changes in techniques, equipment and software" (OECD & Communities 2005). Such innovations are increasingly important in a HVLV manufacturing environment given the heavy reliance on cost and delivery time as key competitive criteria. Indeed, as one director of a mid-sized HVLV manufacturer of capital goods mentioned in the questionnaire (to be described in the next Chapter) *"[the] customer [is] interested only in lowest price"*. However, given the project-based nature of their operations, use of general-purpose machinery and the fact most can be characterised as manufacturing service providers, a focus on product innovation or producing proprietary equipment may not be appropriate. Thus, in-line with other HVLV manufacturing literature, we also extend the above definition to simply include "the innovative way in which operations are managed"(Petroni, Zammori & Marolla 2017).

The importance of operational flexibility and process-based innovations can also be demonstrated in Germany's Mittelstand organisations, as discussed in Katic & Agarwal (2018). A large portion of Mittelstand organisations are SMEs that focus their efforts towards providing customised solutions at the lowest possible lead-time – akin to the characteristics of HVLV manufacturers in general. They are also known for their resilience to economic hardships where companies like Sennheiser (albeit a large manufacturer though still considered part of the Mittelstand) only suffered a 1% decline in revenue during the global financial crisis in 2009 (Weber 2016). Examples of manufacturing SME resilience is also found in KfW (2016) where manufacturing SMEs in general were seen to experience continuous growth through times of economic downturn. The following discussion draws from Venohr, Fear & Witt (2015) in describing the Mittlstand's success.

From a strategic perspective, Mittelstand organisations cater to a very narrow sub-market and mould their entire business model around the needs of customers (primarily other businesses) within that market. This means there is a focus on providing customers with specialised solutions to solve an existing problem and leverage the homogeneity of this need (and solution) in a global context. Indeed, customer needs change over time with respect to advancements in technology and through close collaboration with customers in creating customised solutions, manufacturers in the Mittelstand often have the ability to correctly perceive the latent needs of customers and adjust their business model to suit. In this instance, innovation is led by solving real-world problems through the novel use of existing technologies. Such innovations give way to new market niches and foster a reinforcing cycle of exploration and exploitation.

Lastly, similar emphasis on operational excellence and process-based innovation has also become a hall-mark of best practice in high labour cost countries such as Australia (see Green, Toner & Agarwal (2012) for a description of measures to thrive by taking the "high-road" to productivity) where HVLV manufacturers including Marand Precision Engineering have managed to not only survive amidst the decline of key industries but also thrive as an exemplar of innovation in a high cost economy. Marand was significantly impacted by the demise of automotive manufacturing in Australia. Through leveraging their existing resources and engaging in emerging (global) business ecosystems they were able to maintain a strong focus on innovation aimed at achieving flexibility through novel manufacturing methods using existing technologies as well (AAMC 2017; KPMG 2015).

3.4.2 Production Planning and Control and Human Resource Management as Better Management Practices

The identification and dissemination of better management practices is saturated in complexities – some of which we have already addressed in Chapter 2. Of particular interest here, however, is the more theoretical issue involving the relationship between an action and outcome. In this regard, finding cause and effect relationships becomes crucial to justifying the existence of best-practice – if you can't prove that a certain practice improves the organisational performance of a type of firm then how can it be proclaimed best practice? Again, such a simple notion as cause/effect appears to be, it is (and continues to be) a problematic area of best-practice research. Different approaches have been taken to demonstrate cause and effect within different contexts, for example quantitative approaches using econometrics by Bretschneider, Marc-Aurele & Wu (2005) and Bloom et al. (2007), qualitative approaches by Bardach (1994) and mixed methods as suggested by Veselý (2011). The fact remains that validity of cause/effect relationships is of major concern to the credibility of best-practice research – particularly when combined with the need to establish comparability by way of constant sample (Bretschneider, Marc-Aurele & Wu 2005). Some authors have gone so far as to denounce the use of the term "best" altogether, suggesting that achieving comparability and cause/effect is practically impossible given it requires analysis of every organisation exhibiting the same characteristics (Veselý 2011). If one was to use a defined sample within a specific area to characterise or test best practice, then by definition it cannot be "best" (part of the reason why we opt for the term "better" instead).

In this thesis, extensive efforts in reviewing literature concerning HVLV manufacturing better management practices has been undertaken to mitigate against misattribution of effects and their stance as "better" than others. Such an extensive review also adds to comparability by way of consistency between the management practices and the strict focus on HVLV manufacturing (as is also evident in the characteristics of respondents outlined in Chapter 5). The criteria and selection mechanisms adopted for the dissemination of better management practices are identical to those studies that adopt the "success factor" method (Castro, Frazzon & Morosini 2017; Wellstein & Kieser 2011) whereby key characteristics of HVLV manufacturing organisations provide the basis for the selection of better management practices. The value chain commonly outlined in postponement studies (in relation to the customer order decoupling point, for instance) can be seen as a framework for the selection of key processes. Given also the issues associated with equifinality and the apparent role agency plays in the identification, extrapolation and explanation process associated with adopting better management practices, we opt to focus on "values" or "principles" rather than the specific tools to be able to enact them, per se (Muda & Hendry 2003). In light of this, and the limitations regarding the sample size of this research project, we opt to select production planning and control and human resource management practices as key better management practices. The way they are operationalised as well as their significance is discussed next.

3.4.2.1 Production Planning and Control as a Better Management Practice

Production planning and control in a HVLV manufacturing context is, in a literal sense, one of the most critical operations in the product realisation process – accounting for the majority of reasons why a particular job fails to meet its cost, quality and delivery objectives (Land & Gaalman 2009). The HVLV manufacturing environment is unforgiving when it comes to producing a high variety of customised products. Aside from the deficiencies associated with being an SME in general, the uncertainty stemming from the nature of their operations quite often results in poor estimating (both delivery date and cost of the project), ineffective production routing and conflicting organisational objectives (manufacturers need to meet deadlines, deal with high WIP and at the same time minimise low resource utilisation) (Persona, Regattieri & Romano 2004).

Production planning and control typically consists of all those activities associated with receiving a request for quotation, accepting the request, sales and estimation activities all the way through production planning and levelling on the shopfloor (Adrodegari et al. 2015; Stevenson, Hendry & Kingsman 2005). In order to be effective, PPC in a HVLV manufacturing environment should involve high levels of inter-functional coordination (Kingsman, Hendry, Mercer & De Souza 1996; Konijnendijk 1994; Land & Gaalman 2009), a systematic method of quotation and estimation management (Zorzini et al. 2008) and effective work-load control by means job-entry and release mechanisms (Hendry, Huang & Stevenson 2013).

3.4.2.2 Coordination in Production Planning and Control

This functional dissonance between manufacturing and sales in HVLV-style manufacturers was a common point of concern for early studies in HVLV production planning and control. Works including Kingsman et al. (1993), Kingsman & Mercer (1997) and Hendry & Kingsman (1989) all recognise the implications of a lack of integration in this regard and its impact on carrying out effective production of customised goods and, hence, organisational success. Though much has been done in regards to production planning and control in HVLV manufacturing since these earlier days (Aslan, Stevenson & Hendry 2015; Hendry, Huang & Stevenson 2013; Stevenson 2009; Stevenson, Hendry & Kingsman 2005; Thurer et al. 2016) inter-functional coordination (Land & Gaalman 2009; Little et al. 2000) and inter-firm coordination (Mello et al. 2017; Mello, Strandhagen & Alfnes 2015) still remain key issues in HVLV manufacturing literature.

As was apparent in the literature review in Chapter 2, the emphasis on inter-functional coordination stems from the well-known divide between marketing/sales and production activities. In HVLV manufacturing, the increased dynamism from the high variety of customised products requires very specialised capabilities in both departments. Because each order is often something different from the next, the sales process takes a considerable amount of time. Determining and understanding the customer's performance requirements (where only vague descriptions are often provided) and providing competitive quotations are the main functions of sales in HVLV manufacturing. Production, on the other hand, are more concerned about meeting technical specifications using precision and skill, it is not the performance of a product that matters, rather how it is built (Konijnendijk 1994). Because of sales' focus on price and productions' focus on cost (Zorzini, Corti & Pozzetti 2008), it is also often the case where sales will issue a quotation to the customer based on unrealistic deadlines, budgets, specifications or all three (Land & Gaalman 2009). The production function bears the grunt of the uncertainty stemming from the variety of products in having to constantly juggle the workload amongst work centres (Clegg & Fitter 1981) . Given this, the production function is also an easy scape goat for not meeting organisational goals – this conflict can have lasting impacts on organisational performance outcomes (Clegg & Fitter 1981).

Effective inter-functional coordination thus begins with setting realistic deadlines and budgets. In this instance, all departments should have a clear understanding of (and access to) key capacity and resource information to ensure, at the least, a good understanding of pending lead-times is achieved (Zorzini et al. 2008). The competitiveness of quotations is going to be reflected in their capability for rapid adjustments in planning if required (Kingsman, Hendry, Mercer & De Souza 1996).

Another key criterion for inter-functional coordination is in the coordination and liaison between suppliers when addressing customer requirements (Mello, Strandhagen & Alfnes 2015). Given the constant changes in materials and customer specifications, building supplier relationships is often not possible (Portioli-Staudacher & Tantardini 2012b). A lack of close coordination with suppliers impacts both sales (in their estimation activities) and manufacturing (in workflow requirements).

This also leads us to the closely related, yet distinct, function of production planning and control in quotation and estimation management.

3.4.2.3 Quotation and Estimation Management in Production Planning and Control

The most fundamental difference between HVLV manufacturing and other production strategies is the fact that production does not commence until the customer order has been received. The requirements acquisition, quotation, design/engineering and planning/scheduling functions are all critical process in not only ensuring the customers' expectations on delivery time, cost and quality are met but in also obtaining the customer order in the first place. As mentioned, each enquiry or tender proposal put through often presents different customer requirements. These requirements can be in the form of either vague-descriptions of performance outcomes (examples can include flow-rates and production throughput) or detailed drawings with clear specifications (Chua, Cai & Low 2008). Before the quotation can be put through there are important strategic decisions which are required to be made including whether or not to provide a quotation in the anticipation of doing the work or not. Factors involving the relationship with the customer (long standing relationships can influence the choice of performing works typically not offered by the firm, for example) (Amaro, Hendry & Kingsman 1999); whether the organisation wants to enter a particular market (Kingsman et al. 1993); whether the cash flow is down or machines are laying idle (Kingsman et al. 1993) can all play a role in the HVLV manufacturer's decision to provide a quotation.

Once a decision to provide a quotation is reached, the estimation process commences. This involves estimating delivery dates and costs and is of significant importance to the survival of HVLV organisations; in fact this stage of the production process is commonly referred by authors as *the* most important problem faced by HVLV manufacturers (Bortolotti, Danese & Romano 2013; Zorzini et al. 2008). In essence, this is a forecasting exercise comprising of multiple stages with many different decision points, and as discussed in the preceding section, involving close coordination with internal stakeholders including owner(s), designers, engineers and production managers as well as external stakeholders including, for example, the customer, suppliers and subcontractors (Chua, Cai & Low 2008; Matt, Dallasega & Rauch 2014).

An often overlooked consideration in this instance is that smaller organisations need to invest a lot of time in order to create an accurate estimation of costs and delivery dates (Kingsman, Hendry, Mercer & De Souza 1996). Customer tender specifications will often have time limits imposed as well, so the decision maker (often looking after multiple tender requests) will need to consider the trade-off between accuracy and cost/time amongst multiple opportunities (Chua, Cai & Low 2008). Price setting decisions during the quotation development phase are a completely different phenomenon to that of estimation described earlier. The piece by Kingsman, Hendry, Mercer & De Souza (1996) is one of few that takes an in-depth look at this. They stress that these decisions are made separate to the estimation process though similarly taking into consideration different strategic and marketing concerns. In addition, it was noted that HVLV manufacturers don't have the luxury of separating such decisions and are instead made in unison, often in an ad-hoc basis. Trade-offs in cost/time are more profound as quotations are typically "padded" to include more margin as is necessary. This was seen to arise because the decision maker (typically a member of the top-leadership team) may not have the necessary time to provide an accurate quote.

Thus, effective quotation and estimation activities involve ongoing dissemination of customer requirements (Thürer et al. 2014) , the development of an effective quotation management system to facilitate informed decision making and help improve situational awareness (Kingsman & Mercer 1997; Stevenson & Vanharanta 2015) and a keen understanding of competitor and market dynamics (Muda 2003).

3.4.2.4 Work-Load Control in Production Planning and Control

Feeding off the same issues associated with coordination and quotation and estimation management, workload control aims to prevent counterproductive reactions to heavy uncertainty from reaching the production floor and throwing it into disarray. So far, we have stressed the importance of coordination and effective estimation towards PPC in HVLV manufacturing environments – given such increased interest in literature we could assume smooth running operations would be a result. However, if the people involved in the coordination and estimation activities don't have access to accurate information regarding the time it takes for a product to pass through the production floor, then good coordination and estimation may be in vain (Petroni, Zammori & Marolla 2017).

Perhaps one of the more researched areas in HVLV manufacturing, workload control (WLC) is a systematic method of regulating the release of orders onto the production floor (Sabry Shaaban et al. 2015). It proves particularly helpful in alleviating the occurrence of lead-time syndrome where managers tend to release orders onto the shop floor as soon as they can (Stevenson & Vanharanta 2015). By prematurely releasing the orders onto the shop floor, managers are in effect creating more WIP leading towards poor due date adherence from longer lead-times. As Stevenson & Vanharanta (2015) mention, managers then tend to release orders even earlier to counteract the delay already in the production system, causing even more WIP and even longer lead-times.

To help with this, WLC uses a combination of a pre-shop pool (where orders are stored) and an order release mechanism (based on set limits) to regulate the flow of orders and provide a buffer against unexpected disturbances to the system including, for instance, change in customer requirements or resource allocations (Stevenson, Hendry & Kingsman 2005; Thürer et al. 2014). Combined with a bottleneck detection system, WLC proves particularly important in a HVLV manufacturing environment (Petroni, Zammori & Marolla 2017).

3.4.3 Human Resource Management as a Better Management Practice

The importance of human resource management to the effectiveness of HVLV manufacturers cannot be understated. The workforce in the HVLV manufacturing industry is typically highly skilled, well trained and flexible (Easton & Moodie 1999; Portioli-Staudacher & Tantardini 2012b; White & Prybutok 2001) with workers that fulfil several different roles not uncommon – as a Director of a small HVLV manufacturer mentioned in the questionnaire conducted as part of this research *"In terms of adopted processes/strategies and notions such as design, ordering and manufacturing staff, our business has 3 people that fill all of these roles, and processes are formed by talking to one another".*

However, SMEs in general also exhibit a high turn-over rate with floor staff as well as the managerial staff members exhibiting lower amounts of skill and expertise knowledge (Holweg 2007) with their meagre management practices often resulting from a lack of skill (Ates et al. 2013). This can also be attributed to the fact that owners/executives in HVLV firms generally look for immediate positive results when releasing funding for a particular business development goal (Miltenburg 2005). In this scenario the chances of allocating resources to the training of managerial staff over improvements in the production function are slim.

Though human resource management, appears to be a universal activity beneficial to all types of manufacturing organisations (Bloom et al. 2012), there are indeed subtle differences in the HRM practices according to an organisations' overarching strategy. For instance, in a low variety setting where flexible manufacturing is key, employees play a more central role. Employees are encouraged to problem solve, make decisions and undertake their own analysis (MacDuffie 1995). This is reminiscent of the HR policies and practices found in studies related to the Toyota production system (Liker 2005). Though, these practices require enormous efforts from individuals so there is a heavy focus on recruitment criteria and retention strategies to ensure employees are up to the task as well as are motivated to do all these "extra" activities in the first place (MacDuffie 1995).

In addition to the above, and because the HVLV manufacturing environment can observe many products being designed, manufactured and assembled at any one time, there is a heavy emphasis on problem solving and creativity capabilities. The workforce is assumed to be multi-skilled and well trained by virtue of the manufacturing strategy being adopted. In this case, they are already well equipped to deal with erroneous circumstances as they occur quite frequently. The emphasis here should be placed on specific job enlargement and job enrichment strategies (Bevilacqua, Ciarapica & De Sanctis 2017).

3.4.4 Ambidexterity

Ambidextrous capabilities are presented as the ability to simultaneously undertake exploration and exploitation. The latter is characterised by incremental improvements in operational efficiency. This means using todays' technology and management practices to serve today's market and, thus, todays' customers (Lubatkin et al. 2006). The former, however, rely on un-tapped tacit knowledge that, when engaged, disseminated and deployed, allow an organisation to innovate and change for tomorrows markets and tomorrows customers (Lubatkin et al. 2006).

As mentioned, too much emphasis on exploitation can lead to an organisational inertia that proves difficult to overcome as well as increasing the chances of an organisation falling into simplicity traps. On other hand, a heavy emphasis on exploration can lead to stunted growth in the inability to develop well-honed skills. Thus, there appear to be trade-offs.

Taking ambidexterity as a dynamic capability means taking into consideration these trade-offs as it becomes clear that one certainly requires different resources, structures and skills than the other (March 1991; O'Reilly & Tushman 2008). This is not to say they aren't complimentary (as we've argued in this chapter), instead we put forward the fact that they are, for all intents and purposes, separate constructs and should be treated as such (D'Souza, Sigdyal & Struckell 2017).

This thesis takes on the conceptualisation of ambidexterity as the culmination of two disparate constructs in exploration and exploitation. At the risk of repetition, the implications of this are discussed in more detail in Chapter 4, though, at this stage it is important to bear in mind the two activities influence performance in different ways (He & Wong 2004). In addition, because it is a capability, there are limits in which an emphasis on either exploration and exploitation will result in any measurable performance gains (D'Souza, Sigdyal & Struckell 2017) – the law of diminishing returns does seem to apply here as well.

3.4.5 Control Variables

The control variables used in this research model relate to the two critical contingencies in HVLV manufacturer size and age.

Despite their stature as SMEs, there are indeed marked differences between the efficacy of adopting better management practices and achieving the performance outcomes of operational flexibility and process innovation of smaller firms vs those nearing 200 employees. Given greater access to resources and technologies, larger organisations also have a greater propensity to innovate and adapt to changing circumstances (Agarwal, Brown, et al. 2014). Thus, prompting us into considering larger HVLV manufacturers to be more flexible and enable greater process innovations than smaller manufacturers. In the same vein, large-scale studies on better management practices have also consistently shown firm size to be a contributing factor to their adoption (Agarwal, Bajada, et al. 2014; Bloom et al. 2017). Translating this into our study, we would also assume HVLV manufacturer size to be a control for the adoption of better management practices by way of PPC and HRM.

In addition, firm age seems to also play a role in a firm's ability to adapt and innovate. Younger organisations tend to be more nimble in regards to sales-growth rates, though have trouble in sustaining them (Ciriaci, Moncada-Paternò-Castello & Voigt 2014).

Younger firms also typically suffer from a lack of resource base, experience and legitimacy that has a bearing on their ability to build-in flexibility (Carayannopoulos 2017). Larger organisations, though facing increasing difficulties in breaking path-dependence and inertia, tend to be better at incremental innovations and building on existing foundations (Huergo & Jaumandreu 2004). That said, more mature manufacturing organisations have a higher propensity to adopt better management practices (such as Lean and TQM) as well (Dukeov et al. 2018). Based on this evidence, we put in place HVLV manufacturer age as an additional control variable.

3.4.6 Ambidexterity, Adoption of Better Management Practices and HVLV Manufacturer Performance: Articulation of Research Hypotheses

The link between ambidexterity and firm-level performance has seen increased attention in recent times with a plethora of work being conducted in this space. It is quite safe to say that, in a general sense, ambidexterity does indeed have an impact on performance outcomes. However, when observed in an environment characterised by such high variability and environmental dynamism, the impact of this capability on firm outcomes may not be so straightforward. The uncertainty stemming from their manufacturing strategy and the market in which they compete has follow-on effects that stem from the unintended consequences of organising. From the organisational design, to the individual characteristics of managers and floor staff, there are significant challenges that must be faced. Thus, the hypothesised links between ambidextrous capabilities, firm level outcomes and better management practices adopted requires further elaboration.

3.4.6.1 Ambidexterity and HVLV Manufacturer Performance

The evidence so far in Chapter 2 and in this present chapter would suggest ambidextrous organisations have an innate ability to do what they do best (their core capabilities) and at the same time find ways to extend or improve this competency base. However, as we have demonstrated, inherently ambidextrous organisations such as HVLV manufacturing, though flexible and innovative, find it increasingly more difficult to operationalise these capabilities towards increased competitiveness. In Section 3.2.4 this was attributed to the link between capabilities, their constituent routines and organisational performance outcomes (whatever they may be). Ambidextrous capabilities are not enough to facilitate direct links to operational performance. The capabilities themselves rely on a synthesis between competing objectives which is resolved through the adoption of routines. As per the routines-based view, it is the configurations of routines that drives performance outcomes, not the capabilities themselves. Given HVLV manufacturing core competencies in operational flexibility and process innovations, we construct the following hypotheses.

H1a: Ambidexterity does not have a significant impact on HVLV manufacturer operational flexibility.

H1b: Ambidexterity does not have a significant impact on HVLV manufacturer process innovation.

3.4.6.2 Ambidexterity, the adoption of Human Resource Management Practices and HVLV Manufacturer Performance

When treating ambidexterity as the simultaneous pursuit of exploration and exploitation, whether you are creating separate business units to address both or building organisational contexts, both approaches require careful strategic alignment, shared values, culture and inter/intra organisational integration (Raisch and Birkinshaw, 2008, Turner et al., 2015). Indeed, what is presented is much more of a leadership problem than it is an organisational one (O'Reilly and Tushman, 2013). The problem for leaders is that in order to help facilitate ambidexterity, they must first be able to handle it themselves. This means holding the ability to recognise tensions between seemingly disparate elements and leveraging the synergies as well as contradictory interactions in order to enhance the ability of an organisation to undertake competing goals. This is not, however, the sole responsibility of the top management team. Rather, middle managers and floor-staff should also hold these capabilities (Miron-Spektor et al., 2017).

HRM is treated as a multivariable construct in this thesis with the assumption that the various practices (described earlier) are complementary to each other. This is also observed in the high-performance work practices literature where complementary bundles including employee training, selection, job-security and involvement are said to perform synergistically (Chang 2016). Within this stream, such management practices are said to improve an employee’s ability, motivation and opportunity to perform. This includes the ability to think creatively, leverage competing strategic demands and uncertainty as well as effectively navigate and make sense of organisational paradoxes in pluralistic contexts. Such practice bundles are also observed to provide a context from which ambidextrous capabilities can emerge – focusing on the key elements of ambidexterity in achieving alignment, fit and stretch by way of continuously striving for more (Gibson & Birkinshaw 2004). Given individual motivation, know-how, skill, experience and attitude are also drivers of translating capabilities into routines and routines into organisational performance outcomes, we construct the following hypotheses:

H2a: Ambidexterity is positively associated with the adoption of HRM practices

H2b: HRM practices are positively associated with HVLV manufacturer operational flexibility

H2c: HRM practices are positively associated with process innovation performance

3.4.6.3 Ambidexterity and Production Planning and Control Practices

Following on from above, effective production planning and control (PPC) is also observed to be a key concern for ambidextrous organisations such as HVLV manufacturing. Though having been an ongoing concern in the field of operations management for many decades, its impact towards reconciling divergent strategic interests in HVLV manufacturing has only fairly recently caught the interest of the PPC authorship (Stevenson, Hendry & Kingsman 2005).

Effective PPC in a HVLV manufacturing environment includes the use of a “pre-shop pool” separating the order entry and order release stages prior to production (Silva, Stevenson & Thurer 2015). This almost counterintuitive approach effectively tells managers to hold back orders until such time as the production systems can handle it. At the front-end, good PPC practice also includes the management of customer enquiries and advocates the use of systematic “strike rate” matrices to help with estimation and price-setting (Kingsman & Mercer 1997; Thürer et al. 2014). The use of such mechanisms has been linked with greater performance by way of setting appropriate cost and lead-times and leading to increased competitiveness (Hendry, Huang & Stevenson 2013).

In addition, whilst more intuitive approaches to PPC seem appropriate when business is slow, as soon as the order-book begins to rise those HVLV manufacturers with effective PPC practices are said to exhibit increased levels of decentralisation and less myopic managerial decision making (more open minded) (Stevenson & Vanharanta 2015). Being SMEs the top leadership team are often heavily involved in PPC decisions as rush-orders and re-organisation of the production floor may be critical in maintaining key customer relationships or winning a lucrative order (for instance)(Kingsman, Hendry, Mercer & Souza 1996). Thus, by taking on formal and rationalised PPC practices, the top management team are free to perform more strategic and long-term decision-making. As Petroni, Zammori & Marolla (2017) also assert, effective PPC is in itself a form of innovation for HVLV manufacturers.

Thus, given the above we hypothesise the following:

H3a: Ambidexterity is positively associated with the adoption of PPC practices

H3b: PPC practices are positively associated with HVLV manufacturer operational flexibility

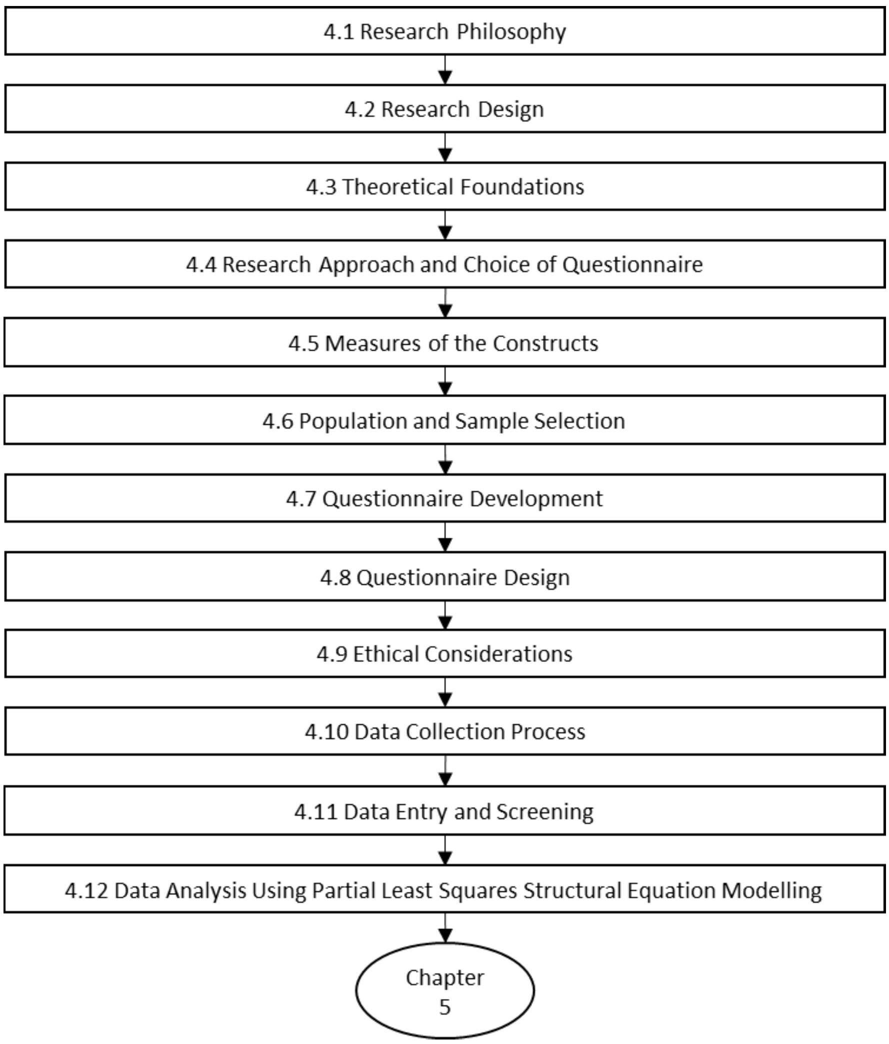
H3c: PPC practices are positively associated with HVLV manufacturer process innovation performance

The next chapter outlines the overarching research methodology undertaken in this thesis, including the hypotheses testing procedure.

Chapter 4 Research Methodology

This chapter articulates the research methodology adopted in this thesis. The philosophical dispositions guiding many of the choices for methodology are first articulated, followed by the overarching research design and theoretical foundations. Next, the choice of questionnaire is justified as well the measures used within it. The population and sample selection process is then discussed in detail, proceeded by the questionnaire development and design process itself. Ethical considerations are discussed, followed by an overview of the data cleaning, entry and screening processes. Finally, the use of partial least squares (PLS) structural equation modelling (SEM) as a data analysis technique is both justified and discussed. An overview of this chapter is provided in Figure 4-1.

Figure 4-1 Overview of Chapter 4



4.1 Research Philosophy

Organisations can be seen through many lenses. Some may see an object or a thing that can be manipulated and controlled whilst others might see a collection of individuals doing things with other individuals and in the act of doing, they form an organisation. Others, still, might see an organisation as a political process. The same goes for the notion of strategic management or operations management within which this thesis is positioned. Here, we can see strategy or operations as planning and tools, learning processes or as something that only exists in an individual's mind (Stacey & Mowles 2016). The point is, our "lens" is a reflection of what we believe to be true, and it is this that guides our journey through the knowledge creating process that is research.

The way we make sense of reality is typically guided by the field of research, the research aims and objectives as well the researcher's own experience and beliefs (Karlsson 2016). Creswell (2009) defines four overarching "worldviews" in this respect:

1. Post positivism is often associated with the basic scientific method (Sekaran & Bougie 2013). Here, the assumption is a given reality already exists – it is observable and thus subject to enquiry and measurement. This lens is deterministic in its desire to uncover cause and effect through reductionist approaches associated with breaking down phenomena into observable variables that contribute to building hypotheses and models (Creswell 2009). In this sense, a positivist lens is often related to quantitative research.
2. Social constructivists, on the other hand, don't quite believe in an objective truth, for them, the truth is what an individual makes it – thus it is in our minds (Sekaran & Bougie 2013). The aim for a social constructivist is to uncover the mechanisms guiding a certain person's beliefs by investigating how they interact with others and the context within which this interaction takes place (Creswell 2009). Qualitative methods are typically associated with this approach.
3. The advocacy/participatory world view holds that politics and political agendas are key factors in research efforts (Creswell 2009). Here, the idea is to bring about change to peoples' lives through action.
4. Finally, a pragmatist would assume that there is no one right way to understand reality, rather the researcher should use any and all tools/philosophies that will

help, given the particular aims of research (Creswell 2009). Through this lens, there is no definite reality, it is always changing in a constant state of flux and the tools we use to understand this should change with reality itself (Stacey & Mowles 2016). Here, practice informs theory and theory serves to inform practice (Sekaran & Bougie 2013). Thus, for a pragmatist the value of a research project is in its relevance to practice.

Returning to the research presented in this thesis, it is clear that a single “worldview” or conceptualisation of reality isn’t quite observable in that we base our theory building on a wide variety of research paradigms and concepts. For instance, we draw on paradox theory, the tradition of routines-based thinking and the behavioural/knowledge-based view of the firm to explain the relationships between ambidextrous outcomes and firm level performance in what (on the surface) appear contradictory. We adopt a contingency lens in our justification of the HVLV manufacturing context and even draw on a more positivist stance in our choice of research design. Whilst the implementation of these theories appears to be of a contradictory nature itself - the philosophical divide between contingency theory and paradox theory is a well-known example (Smith & Lewis 2011) - we are of the viewpoint that the adoption of multiple theories can be mutually beneficial.

As such, we don’t prescribe to a particular research paradigm, nor do we adopt any of the more “traditional” epistemological perspectives. Rather, we see paradigms, perspectives and world-views as “heuristics” of which can be drawn upon to provide new insights as and when they become necessary (see Maxwell 2012 for a discussion on this). Thus, we seek to maximise the opportunities provided by these theories towards a deeper understanding of the relationships we want to investigate (rather than just confirm they may/may not exist). This philosophy is also espoused in our research design, explained next.

4.2 Research Design

This thesis aims to uncover the role of better management practices in operationalising ambidexterity in an organisational context known as HVLV manufacturing. Ambidexterity as a capability that enables an organisation to make sense of and leverage the paradox of exploration and exploitation. From the various cases described earlier, as well as being a major theoretical challenge for ambidexterity literature in general, it is a real-time problem that HVLV manufacturers are facing. Thus, the research design must also be able to fit the problem as well as the theory and philosophy bounding the problem. In addition. the decision must also take into consideration the maturity of the field being studied as well as the intended contributions to knowledge (Åhlström 2016).

Our philosophical stance is guided by the problem we are investigating. Clegg, da Cunha & e Cunha (2002), in providing a relational view of management paradoxes, pays close attention to the boundaries drawn between practice and theory when coming up with solutions on how to deal with such managerial issues such as the exploration/exploitation paradox. From their perspective, we can appreciate that organisations are in a constant state of flux, yet decisions still have to be made – whatever way the decision maker perceives them. Taking a "heuristics" approach, then, involves disseminating a methodology that can improve our understanding of the phenomenon whilst retaining an outcome that can guide managerial decision making towards more objective and evidence-based decisions. This places the methodology we choose in the realm of scientific methods of enquiry (Sekaran & Bougie 2013).

This line of enquiry is purposive and has the advantage of increased rigor (Sekaran & Bougie 2013). It is also more objective, thus allowing the researcher to better draw on critical factors that can be leveraged in solving real-world problems (Sekaran & Bougie 2013). Indeed, as spanning from its roots in the natural sciences, it does assume a pre-existing reality that, the more you look into it, the more of the reality emerges – effectively doing away with how others may see the world (Stacey & Mowles 2016). Though, this does not preclude us from adopting different theoretical lenses to approach different theoretical (and practical) problems (Sekaran & Bougie 2013). This is also part of the reason why such an approach is the primary means of research in operations management, bearing its roots from manufacturing and industrial engineering related problems (Åhlström 2016).

Based on the scientific method, this research follows what came to be known as the hypothetico-deductive methodology (Sekaran & Bougie 2013). Such a methodology is deductive in nature and thus follows a process that spans from the identification of a problem, determining hypothesis, testing them and finally interpreting the findings. Based on this approach and the guidelines set forth by Flynn et al. (1990), Sekaran & Bougie (2013) and Forza (2016), we follow the research process as shown in Table 4-1.

Table 4-1 Overview of the Research Methodology

Stage	Description	Activities
1	Theoretical Foundations	• Descriptive and Theory Verification
2	Research Approach	• Quantitative with limited Qualitative Insights
3	Data Collection Method	• Survey
4	Implementation	• Develop Measures • Population and Sample Selection • Questionnaire Development • Ethical Considerations • Data Collection • Data Cleaning and Entry
5	Analysis	• Partial Least Squares Structural Equation Modelling o Evaluation of the Measurement Model o Evaluation of the Structural Model

4.3 Theoretical Foundations

The theoretical foundations provide an outlook of the purpose for this study (Sekaran & Bougie 2013). The end goal is to shed some light on how organisations operationalise ambidexterity. Given our context in HVLV manufacturing, it was imperative to understand the characteristics that govern their operations and the strategic initiatives involves in this process. An extensive literature review was conducted to uncover some of these factors that can have an influence on their ambidextrous orientation.

In addition, the focus of this research also concerns the role of better management practices. Here, it was also necessary to uncover the possible relationships between ambidexterity, better management practices and HVLV manufacturer performance outcomes in lieu of their unique characteristics. The literature review and theory building exercise appear descriptive in nature in their implicit focus on understanding the characteristics of HVLV manufacturers and the relationships between the various elements of focus in this thesis.

On the other hand, this thesis is also a verification study (Flynn et al. 1990) based on the required understanding of causal relationships between ambidexterity, the better management practices of production planning and control and human resource management as well as their impact on process innovation and operational flexibility performance. The hypothetico-deductive research design means hypotheses should be developed based on theory, then tested and finally inferences made based on these (Sekaran & Bougie 2013) – also providing further evidence of theory verification.

4.4 Research Approach and Choice of Survey Methodology

The research approach is governed by multiple factors including, for instance, philosophical stance, theoretical foundations, time and budget constraints as well as researcher knowledge and experience, amongst others (Åhlström 2016; Flynn et al. 1990; Forza 2010; Sekaran & Bougie 2013). Based on the research aims, as well as taking into consideration key time and budget constraints, adopting a heuristics-based lens suited towards pragmatic solutions, taking into consideration all relevant factors, we have opted for a quantitative research approach though allowing for limited qualitative insights.

The quantitative research approach lends itself squarely in the realm of the scientific method (thus the hypothetico-deductive methodology) (Sekaran & Bougie 2013). It is also fundamentally underpinned by a philosophical stance centred on "realism" or "positivism" (Creswell 2009). It is a common approach in better management practices studies (Bloom et al. 2017) with its roots in the field of operations and industrial management (Flynn et al. 1990). Allowing for the establishment of causal relationships

(Sekaran & Bougie 2013) and in the interest of generalisability to the HVLV manufacturing cohort, the quantitative approach based on deduction appears both relevant and promising.

However, because of the nascent understanding of ambidexterity in this domain, and the impact of better management practices, this study should also include some qualitative elements that can help explain the observed relationships from a causal study (Ivankova, Creswell & Stick 2006). In this case, the research approach begins to err on the side of mixed-method through a sequential-explanatory research design (Ivankova, Creswell & Stick 2006), however, it differs in the type of qualitative information received and how.

This research is significantly constrained by both the time available to do the research as well as the peculiarities associated with the HVLV manufacturing industry itself. One of the benefits of adopting a study where qualitative insights help build on a quantitative research design is its straightforwardness (Creswell, 2009) and the flexibility associated with priority weightings on either method, allowing for considerable insight in a small amount of time (Ivankova, Creswell & Stick 2006).

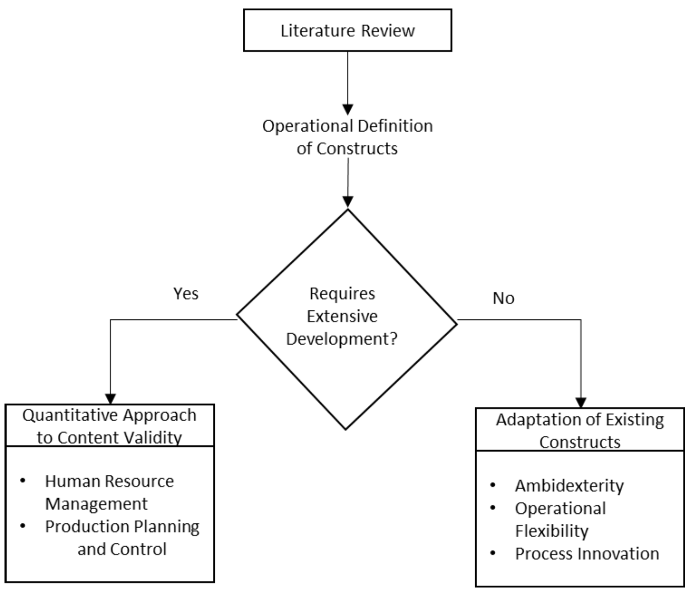
In the research design of this thesis, the priority is given to the quantitative study that seeks to gain a general understanding of the research problem. In this portion of the research, we wish to investigate the predictive power of better management practices in the relationship between ambidexterity and HVLV manufacturer performance outcomes. The qualitative information, in the form of an open-ended question for comments, will be used to provide support for the outcomes that result as well as during the theory building exercise in Chapter 3.

To accommodate our needs in establishing causal relationships through quantitative and deductive reasoning and allow for some qualitative insights, an online survey questionnaire was chosen as the preferred mechanism through which data is collected. Such a method meets the requirements of a limited budget and allows for more effective and accurate data collection (Forza 2016; Sekaran & Bougie 2013). At the same time, open-ended questions are becoming commonplace in survey research designs that allow for more qualitative insights (Aslan, Stevenson & Hendry 2015; Forza 2016). In addition, an online survey tool usually results in greater response rates from convenience (Sekaran & Bougie 2013). Given the limited sample of HVLV manufacturers and the fact they are spread all throughout Australia makes the survey method also appealing in this regard.

4.5 Measures of the Constructs

In developing the measures for constructs used in this thesis, we adopt the guidelines set-forth by Forza (2016). This approach is a two-step process that involves: 1) clearly articulating an operational definition of the construct followed by; 2) testing the operationalisation of the construct for content validity. However, different methods for assessing content validity are appropriate under different circumstances. For instance, more quantitative approaches to this validation process are useful (and, indeed, necessary) if the creation of new constructs are being undertaken (Ambulkar, Blackhurst & Grawe 2015). Thus, for some of the more established constructs we adapted (where appropriate) existing measures in consultation with a limited number of expert consultations. On the other hand, where constructs required more extensive development, then a quantitative procedure was adopted where a larger number of experts were participating. The flow of this process is shown in Figure 4-2.

Figure 4-2 Construct Measure Development Process



4.5.1 Overview of the Quantitative Approach to Content Validity: The Content Validity Index

Content validity refers to the "degree to which a sample of items, taken together, constitute an adequate operational definition of a construct" (Polit & Beck 2006, p. 490). There are numerous ways in which this can be quantified including, for instance, the determination of Cohen's Kappa ratio and other reliability indexes and measures (Polit & Beck 2006) which also feature in HVLV manufacturing literature (e.g. Aslan, Stevenson & Hendry 2015). This study, however, adopts another commonly used technique in quantitively assessing the content validity of developed construct known as the content validity index (CVI) (Forza 2016; Polit & Beck 2006).

In this technique a group of experts are asked to assess the degree to which a particular item helps explain the construct it is trying to measure (Polit & Beck 2006). In our case, a group of 13 subject matter experts were sent an invitation to complete an online survey which asked them to assess the importance of the knowledge/ability captured by the items to the understanding of the construct being assessed. A five-point Likert scale was used to evaluate their responses, ranging from not important (1) to very important (5). An "unsure" option was also included in the instance where the subject matter expert was not familiar with a certain construct, in which case we could then remove this from the sample. Relevant excerpts of the content validity survey are illustrated in Appendix 1[8]. In all, 13 subject matter experts participated in this questionnaire which is well above the minimum requirement of three subject matter experts for such an evaluation of content validity (Lynn 1986).

Next, an evaluation of CVI requires two separate calculations namely, at the individual item level (I-CVI) and at the entire scale level (S-CVI) (Lynn 1986). To calculate the I-CVI, we first code those responses that ranged from important (4) to very important (5) as an indicator of relevancy. Then, we calculate the I-CVI by dividing the number of subject matter experts that responded with a 4 or 5 by the total number of experts. This, of course, is a general indicator of the proportion of agreement amongst subject matter

[8] Note these are only excerpts of the original content validity survey that are relevant to this study in its present form. Other management practices were also included, as was the original intention. However, these were subsequently excluded due to the limitations in sample size and missing values.

experts regarding the importance of an individual item to the understanding of the construct. However, there is a likelihood this value could be inflated due to chance agreement (Polit & Beck 2006). To help combat this, the approach by Zamanzadeh et al. (2015) was adopted and the modified Kappa statistic that takes into consideration the probability of chance agreement was used. This is calculated using Equation 4-1 below:

Equation 4-1 Probability of Chance Agreement

$$P_c = \left[\frac{N!}{A!\,(N-A)!}\right] * 0.5^N$$

Where N is the number of subject matter experts in the panel and A is the number of subject matter experts that agree the item is important (thus, responding with a 4 or a 5).

The modified Kappa statistic is then calculated using equation 4-2:

Equation 4-2 Modified Kappa Statistic

$$K = (ICVI - P_c)/(1 - P_c)$$

According to Zamanzadeh et al. (2015), we then evaluate the modified Kappa statistic based on the criterion as follows. Values of K above 0.74 can be considered excellent whilst values between 0.6-0.74 can be considered good and values of 0.4-0.59 can be considered fair.

The content validity at the entire scale level is then calculated, where S-CVI is found by averaging the item level CVI's (Polit & Beck 2006).

Based on the above procedure, the results of the respective CVI calculations are presented in the explanation of the relevant constructs to be discussed next. In discussing the measurement of each construct, we follow a logical sequence in the appearance of these constructs in our model, starting with ambidexterity.

4.5.2 Ambidexterity

Ambidexterity in this thesis is defined as a dynamic capability that enables the simultaneous pursuit of exploratory and exploitative activities (O'Reilly & Tushman 2008). What is important to keep in mind here is that this then becomes a maximising exercise where the combinatory power of both exploration and exploitation results in greater organisational performance. This is different to the perspective where exploration and exploitation represent a trade-off where organisations should strive for balance. The understanding thus far during the theory building stage of this thesis is that HVLV manufacturers are already adopting the trade-off model given their exploratory orientation. In this case, we are interested in understanding how HVLV manufacturers can leverage the contradictions stemming from their manufacturing strategy towards greater organisational performance and thus maximising the tensions between exploration and exploitation.

From this respect there is an ongoing debate as to the appropriate measures for ambidexterity. Whether a singular one-dimensional scale should be adopted (Simsek et al. 2009) or a scale based on maximisation or balance (Cao, Gedajlovic & Zhang 2009). There is also ongoing discussion regarding the use of reflective (Kortmann et al. 2014) or formative factors (Pertusa-Ortega & Molina-Azorín 2018).

In taking the routines-based view, we recognise that exploration and exploitation are two fundamentally distinct activities. Even though they are both required in achieving ambidexterity, they also impact organisational performance differently (Benner & Tushman 2015). This, of course, means the routines that form exploratory and exploitative activities are unique in their inputs, structure and processes (O'Reilly & Tushman 2008). This leads us to believe that ambidexterity is a second-order reflective-formative construct consisting of exploratory and exploitative activities (Pertusa-Ortega & Molina-Azorín 2018). It is formative in the fact that both, whilst necessary for ambidexterity, are incompatible with each other and should thus be treated as such. To base the assumption on the opposite scenario (reflective factors) would assume exploration and exploitation are highly correlated in both their purpose and their impact towards ambidexterity. This is not to say that second-order reflective approaches are not correct, it depends significantly on the research questions being investigated and hence the type of research itself. For the purposes of this thesis, including the conceptualisation of ambidexterity as a dynamic capability and our interest in understanding the factors that impact operationalising ambidexterity, a second-order reflective-formative model seems appropriate.

The measures for the first order reflective constructs of exploration and exploration are adapted from a five-point Likert scale developed by Lubatkin et al. (2006). They base their operationalisation of exploration and exploitation on the popular approach by He & Wong (2004), though extend this to include the conceptualisation of exploration and exploitation by Benner & Tushman (2003). In that, they recognise the differences in exploration and exploitation to lie in an innovations “proximity” to either existing customers/markers (exploitation) or new customers/markets (exploration). Having been based on one of the seminal studies in operationalising ambidexterity through management practices, we believe this to be appropriate for our circumstances.

A description of the measures, coding for analysis purposes and their status as adapted, adopted or removed is shown in Table 4-2 for exploration and Table 4-3 for exploitation.

Table 4-2 Measures for Exploration

Code	**Description of Measures**	**Status**
Explore1	We look for novel technological ideas by thinking outside the box	Adopted
Explore2	We base our success on our ability to explore new technologies	Adopted
Explore3	We create products and/or services that are innovative to the firm	Adapted/Removed
Explore4	We look for creative ways to satisfy our customer needs	Adopted
Explore5	We aggressively venture into new market segments	Adopted
Explore6	We actively target new customer groups	Adopted

Table 4-3 Measures for Exploitation

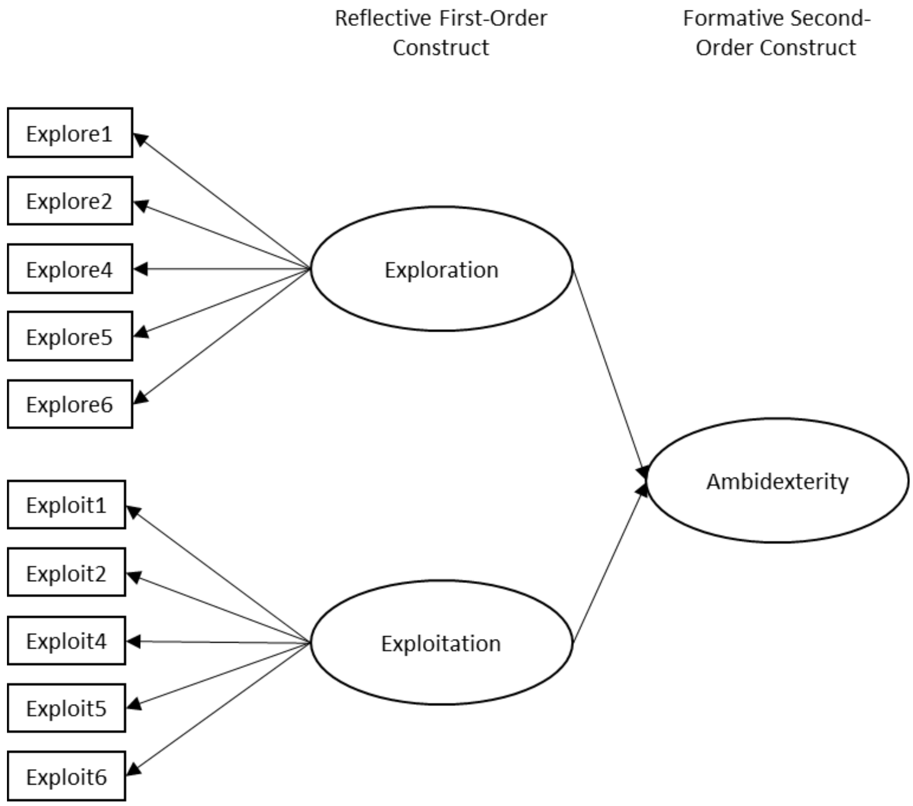
Code	Description of Measures	Status
Exploit1	We commit to improving quality and lowering costs	Adopted
Exploit2	We strive to continuously improve the reliability of our products and/or services	Adapted
Exploit3	We place focus on increasing the level of automation in our operations	Adapted/Removed
Exploit4	We constantly questionnaire the customer satisfaction levels of our existing customer base	Adapted
Exploit5	We fine-tune what we offer to keep our current customers satisfied	Adopted
Exploit6	We place focus on penetrating more deeply into our existing customer base	Adapted

Content validity is a major concern for formative second-order constructs (Ringle, Sarstedt & Straub 2012). A lack of content validity can jeopardise the reliability of the results in that developing formative constructs often results in an incomplete picture of all the different elements that contribute to its ultimate understanding (Hair, Hult, et al. 2017). Fortunately, there exists a rich literature on organisational ambidexterity, including the manner in which it is operationalised (Birkinshaw & Gupta 2013; Junni et al. 2013). In addition, our extensive literature of what ambidexterity means in a HVLV manufacturing environment allows for a more fine-grained understanding of the appropriateness of each measure.

Nonetheless, content validity was further validated by the use of an expert workshop consisting of four academics with a keen understanding of organisational ambidexterity.

During the workshop, questions were raised over the efficacy of including Explore3 and Exploit3 as measures of ambidexterity, given the HVLV manufacturing context. It was concluded that the nature of HVLV manufacturing as almost “knowledge-based” enterprises where skill and expertise in manufacturing a wide variety of products as well as offering other manufacturing related services, renders the creation of new products/services limited in applicability. Consequently, Explore3 was removed. Similarly, automation is of limited relevance in a HVLV manufacturing environment where predictive engineering techniques or pre-production activities is only applicable at higher levels of predictability (Haug, Ladeby & Edwards 2009). Automation appeared more useful for manufacturing operations where high volumes are commonplace. Given this, a decision was made to remove Exploit3 from the operationalisation of ambidexterity as well. The final second-order formative construct is shown in Figure 4-3.

Figure 4-3 Final Structure of the Ambidexterity Construct



4.5.3 Human Resource Management Practices

Human resource management literature provides an exhaustive list of management practices that appear better than others at delivering organisational performance outcomes. For instance the work on high-performance work systems (HPWS) would often segregate 18 human resource management practices into 3 higher order constructs concerning effective staff selection, training and development, performance management and the effective use of reward systems (Úbeda-García et al. 2018). Other studies would offer a more comprehensive outlook on the adoption of human resource management practices by offering a list of 44 items, though largely based on similar sub-categories (Chang 2016).

Because we adopt the notion of better management practices, it would be fitting to adopt similar measures as those within the domain. Thus, our measures of human resource management practices were adapted from the mass-scale survey studies on better management practice (Agarwal, Brown, et al. 2014; Bloom et al. 2017; Bloom & Van Reenen 2006). Here, they are also based off the sub-categories as identified in HPWS literature in attracting, retaining, developing and dealing with poor performing talent. Adapting the more qualitative scale developed by Bloom & Van Reenen (2006) into our research domain yielded the following measures shown in Table 4-4.

Table 4-4 Initial Measures of Human Resource Management Practices

Code	Description of Measures	Status
HRM1	Senior managers are evaluated and held accountable for the strength of the talent pool they actively build	Adapted
HRM2	We strive to outperform the competitors by providing ambitious stretch targets with clear performance related accountability and rewards	Adapted/Modified
HRM3	We move poor performers out of the company or to less critical roles as soon as a weakness is identified	Adapted/Modified
HRM4	We actively identify, develop and promote our top performers	Adapted
HRM5	We provide a unique value proposition above our competitors to encourage talented people to join our company	Adapted
HRM6	We do whatever it takes to retain our talent	Adapted

Considering it was imperative to adapt the measures from these large-scale studies into this research context, achieving content validity required more than an extensive literature review process. In this instance, and as per the recommendations by Forza (2016), we adopted a quantitative method of testing for and achieving content validity known as the content validity index (Polit & Beck 2006) explained in section 4.5.1.

The results of this procedure for the human resource management construct are shown in Table 4-5.

Table 4-5 Results of the Content Validity Index for Human Resource Management

Code	No. of 4-5 rating	I-CVI**	P_c***	K****	Interpretation
HRM1	12	0.923	0.003	0.923	Excellent
HRM2	7	0.538	0.419	0.206	Poor
HRM3	6	0.462	0.419	0.073	Poor
HRM4	11	0.846	0.019	0.843	Excellent
HRM5	12	0.923	0.003	0.923	Excellent
HRM6	11	0.846	0.019	0.843	Excellent
	S-CVI (Average)*	0.756			

*S-CVI is the scale content validity index, **I-CVI is the individual content validity index, *** P_c is the probability of chance occurrence, ****K is the modified Kappa statistic where above 0.74 is excellent, 0.6-0.74 is good and values from 0.59-0.4 can be considered fair.

The results suggest that the scale needs some adjustment. The S-CVI is below the recommended threshold of 0.8 (Polit & Beck 2006). It is also apparent that HRM2 and HRM3 require further attention from their low modified Kappa statistic. Given the importance of accountability and related rewards systems in HRM studies (Chang 2016) and further discussions with the supervisory panel led us to believe that it was worthwhile to modify HRM2 to reflect a measure that was simpler and more comprehensible. HRM3 also proved challenging for respondents given the fact that "removing poor performers" may not be the most appropriate action under all circumstances. This is also evidenced in prior HRM studies which focus on development rather than dismissal (Chang 2016). Thus, we have opted to modify this construct to reflect the different strategies organisations can take in "dealing with" underperformers. The revised measured are shown in Table 4-6.

Table 4-6 Revised Description of Measures for HRM2 and HRM3

Code	Revised Description of Measures
HRM2	We adopt an appropriate performance-based rewards and accountability system linked to organisational targets
HRM3	We adopt different strategies (remove, reallocate and/or develop employees) to manage our underperformers

4.5.4 Production Planning and Control

The measurement scale for the production planning and control (PPC) construct was developed in a similar fashion to the human resource management construct. However, due to the novelty of this construct, this involves an additional iteration after the expert panel assessment where we revisit literature and conduct another validation process by reviewing the construct with the supervisory panel before placing it in the model for testing.

The extensive literature review on better management practices in HVLV manufacturing highlighted the key role of PPC in enabling greater HVLV manufacturing performance outcomes. It is even more essential in times of peak business. Initially, PPC was said to consist of two seemingly separate activities in sales and estimation (concerning quotation management and coordination) as well as those in relation to workload control through bottleneck detection, regulating the influx of orders and so forth. Because they are essential in explaining PPC overall and at the same time present themselves as two different sets of management practices, the initial thought was the construction of a second-order reflective-formative construct (similarly to ambidexterity). Based on the extensive literature review conducted in both Chapter 2 and 3, we proposed the following measures (shown in Table 4-7 and 4-8 on the next page).

Table 4-7 Measures for Sales and Estimation Activities

Code	Description of Measures	Key References
Sales1	We keep track of and monitor all quotation (both won and lost) in an easy access database	Muda & Hendry (2003)
Sales2	We have a keen understanding of our competitors and employ a systematic quotation control system in order to help guide cost and lead time estimations for customer enquiries (for example, a strike-rate matrix)	(Kingsman & Mercer 1997); Muda & Hendry (2003)
Sales3	We actively help customers meet their goals rather than just providing customers' wants	Muda & Hendry (2003)
Sales4	There is a high degree of coordination between all departments to ensure we set realistic due dates for customer enquiries	Zorzini et al. (2008)
Sales5	Capacity and resource availability information is readily available to both manufacturing and sales departments when responding to customer enquiries	Kingsman et al. (1993); (Konijnendijk 1994)
Sales6	There is a high degree of coordination between our organisation and our suppliers when we respond to customer enquiries	(Mello et al. 2017); Zorzini et al. (2008)

Table 4-8 Measures for Production Planning and Control Activities

Code	Description of Measures	Key References
PPC1	We implement a systematic method of workload control	(Hendry, Huang & Stevenson 2013)
PPC2	We employ a pre-shop floor pooling and release system to improve flow in manufacturing operations	(Thurer et al. 2012)
PPC3	We have a systematic method of bottleneck detection and reduction	Petroni, Zammori & Marolla (2017)
PPC4	Job priorities are clearly understood by everyone on the shop floor	Muda & Hendry (2003)
PPC5	We rigorously pursue quick change over and set-up times for our machines and strive to improve them	Muda & Hendry (2003); Petroni, Zammori & Marolla (2017)
PPC6	We structure our manufacturing practices and shop-floor layout based on the identification of common product families	Petroni, Zammori & Marolla (2017)

These measures were then used in a content validity test based on the content validity index. The results of this testing are shown in Table 4-9 for Sales and Table 4-10 for Production Planning and Control.

Table 4-9 Results of the Content Validity Index for Sales

Code	No. of 4-5 rating	I-CVI**	P_c***	K****	Interpretation
Sales1	10	0.769	0.070	0.752	Excellent
Sales2	10	0.769	0.070	0.752	Excellent
Sales3	8	0.615	0.314	0.439	Fair
Sales4	12	0.923	0.003	0.923	Excellent
Sales5	13	1	0	1	Excellent
Sales6	9	0.692	0.175	0.627	Good
	S-CVI (Average)*	0.795			

*S-CVI is the scale content validity index, **I-CVI is the individual content validity index, *** P_c is the probability of chance occurrence, ****K is the modified Kappa statistic where above 0.74 is excellent, 0.6-0.74 is good and values from 0.59-0.4 can be considered fair.

Table 4-10 Results of the Content Validity Index for Production Planning and Control

Code	No. of 4-5 rating	I-CVI**	P_c***	K****	Interpretation
PPC1	12	0.923	0.003	0.923	Excellent
PPC2	11	0.846	0.019	0.843	Excellent
PPC3	12	0.923	0.003	0.923	Excellent
PPC4	12	0.923	0.003	0.923	Excellent
PPC5	13	1	0	1	Excellent
PPC6	12	0.923	0.003	0.923	Excellent
	S-CVI (Average)*	0.923			

*S-CVI is the scale content validity index, **I-CVI is the individual content validity index, *** P_c is the probability of chance occurrence, ****K is the modified Kappa statistic where above 0.74 is excellent, 0.6-0.74 is good and values from 0.59-0.4 can be considered fair.

The results of this analysis suggest the relative convergence in the understanding of these items to their respective constructs is mostly sufficient. However, upon reinvestigating literature to cross-validate the findings and discussions with three content validity questionnaire participants, there appeared to be a discrepancy in the validity of the PPC5 and PPC6 items concerning production planning and control activities. Whilst they were valid in understanding the construct of production planning and control in general, their validity in terms of HVLV manufacturing was questioned.

Quick change-over and setup times seems valid for machining and tooling HVLV manufacturers, though appeared less relevant for those in heavy fabrication. Similarly, the restructure of the shopfloor to suit common product families does not appear relevant in versatile manufacturing companies where repeat business is often not possible. For these reasons, PPC5 and PPC6 were removed from the list of measures. In addition, during discussions with three questionnaire participants, it was found that PPC2 can also be considered a subset of PPC1. To avoid confusion, and for the sake of simplification, PPC2 was also removed from the list of measures. Subsequently leaving PPC1, PPC3 and PPC4. Given these three items stem from the concept of workload control in HVLV manufacturing, the name of the construct was also changed to suit.

In terms of the items associated with the Sales construct, Sales3, whilst a prevalent item in HVLV manufacturing literature, required simplification according to the same discussions held after the content validity questionnaire. In this instance, Sales3 was modified to read “we understand our customers’ objectives”. Furthermore, it was suggested that Sales itself could hold two distinct activities in Quotation Management (Sales 1-3) and Coordination (Sales 4-6). Indeed, a post-hoc review of literature revealed the same (as was demonstrated in Section 3.4.2).

A summary of the final measures for each first order reflective construct is shown in Table 4-11 through to Table 4-13. This is also illustrated in the second-order reflective-formative model for production planning and control shown in Figure 4-4.

Table 4-11 Final Measures for Quotation Management

Code	Description of Measures
Sales1	We keep track of and monitor all quotation (both won and lost) in an easy access database
Sales2	We have a keen understanding of our competitors and employ a systematic quotation control system in order to help guide cost and lead time estimations for customer enquiries (for example, a strike-rate matrix)
Sales3	We understand our customers' objectives

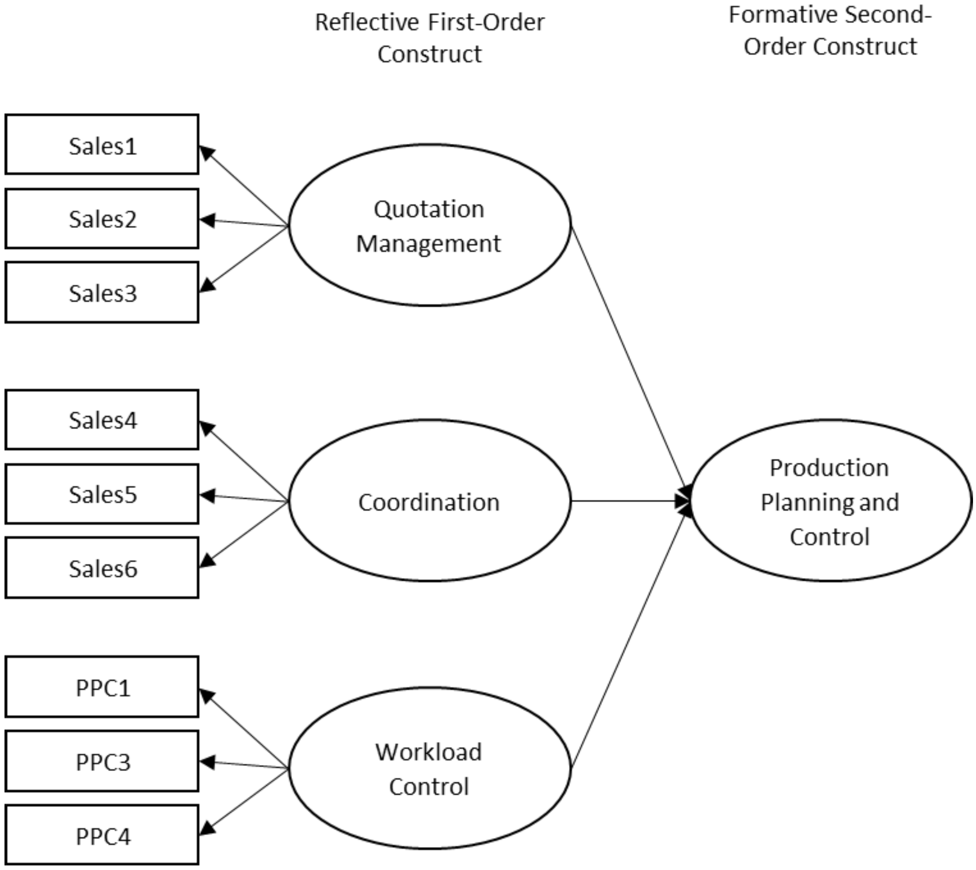
Table 4-12 Final Measures for Coordination

Code	Description of Measures
Sales4	There is a high degree of coordination between all departments to ensure we set realistic due dates for customer enquiries
Sales5	Capacity and resource availability information is readily available to both manufacturing and sales departments when responding to customer enquiries
Sales6	There is a high degree of coordination between our organisation and our suppliers when we respond to customer enquiries

Table 4-13 Final Measures for Workload Control

Code	Description of Measures
PPC1	We implement a systematic method of workload control
PPC3	We have a systematic method of bottleneck detection and reduction
PPC4	Job priorities are clearly understood by everyone on the shop floor

Figure 4-4 Final Second-Order Reflective-Formative Construct of Production Planning and Control



4.5.5 Operational Flexibility

Operational flexibility is defined here as the ability for HVLV manufacturers to produce a wide range of products. Fortunately, operational flexibility has a rich theoretical underpinning in manufacturing strategy literature (Boyer & Lewis 2002; Netland & Frick 2017) as well as in in literature akin to that of HVLV manufacturers (Tamayo-Torres et al. 2017). Nonetheless, in this thesis we have opted to adopt the measures for operational (process) flexibility by Swink, Narasimhan & Kim (2005) given their relevance to the HVLV manufacturing environment. These are shown in Table 4-14.

Table 4-14 Measures for Operational Flexibility

Code	Description of Measures	Status
Perf_Flex1	Ability to customise products	Adopted
Perf_Flex2	Ability to adjust production volumes	Adopted
Perf_Flex3	Ability to respond to changes in delivery requirements	Adopted
Perf_Flex4	Ability to produce a range of products	Adopted

4.5.6 Process Innovation

Process innovation is defined as "new or significantly improved production or delivery methods [including] significant changes in techniques, equipment and software" (OECD & Communities 2005). It has been a central and recurring theme in innovation literature for decades. However, in this instance, we adopt the measures for process innovation by Prajogo & Sohal (2003) shown in Table 4-15. These were adopted given the authors have placed a particular focus on assessing the impact of management practices on organisational outcomes and, hence, their relevance for this study.

Table 4-15 Measures for Process Innovation

Code	Description of Measures	Status
Perf_Innov_Proc1	The technological competitiveness	Adopted
Perf_Innov_Proc2	The updated-ness or novelty of technology used in processes	Adopted
Perf_Innov_Proc3	The speed of adoption of the latest technological innovations in processes	Adopted
Perf_Innov_Proc4	The rate of change in processes, techniques and technology	Adopted

4.6 Population and Sample Selection

Sampling procedures were undertaken based on the recommendations of Forza (2010) and Sekaran & Bougie (2013). It is important to clearly define the rationale behind the selection of a sample in order to ensure the correct methodology is undertaken and, indeed, that a survey method is suitable (Forza 2010). This includes defining the population frame, sample design and sample size (Forza 2010).

The population frame defines all of the elements of a population (HVLV manufacturers) from which the sample will be drawn. Because this research covers a very specific area of interest, concerning manufacturing organisations with unique properties, it is imperative to capture these characteristics in the population frame. Typically, SIC codes are a good way to start defining the population frame (Flynn et al. 1990). Given HVLV manufacturers operate in a wide variety of industries (some with no particular focus on industry type), and are often associated with machining, fabrication, tool making and similar service-based activities it was determined that they fit multiple broad category ANZSIC codes (shown in Table 4-16).

Table 4-16 ANZSIC Codes for Defining the Sampling Frame

ANZSIC Code	Description
2741	Structural Steel Fabrication
2759	Sheet Metal Products Manufacturing
2864	Machine Tool and Part Manufacturing

In addition to this, we also employ size as a control that forms part of the population frame, given HVLV manufacturers are typically characterised as SMEs (Amaro, Hendry & Kingsman 1999; Stevenson, Hendry & Kingsman 2005). In this instance, the Australian Bureau of Statistics (2001) classification scheme for SMEs was adopted; whereby 1-4 employees denotes a micro-business, 5-19 is classified as a small business, 19-199 is a medium business (we split this into 20-99 and 100-199 as an extra level of granularity) and 200 employees and above is a large business. In addition to the 200 employee maximum, we also enforced a minimum of 5 employees as micro-business are unlikely to adopt any systematic method of better management practices (Bloom & Van Reenen 2010).

A multi-method approach to extracting the sample frame was also adopted in this thesis. Due to budget constraints, a free online business directory was initially adopted to collate the sampling frame. Using key words from the ANZSIC codes as a guide, the sampling frame was narrowed to 604 manufacturing organisations in Australia. However, it was noticed that many of the manufacturers that entered through the search process were clearly not HVLV manufacturers by virtue of their business title (this could have been attributed to the use of “keywords” in their business advertisement). This meant the sampling frame had to be meticulously cross validated to ensure the sampling requirements of the thesis are met. Thus, each website (where a website was available) of the manufacturers in this sample was investigated to ensure the manufacturer actually performs manufacturing activities congruent to that of HVLV manufacturing. Unfortunately, this also meant the sampling frame could not be controlled for firm size, instead an ex-post analysis of firm size was conducted to remove responses from manufacturers with less than five employees. Nonetheless, a total of 415 manufacturers was the result.

This was deemed insufficient as the common 10% response rate cited in HVLV manufacturing literature (Aslan, Stevenson & Hendry 2012) would reveal a final sample size of roughly 40 manufacturers – far less than required. We then engaged the services of two List Brokers in the hopes of improving the sample. Basing our criteria on the key ANZSIC codes of interest, limiting company size as per SME status and only targeting key decision makers (also accounting for duplicates) a further 756 manufacturing organisations were identified from one List Broker and 328 from the other. Thus, the total sampling frame for this research began at 1,411 manufacturing organisations.

4.7 Questionnaire Development

Whilst questionnaires are an effective and efficient means of undertaking theory verification and descriptive studies (such as this), there are also critical considerations that need to be addressed. The questionnaire in this thesis will be administered to one organisational member (key decision maker in a HVLV manufacturer) at a certain point in time. Thus, akin to most cross-sectional studies, issues with self-reporting start to arise.

An individual’s propensity to both interpret the questionnaire and actually answer it depend on any number of factors. Traditionally, factors including wording, measure design as well as placement and order of questions are key to mitigating any individual-level impacts on the validity and reliability of the answers given (Forza 2016) . However, more recently there has also been a push to improve our understanding of visual design in survey research, suggesting the size of font, presentation and so forth should also be taken into consideration (Sekaran & Bougie 2013).

In the questionnaire developed as part of this thesis, extensive efforts were made in order to avoid the pitfalls associated with self-reporting in the actual design of the questionnaire.

Firstly, from a presentation point of view, the questionnaire was generated using an online questionnaire development tool known as Survey Monkey. This allowed for effective presentation of the questionnaire through attractive fonts, colours and professional outlook. Care was taken to deliver the invitation letter (Shown in Appendix 2) in a manner that was both appealing and at the same time demonstrated good research practice. Here, potential respondents were greeted with a real-world problem demonstrating relevance to practice. Confidentiality was assured and a research ethics approval number was also provided. In addition, incentives by way of an executive summary and discounted entry to an Australian conference in digital transformation was offered to both build credibility and facilitate greater response rates.

In order to combat some of the biases stemming from self-reporting, the questions were mindful of sensitivity to the business as well. Performance outcomes and turnover are notoriously difficult to report, particularly from SMEs. Such questions can also act as a deterrent to undertaking the questionnaire in the first place. In this instance, we use aggregated measures for turn-over where the manager will select a considerable bracket in which their turnover fits. Additionally, perceptual measures for performance outcomes were used so as not to invoke sensitivity issues with exact figures. Whilst there is certainly a trade-off with regards to reliability in an analysis sense, the trade-off was considered fruitful in maximising the chances of respondents completing the questionnaire truthfully.

Furthermore, randomised question order in each section (to be described next) as well as careful thought in the layout and distribution of the questions was considered in the questionnaire design to help mitigate against the negative consequences of self-reporting.

Once completed, the questionnaire underwent pilot testing. The finished questionnaire was distributed to five academics and one HVLV manufacturing industry professional for feedback. The most recurrent feedback stemmed from the need to shorten the questionnaire in order to reduce cognitive fatigue and drop-out rates.

The first draft of the questionnaire instrument took an average of 25 minutes to complete in its entirety. For an industry professional, this is certainly quite lengthy. Consequently, unnecessary survey questions were removed (regarding specific industry and strategic characteristics), and the survey underwent an additional round of pilot testing by 3 academics. This time the average response rate was 18 minutes. Given the extensive nature of the questionnaire and its ambitious targets, focus was placed on facilitating as much ease-of-use as practicable. Save points were provided more frequently throughout the questionnaire, as was a progress meter outlining how much the respondent had left to complete.

4.8 Questionnaire Design

The full questionnaire (shown in Appendix 3) was structured into four separate sections, discussed in detail here.

Section A: Basic Organisational Characteristics

This section contained 11 questions where the respondents were asked about their individual characteristics and those of their organisation.

From an individual perspective, the respondents were asked for their role, tenure in the organisation and level of education. On the other hand, the organisational characteristics were split into two halves. The first in asking the respondent for the size, age, turnover and industry affiliations (generic organisational characteristics) and the second in more specific HVLV manufacturing characteristics in the degree of customisation offered, scope of responsibility in terms of manufacturing strategy and also the activities undertaken after the receipt of a customer order. Lastly, the respondents were asked to assess the strategic importance of various competitive priorities by using a five-point Likert scale from not important (1) to very important (5).

Section B: Adoption of Management Practices

Section B asked the respondents to assess the extent to which they adopt better management practices. In total eight management practices were assessed, however, as mentioned earlier, this thesis only relies on two (human resource management, and production planning and control), stemming from the constraints in sample size and increased complexity of the model. In the interest of transparency, all questions are disclosed here.

The scale used for all questions was a five-point Likert scale ranging from (1) strongly disagree to (5) strongly agree, with regards to the adoption of better management practices. A non-applicable option was also provided in case the management practice was not applicable to them.

Section C: Ambidextrous Capabilities

In line with Lubatkin et al. (2006), this section asked respondents to assess their propensity to adopt exploratory and exploitative activities based on their organisations' orientation in the past three years using a five-point Likert scale from (1) strongly disagree to (5) strongly agree.

All items for ambidexterity (Explore 1-6 and Exploit 1-6) are grouped into a single question and randomised to reduce the occurrence of biased responses.

Section D: Organisational Performance

This last section consisted of five questions regarding their organisational performance. As with the better management practices, only two of these questions are relevant for this thesis (process/operational flexibility, and process innovation performance).

Organisational performance was assessed based on perceptual measures (rather than objective measures). The reason for this is twofold, firstly perceptive measures – when purposefully conducted and effectively constructed with special consideration to some key practices – can be just as effective as objective measures (Dess & Robinson 1984; Singh, Darwish & Potočnik 2016) and secondly true financial information from SMEs is hard to come by and the accounting practices of SMEs is notoriously lacking.

As such, the respondents were asked to assess their performance against that of their main competitor, somewhat attenuating for industry effects (Swink, Narasimhan & Kim 2005). This was done using a five-point Likert scale from (1) much worse to (5) much better.

Finally, we provide respondents with an opportunity to clarify their answers, for instance, if they had chosen N/A as a response or could not relate to a particular question. This forms the limited qualitative component in this thesis.

A summary of the questions and their related constructs are shown in Table 4-17.

Table 4-17 Summary of Key Constructs and Related Questions

Construct	**Item**	**Question No.**	**Question Description**
Exploration	Explore1	20a	We look for novel technological ideas by thinking outside the box
	Explore2	20b	We base our success on our ability to explore new technologies
	Explore4	20d	We look for creative ways to satisfy our customer needs
	Explore5	20e	We aggressively venture into new market segments
	Explore6	20f	We actively target new customer groups
Exploitation	Exploit1	20g	We commit to improving quality and lowering costs
	Exploit2	20h	We strive to continuously improve the reliability of our products and/or services
	Exploit4	20j	We constantly survey the customer satisfaction levels of our existing customer base
	Exploit5	20k	We fine-tune what we offer to keep our current customers satisfied
	Exploit6	20l	We place focus on penetrating more deeply into our existing customer base
Human Resource Management	HRM1	14a	Senior managers are evaluated and held accountable for the strength of the talent pool they actively build
	HRM2	14b	We adopt an appropriate performance-based rewards and accountability system linked to organisational targets
	HRM3	14c	We adopt different strategies (remove, reallocate and/or develop employees) to manage our underperformers
	HRM4	14d	We actively identify, develop and promote our top performers
	HRM5	14e	We provide a unique value proposition above our competitors to encourage talented people to join our company
	HRM6	14f	We do whatever it takes to retain our talent

Table 4-17 Summary of Key Constructs and Related Questions (Continued)

Construct	Item	Question No.	Question
Quotation Management	Sales1	16a	We keep track of and monitor all quotation (both won and lost) in an easy access database
	Sales2	16b	We have a keen understanding of our competitors and employ a systematic quotation control system in order to help guide cost and lead time estimations for customer enquiries (for example, a strike-rate matrix)
	Sales3	16c	We understand our customers' objectives
Coordination	Sales4	16d	There is a high degree of coordination between all departments to ensure we set realistic due dates for customer enquiries
	Sales5	16e	Capacity and resource availability information is readily available to both manufacturing and sales departments when responding to customer enquiries
	Sales6	16f	There is a high degree of coordination between our organisation and our suppliers when we respond to customer enquiries
Workload Control	PPC1	18a	We implement a systematic method of workload control
	PPC3	18c	We have a systematic method of bottleneck detection and reduction
	PPC4	18d	Job priorities are clearly understood by everyone on the shop floor
Operational Flexibility	Perf_Flex1	21a	Ability to customise products
	Perf_Flex2	21b	Ability to adjust production volumes
	Perf_Flex3	21c	Ability to respond to changes in delivery requirements
	Perf_Flex4	21d	Ability to produce a range of products
Process Innovation	Perf_Innov_Proc1	25a	The technological competitiveness
	Perf_Innov_Proc2	25b	The updated-ness or novelty of technology used in processes
	Perf_Innov_Proc3	25c	The speed of adoption of the latest technological innovations in processes
	Perf_Innov_Proc4	25d	The rate of change in processes, techniques and technology

4.9 Ethical Considerations

This thesis meets the requirements set forth by the Human Research Ethics Committee at the University of Technology Sydney (UTS). Two rounds of ethics approval were required based on changes during pilot testing that concerned the structure and questions of the questionnaire submitted for the first ethics approval process. The ethics approval letter for both the initial questionnaire and the amended final questionnaire used to conduct this research is shown in Appendix 4.

4.10 Data Collection Process

This study applied multiple delivery methods for data collection. A first round of data collection was conducted based on a two-step process. Firstly, using the list of organisations that qualified as HVLV manufacturers created based on a search within a free online business directory, potential respondents were telephoned in order to conjure interest in the research and build a rapport with the respondent to increase response rates. Then, those that responded favourably provided a direct email address for key decision makers where the questionnaire will be sent. The result was 106 HVLV manufacturers were called from the sample of 415 within the online business directory list; 63 of which provided a direct email address for a key decision maker. Here, 11 responses were received from three reminders spanning two weeks apart from each other. This equated to a response rate of 18%.

A decision was then made to send the questionnaire to the remaining emails gathered from the free online business directory. A total of 309 invitations were sent. On this occasion, 36 responses were collected after also having sent three reminders, two weeks apart from each other. Thus, resulting in a response rate of roughly 12%.

After this, a mailing list was purchased from a List Broker tailored to the specifications of the sampling frame in this thesis. Here, 756 invitations were sent and only three responses were received after three reminder emails spanning two weeks apart from each other. Upon investigating the data provided by Survey Monkey, it was found that only 138 respondents had received the email invitation, the rest had either bounced back or remained unopened. The total sample of 138 responses reveals a response rate of 2%. Again, upon investigating the purchased list from the List Broker, the majority of email addresses were not personalised to any one individual.

Finally, a specialist List Broker was consulted to provide personalised emails for key decision makers in the manufacturers that spanned the characteristics of the sampling frame in this thesis. In this instance, 328 invitations were sent and resulted in 23 completed responses after three rounds of reminders spanning two weeks apart from each other.

The data collection methods and resultant responses received is summarised in Table 4-18.

Table 4-18 Summary of Data Collection Methods and Results

Method	Invitation Sent	Total Responses Received
Cold-Calling (business directory)	63	11
Cold-Email (business directory)	309	36
Purchased List No.1	138*	3
Purchased List No.2	328	23
Totals	**838**	**73**
Overall Response Rate	**9%**	

*taking the 138 individuals that received the invitation email.

4.11 Data Entry and Screening

Data entry and data screening were undertaken using IBM SPSS Statistics 25 (IBM Corp. 2017). Here, missing data was screened as per the guidelines set forth by Hair, Hult, et al. (2017). In addition, the patterns of missing data were analysed using Little’s test (Little 1988) to determine the most appropriate remedy.

Next, the distributions of the data were assessed for both outliers as well as to check for extreme levels of skewness and kurtosis. As was the case for the data screening procedure, this was done using IBM SPSS Statistic 25 (IBM Corp. 2017).

A more detailed review of this process will be discussed in section 5.1.

4.12 Data Analysis Using Partial Least Squares Structural Equation Modelling

The data analysis and hypothesis testing was accomplished through the use of partial least squares (PLS) structural equation modelling (SEM) within the software SmartPLS 3 (Ringle, Wende & Becker 2015). PLS SEM is a variance-based modelling technique that aims at minimising the unexplained variance in a particular model (as opposed to its covariance counter parts) (Hair, Hult, et al. 2017). As a variance-based approach, it is particularly helpful in modelling and testing a theoretical framework from both an exploratory and predictive sense (Hair et al. 2019), thus making it ideal for this study. It is also seeing increasing use throughout various fields of enquiry including marketing (Henseler, Ringle & Sinkovics 2009), operations management (Peng & Lai 2012) and information systems research (Ringle, Sarstedt & Straub 2012) to name a few. PLS SEM has also been highly regarded as a robust methodology for use in studies concerning management practices, given its ability to model both composites and factors (Henseler, Hubona & Ray 2017; Peng & Lai 2012).

In terms of this thesis, PLS SEM seems again helpful in its capabilities working quite well with smaller samples sizes (Hair, Hult, et al. 2017). However, this is entirely dependent on the complexity of the model being evaluated. Typically, the rule of thumb would suggest a minimum samples size equating to the maximum number of "arrows" pointing towards any one construct multiplied by ten (Hair, Hult, et al. 2017). In this case, the research model observes a maximum of five arrows pointing towards a construct, thus a minimum sample size of 50 is recommended. Fortunately, this research fits the bracket, though as more sophisticated sample size calculations in Chapter 5 would show, this is in fact more than sufficient.

In addition, the research model relies on two second-order reflective-formative factors in ambidexterity and production planning and control. PLS SEM is uniquely qualified to evaluate such models given its innate ability to model formative constructs (in comparison to other covariance-based methods that require modifications in order to factor in these types of models) (Hair, Hult, et al. 2017; Hair et al. 2019). Further, it makes no assumptions about distributions, thus is robust against higher levels of skewness and kurtosis (Hair et al. 2019).

To assess a PLS SEM model, one is required to undergo two different procedures. The first in assessing the outer model (measurement model) and the second in assessing the inner model (structural model). At the risk of repetition, the following only briefly summarises how this is accomplished in this research. A more in-depth discussion of this occurs in Chapter 5 as the research steps are explained at each stage of the evaluation process for better comprehension of the results themselves.

4.12.1 Evaluation of the Measurement Model

The evaluation of the measurement model informs us of the reliability and validity of the measures used in the model and is performed differently for reflective and formative factors. In the former, reflective model assessment involves investigating the loadings of each individual factor, the internal consistency reliability of the constructs and finally the evaluation of convergent and discriminant validity. Whilst, in the latter, formative factors are assessed based on their convergent validity, collinearity as well as statistical significance and relevance.

Factor loadings are assessed based on the criteria set forth by Hair, Hult, et al. (2017) where they state values above 0.4 may be acceptable under certain circumstances. Typically a value of greater than 0.7 is sought (Peng & Lai 2012). On the other hand, in order to calculate internal consistency reliability there are a multitude of available options where the most common include Cronbach's alpha, composite reliability and Rho A (P_A). Composite reliability is more precise than Cronbach's alpha, though it also appears to produce higher values. P_A, however, stands as a middle ground between the two. In this thesis, and for comparison purposes because of these discrepancies, we report on the composite reliability and P_A where values should lie between 0.6 and 0.95 in either case (Hair, Hult, et al. 2017).

Convergent validity and discriminant validity checks to ensure the relationship between items is consistent with the type of factor they are trying to build. Convergent validity, assessed using the average variance extracted (AVE), checks to see if the indicators that are meant to be related, are indeed related (Hair et al. 2019). Values for the AVE should be greater than 0.5 (Hair, Hult, et al. 2017). Next, discriminant validity checks to see if the items that are not meant to be related are not related. In this thesis, this is accomplished by way of assessing the heterotrait-monotrait (HTMT) ratio, where values should be less than one (Henseler, Ringle & Sarstedt 2015).

Formative models, however, are assessed based on different criteria, given they represent distinct constructs. In this case, an assessment of collinearity is crucial where the variance inflation factor (VIF) is used (Hair, Hult, et al. 2017). In this thesis, the formative factors that constitute ambidexterity (exploration and exploitation) and production planning and control (quotation management, coordination and workload control) should observe VIF values of less than three (Hair, Hult, et al. 2017). In addition, the statistical significance of each formative factor should be assessed using a bootstrapping procedure. If the formative constructs demonstrate good statistical relevance and significance, the formative factor is said to be sufficient (Hair, Hult, et al. 2017) .

4.12.2 Evaluation of the Structural Model

The evaluation of the structural model tells us the extent to which our theory is supported by our data – thus, it is a method of hypothesis testing. Typically, this includes a five-step process (Hair, Hult, et al. 2017). However, in this thesis, there is an additional step involved where the latent variable scores of lower-order constructs are used to model the higher order constructs of ambidexterity and production planning and control. This so-called repeat-indicators approach (Hair, Sarstedt, et al. 2017) proves particularly helpful for modelling second-order reflective formative constructs.

Once this is completed, a bootstrapping procedure is undertaken to obtain the standardised path coefficients and their related *p* and *t* statistics. These values combined would determine the direction of influence of each relationship in the model and their statistical significance and relevance.

Next, the coefficient of determination (R^2) is calculated using the regular PLS algorithm due to the inclusion of formative factors in the model (Hair, Hult, et al. 2017). This will draw conclusions about the predictive accuracy of the model where R^2 values equalling

0.25, 0.5 and 0.75 represent weak, moderate and substantial, respectively (Hair et al. 2019).

At the same time, the effect size of each relationship within the model is calculated by determining the f^2 value. This value represents the change in the R^2 value of a particular endogenous construct when an exogenous construct is removed from the model and retained in the model (Hair, Hult, et al. 2017). An f^2 value of 0.02, 0.15, 0.35 represent small medium and large effect sizes, respectively (Henseler, Ringle & Sinkovics 2009). The calculations for effect size are shown in parallel to the results in Chapter 5.

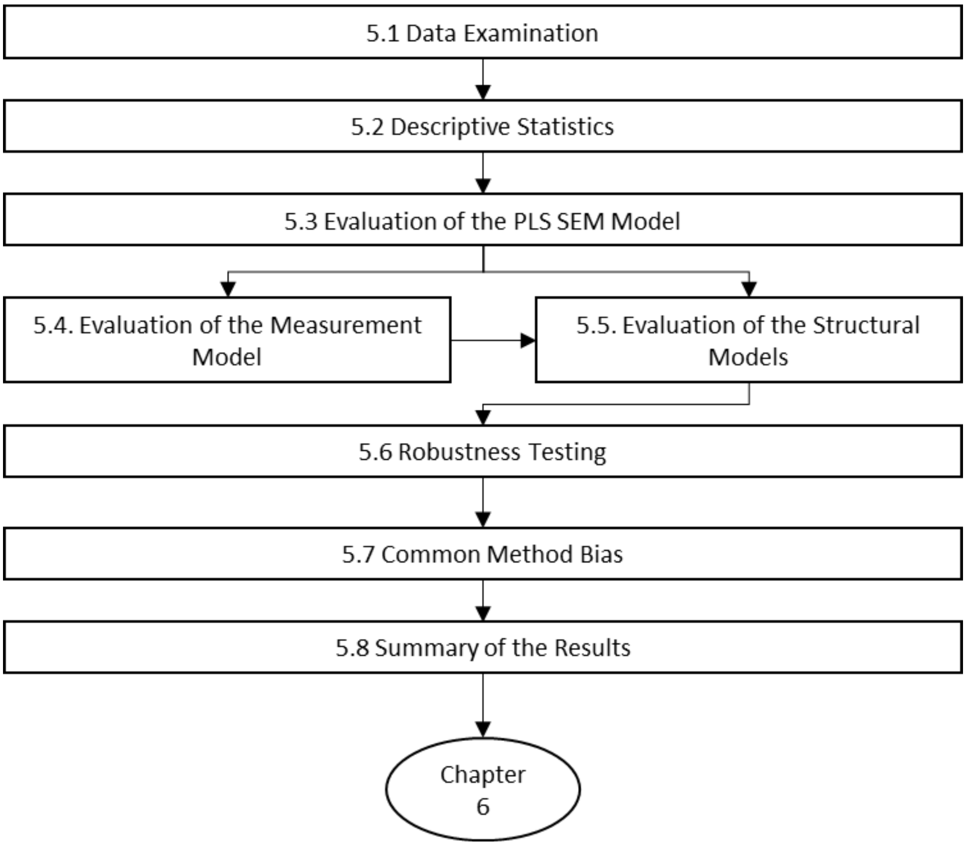
An additional calculation is then undertaken to determine the predictive relevance (Q^2) of the model. Here, a blindfolding technique is undertaken to determine the cross-validated redundancy figures that provide an indication of predictive relevance (Hair, Hult, et al. 2017). Figures of Q^2 which are greater than one are said to observe predictive relevance (Hair et al. 2019).

Finally, the effect size concerning the predictive relevance is calculated. Similarly to the effect size of predictive accuracy, the q^2 value are determined by computing the change in Q^2 of an endogenous variable when an exogenous variable is included and excluded from the model (Hair, Hult, et al. 2017). Again, a q^2 value of 0.02, 0.15, 0.35 represent small medium and large effect sizes, respectively (Henseler, Ringle & Sinkovics 2009). The calculations for q^2 are similarly shown in parallel to the results in Chapter 5.

Chapter 5 Analysis and Results

This chapter presents the results of the empirical work in this thesis. We begin by undertaking a data examination exercise, investigating the patterns of missing data and the distribution of responses per item. Next an overview of the descriptive statistics including the profile of responses, general characteristics of their respective HVLV manufacturing organisations and a more detailed outlook of their specific HVLV manufacturing characteristics is undertaken. This is followed by an overview of the evaluation procedure of the partial least squares (PLS) structural equation modelling (SEM) exercise where we conduct our hypothesis testing. The evaluation of the measurement model proceeds, where we test the validity and reliability of the reflective and second-order reflective-formative constructs. This is followed by the evaluation of the structural models where results of the path-coefficients of both models with and without control variables are revealed and hypotheses are revisited. We then run additional testing concerning a mediation analysis, post-hoc statistical power calculation and review the significance and relevance of the observed relationships within the models by observing the R^2 and Q^2 values. A robustness testing exercise is undertaken to provide further support for the results. A test for common method bias was also undertaken. Lastly a summary of the results is provided. An outline of this Chapter is provided in Figure 5-1.

Figure 5-1 Outline of Chapter 5



5.1 Data Examination

The previous chapter outlined key sample size considerations that ultimately led to a final sample of 73 respondents. Here, in addition to the explanation previously, we demonstrate the data cleaning and examination techniques adopted before any analysis took place. The following procedures are based on the guidelines set forth by Hair and colleagues (Hair, Hult, et al. 2017; Hair et al. 2019; Hair, Sarstedt, et al. 2017) and those more relevant to operations management literature (Forza 2016; Peng & Lai 2012) with regards to partial least squares (PLS) structural equation modelling (PLS SEM) analysis methods.

5.1.1 Missing Data and Suspicious Response Patterns

The issue of missing data seems to be a recurring problem in organisation research, particularly as a result of the survey instrument. Missing data results when a respondent fails to answer one or more questions. This can be attributed to, for instance, the length of the questionnaire, perceived sensitivity of the question and perceived applicability (of which we explicitly attempt to account for by including a "not applicable" option in selected questionnaire questions) (Forza 2016; Schlomer, Bauman & Card 2010). Missing data can also be particularly harmful given its effect on statistical power and increased probability of incurring biased estimates (Tsikriktsis 2005). Due to the limitations stemming from the relatively small sample size, considerable care has been taken when dealing with missing values in this thesis.

The treatment of missing data typically concerns itself with two key considerations relating to: 1) the amount of missing data and; 2) the patterns of missing data observed in a data set (Schlomer, Bauman & Card 2010).

Regarding frequencies, if the amount of missing data exceeds 15% of the total questions per observation, the rule-of-thumb would suggest removing that observation from the data set (Hair, Hult, et al. 2017). However, a less liberal approach governed by the actual content that is missing could also be adopted (Hair, Hult, et al. 2017). In this instance, as well as taking into consideration the 15% rule, observations can be removed if, for example, the respondent failed to answer questions that relate to a key variable of interest.

Based on this, out of 64 observations (after removing nine observations belonging to firms with less than five employees) a total of 12 observations breached the 15% rule whilst one observation failed to answer questions relating to a key construct. Consequently, 13 complete observations were removed from the data set - leaving a total of 51 observations.

A visual inspection was also conducted to determine any suspicious response patterns. In line with Hair, Hult, et al. (2017), inconsistencies in the data where a respondent repeatedly selected the same response (straight lining) or pattern of responses (diagonal lining) were investigated. As a result, one additional observation demonstrated straight lining and was removed from the data set, leaving a final tally of 50 observations.

At the variable level, quantities and patterns of missing values are also investigated. There are no agreed upon rules for the acceptance limit of missing values per variable, where some would even suggest proportions in the vicinity of 20% to be acceptable under certain conditions (Schlomer, Bauman & Card 2010). However, given the PLS SEM method of analysis and the sample limitations of this thesis, as well as its grounding in operations management theory, 10% appears a reasonable threshold (Tsikriktsis 2005). Little's test (Little 1988) was adopted to assess whether the patterns of missing values in management practice variables are a random occurrence. The results of this test suggest the missing values are indeed random (chi-square = 84.662, df = 102, sig. = .893). Given this result, and the amount of missing values per variable not exceeding 10% (see also Appendix 5), mean-substitution (as a non-stochastic missing data treatment) was adopted in this study (Tsikriktsis 2005).

5.1.2 Outliers

Outliers (or extreme values) were detected using boxplot analysis created through IBM SPSS 25 (IBM Corp. 2017) and illustrated in Appendix 6. As per the convention in IBM SPSS 25, an asterisk (as opposed to a circle) on a boxplot denotes outliers that require attention. In this instance, the control variables of firm size and firm age do not have any outliers of concern.

Whilst a Likert scale should not contain any outliers (given the responses of questionnaire participants are intentional), box plots from key constructs that are observed to contain "outliers" are also provided in Appendix 6 as a graphical indication of the profile of the data distribution. Here, the key constructs of exploration and exploitation (as part of the second-order construct ambidexterity) are observed to have some responses which differed significantly from others. Though, upon closer inspection, the indicators that were affected included those in relation to problem solving, improving quality and keeping existing customers happy. This is to be expected given finding creating ways of delivering customised solutions is also a core capability of HVLV manufacturers, thus most would respond in a similar fashion. Improving quality and keeping existing customers happy also relate back to the HVLV manufacturing strategy and the profile of the respondents (discussed in section 5.2). HVLV manufacturers will tend to seek repeat business if their respective markets allow, as doing so will help reduce the variability in demand and allow for the exploitation of scale and customer relationships (Amaro, Hendry & Kingsman 1999; Hendry 2010). The issue with improving quality can be brought down to the "generic" understanding of quality as a unified construct relating to the delivery of goods that are on specification – something manufacturers should always strive for (Flynn, Schroeder & Sakakibara 1994). Thus, to have an unusual distribution of responses in this regard is not necessarily surprising.

5.1.3 Data Distribution

Following on from the boxplot analysis, it is also important to obtain a more in-depth understanding of the distribution of responses in each item. Even though PLS SEM is a nonparametric method (hence, doesn't necessarily make any assumption based on the distribution of data), it is still critical to ensure the data isn't excessively skewed towards a single direction (skewness) or steeply localised around a particular value (kurtosis) as excessive non-normality can significantly impact the validity of parameter estimates (Hair, Hult, et al. 2017). A general guideline for skewness and kurtosis suggests that skewness values exceeding ±3 and kurtosis values exceeding ±10 are cause for concern, thus can be classified as exceedingly non-normal (Kline 2015).

Skewness and kurtosis for each item used in this research was determined using IBM Statistics SPSS 25 (IBM Corp. 2017), the results of which are shown in Appendix 5. It is evident that all skewness and kurtosis values for each item are well below the thresholds suggested by Kline (2015), thus indicating excessive non-normality of data is not an issue in this thesis.

5.2 Descriptive Statistics

This section presents the descriptive statistics associated with the profile of survey respondents, general organisational characteristics and specific HVLV manufacturing characteristics.

5.2.1 Respondent Profile

The results in Table 5-1 suggest that respondents were primarily senior decision-makers with at least 86% being general management or higher. The remaining 14% (6 respondents) were also quite highly ranked, with the exception of one respondent indicating their role as an estimator. However, we argue for retaining this observation given the criticality of the estimating function towards HVLV manufacturing strategy.

It is important to keep in mind the key role middle management play in HVLV manufacturing. Here, middle management typically refer to department heads (such as fabrication manager, machine shop manager and so forth) that hold key decisions in resource allocation and work-routing (c.f. Clegg & Fitter 1981). The project-based nature of operations also means the majority of day-to-day problem-solving activities are undertaken by these middle managers, indicating their in-depth knowledge of operational phenomena. In a strategic sense, it is also important to note that strategic decisions in a HVLV manufacturing environment typically concern job acceptance, sales and estimation decisions (Kingsman, Hendry, Mercer & deSouza 1996). Thus, the entry into new markets and the decision to build capabilities is quite often attributed to the job opportunities in season at that point in time. Middle management are critical here as they present the conduit from which strategic decisions are developed and enacted (Wolf & Floyd 2017), thus the efficacy of strategic decision making also depends on them. Estimators play one of the more crucial roles in this instance as they are responsible for price-setting, liaising with other departments to ensure appropriate due-dates and pricing as per the strategic orientation of the manufacturer – suggesting a reputable cohort of respondents in this research.

Table 5-1 Respondent Profile

Respondent Descriptive Statistics	N	% (rounded)
Role		
CEO/Owner/Director	31	62
General Manager	12	24
Middle Management	4	8
Other	3	6
Tenure (years)		
Less than 5	8	16
5-10	8	16
11-15	12	24
16-20	6	12
More than 20	16	32

5.2.2 Generic Organisational Profile

As the results in Table 5-2 illustrate, the HVLV manufacturers participating in this research project are all SMEs. This is consistent with extant HVLV manufacturing literature (Portioli-Staudacher & Tantardini 2012a; Stevenson, Hendry & Kingsman 2005) whereby a simplified definition provided by the European Commission (2003) (in that an organisation has less than 250 employees) is typically adopted. However, in this study, given the Australian context, we take SMEs as less than 200 employees (Australian Bureau of Statistics 2001).

The majority of HVLV manufacturers are also well-established organisations with 98% having been operational for more than 10 years, 72% of which more than 20 years. Most HVLV manufacturers (96%) had an annual turnover of greater than $200k in the year ending 2017, with 70% earning greater than $2m. One manufacturer reported a turnover of less than $50k, though given the size indicated by this manufacturer being greater than 100 employees and being operational for more than 20 years, we expect this respondent to perceive this question as “sensitive” and chose not to disclose the correct information. Nonetheless, given turnover does not present a key variable in this thesis, and in the interest of transparency, the response is retained and recorded herein.

The profile of organisations per industry affiliation also appears to tell quite a typical tale of manufacturers in Australia. The figures presented here represent the *total* industries serviced by these manufacturers i.e., a manufacturer may have more than one industry affiliation. The industries are categorised by their respective Australian New Zealand Standard Industry Classifications (ANZSIC).

Table 5-2 Generic Organisational Profile

Generic Organisational Descriptive Statistics	**N**	**% (rounded)**
Size (No. of employees)		
5-19	29	58
20-99	19	38
100-199	2	4
Age (years operational)		
5-10	1	2
11-15	6	12
16-20	7	14
More than 20	36	72
Turnover		
Less than $50k	1	2
Between $50k - $200k	1	2
Between $200k - $2m	13	26
Greater than $2m	35	70
Industry(s) serviced – Based on ANZSIC		
Agricultural Machinery and Equipment Manufacturing	16	11
Aircraft Manufacturing and Repair Services	4	3
Automotive Electrical Component Manufacturing	1	1
Boat Building and Repair Services	5	4
Boiler, Tank and other Heavy Gauge Metal Container Manufacturing	2	1
Communication Equipment Manufacturing	2	1
Fixed Space Heating, Cooling and Ventilation Equipment Manufacturing	2	1
Lifting and Material Handling Equipment Manufacturing	5	4
Machine Tool and Parts Manufacturing	12	9
Mining and Construction Machinery Manufacturing	15	11
Motor Vehicle Body and Trailer Manufacturing	6	4
Prefabricated Metal Building Manufacturing	6	4
Pump and Compressor Manufacturing	1	1
Sheet Metal Products Manufacturing	22	16
Ship building and Repair Services	2	1
Structural Steel Fabrication	23	16
Other	17	12

In this instance, structural steel fabrication, sheet metal products manufacturing, agricultural machinery and equipment manufacturing, mining and construction machinery manufacturing and machine tool and parts manufacturing round out the top five with 63% in cumulative industry affiliations. This could also be a function of the primary value-add of the agricultural and construction industries in Australia where SMEs represent an 80% and 47% share of all value added per industry, respectively (ASBFEO 2016). At the highest level, those HVLV manufacturers that selected “other” were also contributing to the construction industry where most indicated metal fabrication activities related to commercial and infrastructure developments. Others were more reminiscent of general machine tool and equipment manufacturing where niche industries in relation to tattooing equipment and motorsports, hydraulic equipment, oil and gas equipment as well as general engineering and defence were apparent.

5.2.3 HVLV Manufacturing Profile

The HVLV manufacturer classifications developed by Amaro, Hendry & Kingsman (1999) and adopted by others (Hendry 2010; Petroni, Zammori & Marolla 2017) were adapted in this study to develop a more generalised profile of HVLV manufacturers – focussing on their key peculiarities, as discussed earlier.

As demonstrated in Table 5-3, all HVLV manufacturers were observed to undertake at least some level of customisation activities. 38% of HVLV manufacturers studied undertook a great deal of customisation work, where each product manufactured is effectively different from the last. 36% were more reminiscent of repeat business companies (Hendry 2010) where they still undertook significant customisation activities, though attempts to increase efficiency were sought through repeat business. 22%, on the other hand, attempted to offset their perceived disadvantage with regards to scaling and efficiency by also developing their own products. This is quite common practice in HVLV manufacturers operating during periods of slow sales or economic decline. In this instance, these manufacturers still undertake a considerable degree of customisation work, though this customisation seems to be localised to pre-defined designs. Only 4%

of the HVLV manufacturers studied preferred to focus on the production of mainly standard products.

Table 5-3 HVLV Manufacturer Descriptive Statistics

Specific High-Variety, Low-Volume Manufacturing Descriptive Statistics	N	% (rounded)
Degree of Product Customisation		
Pure Customisation	19	38
Mainly Pure though some made on repeat basis	18	36
Mixture of bespoke and standard products	11	22
Mainly Standard	2	4
All products are standard; orders are fulfilled from inventory	Nil	Nil
Scope of Responsibility		
Designing the product	15	30
Setting the specifications	34	68
Purchasing the required materials for production	35	70
Activities after receiving customer order		
Delivery	39	78
Assembly	42	84
Processing	45	90
Purchasing	44	88
Routing	36	72
Specification	39	78
Design	29	58

Moving deeper into the scope of responsibility and the activities HVLV manufacturers do after receiving a customer order gives us a more fine-grained view of the operational characteristics of the manufacturers. Table 5-3 suggests that although the majority of HVLV manufacturers participating in this research undertake a high degree of customisation work, only 30% of them are responsible for designing the product. Furthermore, only 30% of HVLV manufacturers do not undertake purchasing activities where the customer supplies all of the necessary material for processing. This, of course, is a key strategic decision for HVLV manufacturers as the results suggests that at least 70% of the HVLV manufacturers in this sample do not view technical skills in design as an important capability to hold – they only focus on building internal manufacturing capabilities and capabilities in relation to effective procurement of material, parts and assemblies for production. This is also something Amaro, Hendry & Kingsman (1999) observed in their study.

The last dimension in Table 5-3 provides an indication of the cost and lead-time associated with the production of goods. Here, as in Amaro, Hendry & Kingsman (1999), design refers to the basic idea behind the product and a rough set of drawings for illustrative purposes. Specification refers to developing detailed production drawings for the shopfloor and routing refers to the identification of the actual path a job will take throughout the manufacturing value-chain. A HVLV manufacturer can indeed perform multiple activities after the receiving a customer order, so the percentages highlighted here are cumulative for the entire sample. Thus, it becomes apparent that the majority of HVLV manufacturers participate in the entire product-realisation process where almost two thirds also undertake some design duties.

From the micro-perspective, Appendix 7 illustrates the individual characteristics of the HVLV manufacturers that participated in this study. Overall, there are 35 distinct HVLV manufacturer typologies according to the degree of customisation offered, responsibility for design, specification and purchasing, as well as the extent of activities conducted after the receipt of a customer order. Interestingly, from this perspective there also appears to be more heterogeneity in HVLV manufacturing than previously thought. For instance, there are also HVLV manufacturers with a primary focus on design and specification, yet do not undertake much of the physical activities involved in manufacturing a product. Such manufacturers would presumably rely on other HVLV manufacturers with better manufacturing capabilities to actually realise a finished product. A more plausible scenario could also be attributed to their identity as HVLV manufacturers, where some would perceive themselves to be manufacturing service providers, thus doing everything and anything they have the capabilities and know-how to do. From the literature review conducted in Chapter 2, it is apparent that identity has a significant bearing on their perceived strengths as manufacturers and their perceived competitive priorities. Thus, it is more likely that such HVLV manufacturers do not participate in the realisation of a product *per se*, rather undertaking other production related activities associated with the refurbishment, repair and service of existing products – as one survey respondent found *“our business is 50% manufacturing service* *and 50% internal products making some questions harder to answer due to categorization”*.

5.3 Evaluation of the PLS SEM Model

A PLS model is assessed based on a two-stage approach. As shown in Table 5-4, the first stage assesses the reliability and validity of the measurement (outer) model whilst the second stage assesses the structural (inner) models. The evaluation of reliability and validity was undertaken using the SmartPLS 3 software (Ringle, Wende & Becker 2015).

Table 5-4 Evaluation of PLS SEM Results

Evaluation of the Measurement Model	
Reflective Measurement Model	*Formative Measurement Model*

• Reflective indicator loadings (≥ 0.708)
• Internal consistency reliability
  ○ P_A (0.60 – 0.95 in exploratory research)
• Convergent Validity
  ○ AVE (≥ 0.5)
• Discriminant Validity
  ○ HTMT (<0.9)
	• Convergent Validity (≥ 0.70 correlation)
	• Collinearity
	  ○ VIF (<5)
	• Statistical Significance and Relevance

Evaluation of the Structural Model(s)	
• Size and significance of path coefficients • Coefficients of determination (R^2) • Predictive relevance (Q^2)	• *f2* effect sizes • q^2 effect sizes

Source: Hair, Hult, et al. (2017) and Hair et al. (2019)

5.4 Evaluation of the Measurement Model

Evaluation of the measurement model depends on the type of relationship between indicators and their constituent variables. Because this research involves the use of both reflective models and formative models (by way of higher-order factors, to be discussed later), the measurement model is assessed using a combination of both approaches. The evaluation of the measurement model was conducted entirely within SmartPLS 3 (Ringle, Wende & Becker 2015) using the standard PLS algorithm.

5.4.1 Reflective Measurement Model Assessment

In the case of reflective measures, the first step involves assessing the loadings of each individual indicator followed by an assessment of the internal consistency reliability. As a general guide, indicator loadings greater than 0.7 appear to have good reliability (Peng & Lai 2012). However, indicators with loadings ranging between 0.4 – 0.7 may also be retained if their removal poses a threat to internal consistency reliability (Hair, Hult, et al. 2017). Internal consistency reliability can be measured in multiple ways (Cronbach's alpha, composite reliability and, more recently, P_A)– each yielding a different result. Cronbach's alpha appears less precise than composite reliability, though composite reliability seems to produce higher values when compared to Cronbach's alpha(Hair et al. 2019) . In this case, we adopt another measure (P_A) that lies in between these two extremes. In either case, we provide both values of composite reliability (CR) and P_A where their respective values for internal consistency reliability should lie between 0.6 and 0.95.

Finally, the last steps of the measurement model assessment involve the evaluation of convergent validity and discriminant validity. Convergent validity checks to see whether related indicators are, indeed, related. This is typically evaluated by way of the average variance extracted (AVE) where an indicator should observe values greater than or equal to 0.5. On the other hand, discriminant validity evaluates the extent to which an in indicator is not related with others. Here, we adopt the contemporary heterotrait-monotrait (HTMT) ratio where correlations between variables should be less than one (Henseler, Ringle & Sarstedt 2015).

Table 5-6 illustrates that most of the indicators used have good loadings (ranging between 0.611 to 0.944). Removal of some indicators in the vicinity of 0.611 did yield minor improvements in internal consistency reliability, though it raised concerns over content validity and were retained. Removal of others, including Flex4, resulted in negative effects on internal consistency reliability and were hence retained as well. The indicator HRM6, however, observed a loading of 0.489 - far below recommended guidelines. Once removed, the AVE value of the HRM construct was raised from 0.455 to 0.520 (as shown in Table 5-5). Consequently, HRM6 was removed from the model.

Table 5-5 Human Resource Management Construct Reliability and Validity

	AVE	**CR**	**P_A**
HRM (including the HRM6 item)	**0.456**	0.831	0.770
HRM (without the HRM6 item)	0.520	0.843	0.797

Table 5-6 Final Measurement Model Evaluation (Reflective Measures)

Construct	**Items**	**Loadings**	**AVE**	**CR**	**P_A**
Exploitation*	Exploit1	0.699	0.548	0.861	0.818
	Exploit2	0.802			
	Exploit4	0.673			
	Exploit5	0.835			
	Exploit6	0.679			
Exploration*	Explore1	0.774	0.556	0.858	0.809
	Explore2	0.747			
	Explore4	0.83			
	Explore5	0.749			
	Explore6	0.611			
Human Resource Management**	HRM1	0.643	0.520	0.843	0.797
	HRM2	0.706			
	HRM3	0.682			
	HRM4	0.754			
	HRM5	0.810			
Quotation Management	Sales1	0.717	0.546	0.782	0.599
	Sales2	0.818			
	Sales3	0.674			

Table 5-6 Final Measurement Model Evaluation (Reflective Measures) (Continued)

Construct	Items	Loadings	AVE	CR	P_A
Coordination	**Sales4**	**0.828**	**0.690**	**0.87**	**0.789**
	Sales5	0.857			
	Sales6	0.807			
Workload Control	PPC1	0.875	0.758	0.904	0.840
	PPC3	0.853			
	PPC4	0.883			
Operational Flexibility	Perf_Flex1	0.665	0.605	0.857	0.960
	Perf_Flex2	0.879			
	Perf_Flex3	0.904			
	Perf_Flex4	0.624			
Process Innovation	Innov_Proc1	0.861	0.79	0.937	0.920
	Innov_Proc2	0.885			
	Innov_Proc3	0.944			
	Innov_Proc4	0.862			

* Exploit3 and Explore3 were removed earlier due to applicability in the HVLV manufacturing context.

** HRM6 was removed due to validity and reliability concerns.

Table 5-6 also illustrates that each reflective indicator has good convergent validity, moving beyond the recommended guidelines. Quotation management, however, did have convergent validity issues with a P_A value of 0.599, though this presents only a minor deviation from recommended guidelines given its composite reliability is greater than 0.7 as well, thus the quotation management construct was not modified.

Discriminant validity of all constructs used this study was assessed based on the more contemporary heterotrait-monotrait (HTMT) method (Henseler, Ringle & Sarstedt 2015). The resultant correlation matrix in Appendix 8 demonstrates all possible correlations are less than one, indicating discriminant validity. It is also important to keep in mind that values approximating 0.9 are possible for conceptually similar constructs (Henseler, Ringle & Sarstedt 2015). This is the case for those constructs that make-up the second-order formative factors of production planning and control and ambidexterity. For these factors, the evaluation of validity and reliability is slightly different, as explained next.

5.4.2 Reliability and Validity of Reflective-Formative Second-Order Factors

Reflective-formative higher order factors are prone to misattribution of effects given it is quite difficult to judge whether the indicators that are representative of the formative construct are sufficient (Ringle, Sarstedt & Straub 2012). In this thesis, efforts to ensure content validity of the formative factors were extended to include quantitative analysis on the basis of a content validity index where appropriate (as per the previous chapter). In addition, a thorough literature review was conducted to ensure the choice of formative factors was justified – particularly when it came to modelling ambidexterity.

Other considerations for the second order reflective-formative constructs include investigating the collinearity among the indicators that form the second order factor and their statistical significance and relevance. Collinearity is evaluated using the variance inflation factor (VIF) where a value of greater than three is typically cause for concern. As demonstrated in Table 5-7, the formative factors of exploration and exploitation that constitute the second-order construct of ambidexterity both have a VIF value of 1.891, thus no collinearity issues exist. Similarly, the formative factors of quotation management, workload control and coordination achieved VIF values of 2.113, 2.000 and 1.852, respectively.

Table 5-7 Second-Order Reflective-Formative Measure Evaluation

	Weights	**T-values**	**VIF**
Ambidexterity			
Exploration	0.558	11.540***	1.891
Exploitation	0.530	11.705***	1.891
Production Planning and control			
Quotation Management	0.331	9.044***	2.113
Workload Control	0.437	10.729***	2.000
Coordination	0.400	11.531***	1.852

***p<0.001

A bootstrapping procedure was undertaken to assess the statistical significance and relevance of these second-order formative factors. Here, 5000 subsamples were used in a bias-corrected accelerated (BCa) bootstrap with a 0.05 significance level and two-tailed testing. The resultant weights and *t*-values (and corresponding *p*-values) are also shown in Table 5-7 where the statistical significance and relevance of the variables that constitute their respective second-order formative factors is verified.

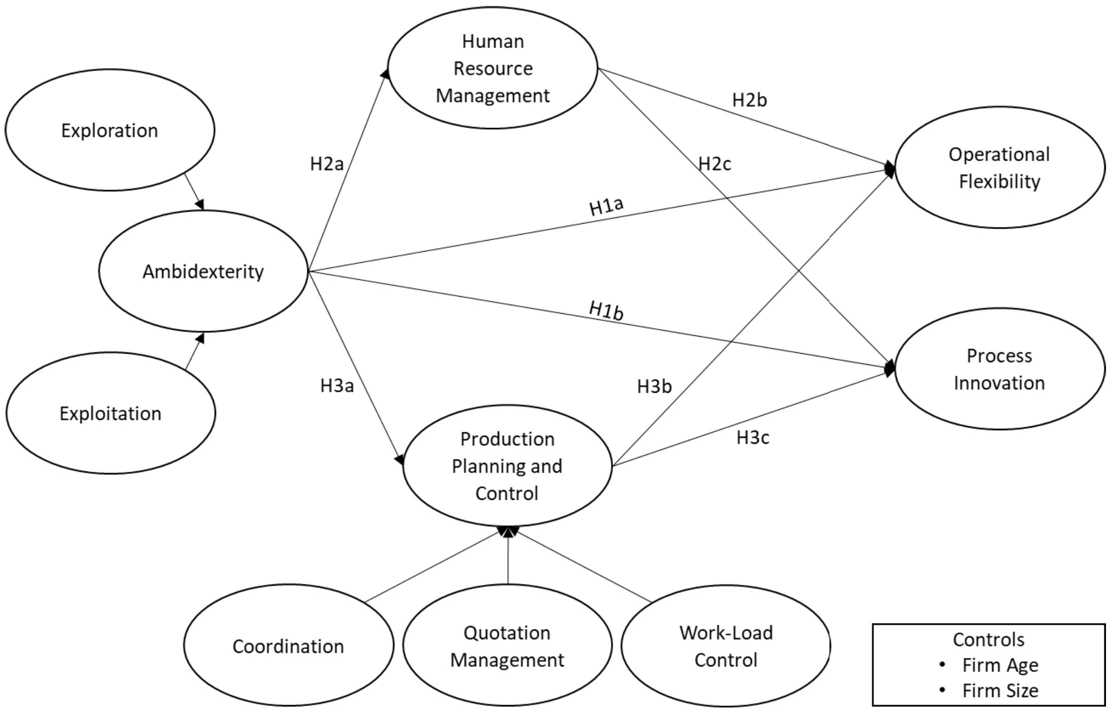
5.5 Evaluation of the Structural Models

The evaluation of the structural model in this thesis is based on the procedure outlined in Hair et al. (2019) and Hair, Sarstedt, et al. (2017). This section also takes into consideration key points of reference by Ringle, Sarstedt & Straub (2012) and Peng & Lai (2012) with regards to assessing second-order factor models.

Firstly, we adopted the repeat indicators approach (Hair, Sarstedt, et al. 2017) in order to the assess structural model shown in Figure 5.2. Here, the latent variable scores from the lower order constructs are used in order to model the higher order constructs (in this case ambidexterity and production planning and control)(Hair, Sarstedt, et al. 2017).

Next, the significance and relevance of direct (and indirect) structural model relationships using the path coefficients (β) and their corresponding *t* and *p* statistics are assessed. This is followed by an assessment of the predictive power of the model based on the coefficient of determination (R^2), predictive relevance (Q^2) and finally the effect sizes (f^2 and q^2) are also evaluated.

Figure 5-2 Structural Model



5.5.1 Results of the Path-Coefficients

The path coefficients and their respective significance were obtained using a bootstrapping procedure in SmartPLS 3 (Ringle, Wende & Becker 2015). As per recommended guidelines for organisational research (Hair, Hult, et al. 2017), 5000 sub-samples were taken and the bias-corrected and accelerated (BCa) confidence interval method was adopted based on a two-tailed test at a significance level of 0.05.

For comparison purposes, the resultant path coefficients and their respective *p* and *t* statistic estimations for direct relationships and control variables are split between two models: one without the effects of control variables (Table 5-8) and the other accounting for the direct effects of control variables (Table5-9 and Table 5-10). An illustration of results including the coefficient of determination (R^2) for endogenous latent variables are also illustrated in Figure 5-3 for a model without control variables and Figure 5-4 for a model including control variables.

The effect size (f^2) and predictive relevance (q^2) corresponding to the significance of each relationships (both for a model with and without controls) is shown in Appendix 9 where a detailed summary of the results is tabulated. We review the hypothesis next.

Table 5-8 PLS SEM results for Direct Relationships without Control Variables

Hyp.	Relationship	Std Beta	t value	p value	Outcome	Confidence Interval 2.5%	Confidence Interval 97.5%
H1a	Ambidexterity → Operational Flexibility	0.249	1.469	0.142	Supported	-0.092	0.559
H1b	Ambidexterity → Process Innovation	0.082	0.446	0.656	Supported	-0.295	0.413
H2a	Ambidexterity → HRM	0.640	5.228	0.000	Supported	0.307	0.798
H2b	HRM → Operational Flexibility	-0.044	0.279	0.780	Not Sup.	-0.356	0.243
H2c	HRM → Process Innovation	0.489	3.254	0.001	Supported	0.213	0.793
H3a	Ambidexterity → PPC	0.599	4.441	0.000	Supported	0.256	0.807
H3b	PPC → Operational Flexibility	0.428	2.947	0.003	Supported	0.134	0.702
H3c	PPC → Process Innovation	0.046	0.269	0.788	Not Supported	-0.318	0.372

Table 5-9 PLS SEM Results for Direct Relationships with Control Variables

Hyp.	Relationship	Std Beta	t value	p value	Outcome	Confidence Interval 2.5%	97.5%
H1a	Ambidexterity → Operational Flexibility	0.188	1.054	0.292	Supported	-0.201	0.486
H1b	Ambidexterity → Process Innovation	0.120	0.661	0.509	Supported	-0.253	0.461
H2a	Ambidexterity → HRM	0.653	4.698	0.000	Supported	0.312	0.833
H2b	HRM → Operational Flexibility	-0.055	0.379	0.705	Not Supp.	-0.345	0.222
H2c	HRM → Process Innovation	0.484	3.14	0.002	Supported	0.185	0.796
H3a	Ambidexterity → PPC	0.646	4.698	0.000	Supported	0.307	0.842
H3b	PPC → Operational Flexibility	0.492	3.257	0.001	Supported	0.218	0.810
H3c	PPC → Process Innovation	0.012	0.063	0.950	Not Supp.	-0.381	0.341

Table 5-10 Direct effects of Control Variables

Relationship	Std Beta	t value	p value	Outcome	Confidence Interval 2.5%	97.5%
Age -> HRM	0.101	0.879	0.380	Not Sign.	-0.131	0.330
Age -> PPC	0.261	1.791	0.073	Not Sign.	-0.050	0.524
Age -> Operational Flexibility	-0.037	0.336	0.737	Not Sign.	-0.264	0.178
Age -> Process Innovation	0.076	0.623	0.533	Not Sign.	-0.173	0.313
Size -> HRM	0.005	0.038	0.970	Not Sign.	-0.252	0.260
Size -> PPC	-0.130	1.238	0.216	Not Sign.	-0.325	0.080
Size -> Operational Flexibility	0.263	2.542	0.011	Significant	0.073	0.479
Size -> Process Innovation	-0.034	0.275	0.784	Not Sign.	-0.250	0.246

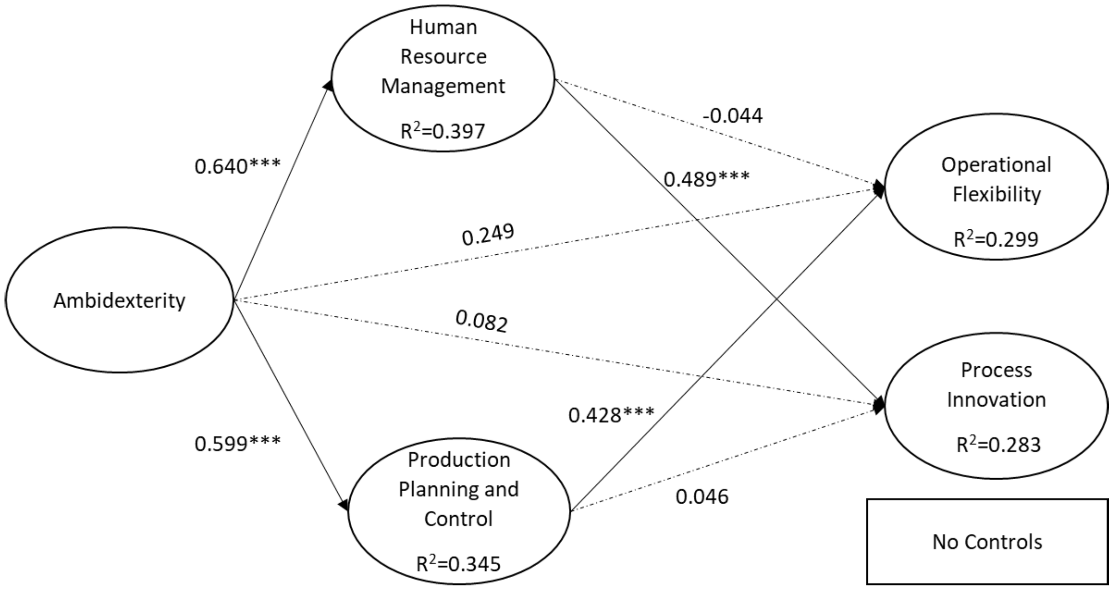


Figure 5-3 PLS SEM Model Direct Relationship Results (Without Controls)

*Notes: ***p<0.01. Dotted arrows illustrate non-significant paths, R^2 stated in this figure is the R^2 adjusted*

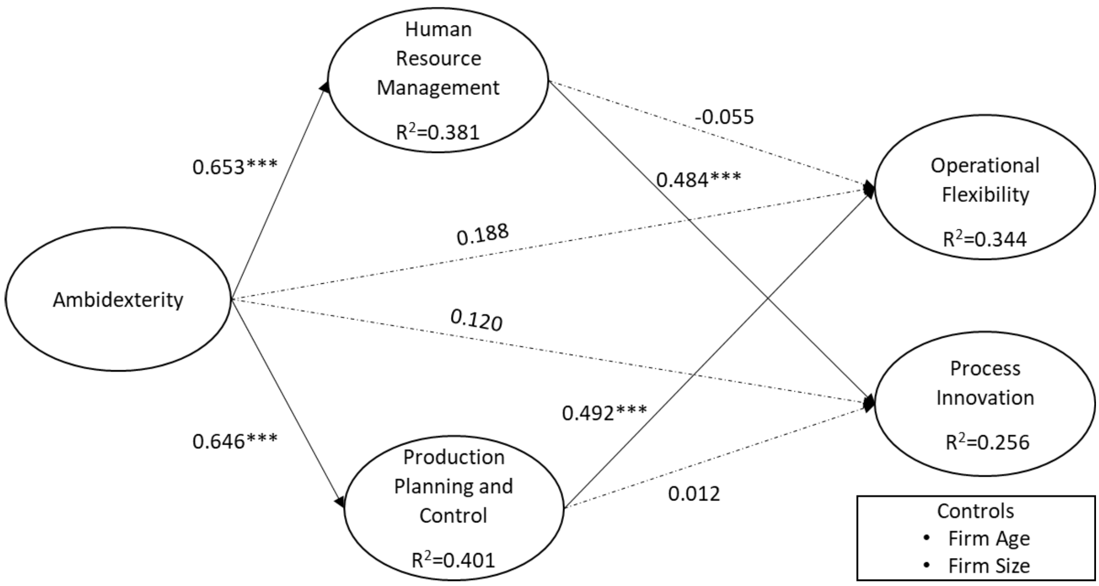


Figure 5-4 PLS SEM Model Direct Relationship Results (With Controls)

*Notes: ***p<0.01. Dotted arrows illustrate non-significant paths, R^2 stated in this figure is the R^2 adjusted*

Hypothesis 1a: Ambidexterity does not have a significant impact on operational flexibility in HVLV manufacturing.

The results of the path analysis conducted in both models (with and without controls) suggests that ambidexterity does not have a significant impact on operational flexibility, thus this hypothesis is supported.

Hypothesis 1b: Ambidexterity does not have a significant impact on process innovation in HVLV manufacturing.

Likewise, both path models also suggest that ambidexterity does not have an impact on process innovation, supporting this hypothesis as well.

Hypothesis 2a: Ambidexterity has a positive impact on the adoption of human resource management practices in a HVLV manufacturing environment.

As put forward during the theory building exercise, the results of both path models (with and without controls) suggests ambidexterity has a significant impact on the adoption of human resource management practices, thus this hypothesis is supported.

Hypothesis 2b: The adoption of human resource management practices has a positive impact on operational flexibility in HVLV manufacturing.

Given our hypothesis concerning the role of human resource management routines and their impact on HVLV manufacturing operational flexibility we find that this relationship, in fact, does not seem to be significant. In this case, the hypothesis is not supported.

Hypothesis 2c: The adoption of human resource management practices has a positive impact on process innovation in HVLV manufacturing.

Based on similar reasoning behind the theory supporting hypothesis 2b, we would likely expect the adoption of human resource management practices to have a significant effect on process innovation. The results, counter to the previous hypothesis, are supported here with a significant positive relationship between the adoption of human resource management practices and process innovation observed.

Hypothesis 3a: Ambidexterity has a positive impact on the adoption of production planning and control management practices in a HVLV manufacturing environment.

Production planning and control management practices were seen as central everyday routines for the ongoing success of HVLV manufacturers. According to the reasoning highlighted in our theory building exercise we would expect a positive and significant relationship between ambidexterity and the adoption of production planning and control management practices. The results of both models with and without controls suggests the hypothesis is supported with a significant positive relationship observed between ambidexterity and the adoption of production planning and control management practices.

Hypothesis 3b: The adoption of production planning and control management practices has a positive impact on operational flexibility in HVLV manufacturing.

Having stemmed from the need to improve operational flexibility in HVLV manufacturers, we would suggest that production planning and control management practices have a positive impact on such performance outcomes. The results of both models suggest the same with a significant and positive relationship between production planning and control and achieving operational flexibility in HVLV manufacturing.

Hypothesis 3c: The adoption of production planning and control management practices has a positive impact on process innovation in HVLV manufacturing

In the same vein, we would assume having improvements in operational flexibility, the adoption of production planning and control would have a positive impact on process innovation as well – the logic remains consistent. However, our results in both models suggests the opposite where there is no significant relationship between production planning and control management practices and process innovation in HVLV manufacturing. In this case Hypothesis 3c is not supported.

5.5.2 Observed Effects of Control Variables

In terms of control variables, HVLV manufacturer age does not have a significant impact on the adoption of production planning control and human resource management practices. Nor does age appear to have an impact on the dependent variables of operational flexibility and process innovation. HVLV manufacturer size, however, does appear to have an impact on operational flexibility performance ($\beta=0.263$, p-value < 0.05), whilst no significant effects on the adoption of production planning control and human resource management practices or process innovation performance are apparent. This will be discussed in more depth in Chapter 6 to follow.

5.5.3 Mediation Analysis

A mediation analysis is also conducted within SmartPLS 3 (Ringle, Wende & Becker 2015). In a similar fashion to the testing of direct effects between variables earlier, a bootstrapping procedure using the same parameters was undertaken (5000 sub samples, BCa confidence interval method, two-tailed test at a significance level of 0.05). Here, the direct effects (calculated earlier) are compared with specific indirect effects (as opposed to total indirect effects) in order to determine the extent to which a mediation relationship exists in the PLS model. This is an important point, if the mediation analysis was undertaken based on a more "traditional" piecemeal approach by testing for mediation effects separately, there is a greater risk of misrepresenting the mediating effects (or direct effects, for that matter) of other variables in the model (Hair, Hult, et al. 2017). Thus, we include all relevant variables in a multiple-mediation analysis.

Table 5-11 PLS SEM Results (Indirect Effects Without Control Variables)

Indirect Relationship	Std Beta	t-value	p-value	Outcome	Confidence Interval 2.5%	97.5%
Ambidexterity -> HRM -> Flexibility	-0.028	0.281	0.779	No Mediation	-0.247	0.158
Ambidexterity -> HRM -> Process Innovation	0.313	2.525	0.012	Full Mediation	0.098	0.579
Ambidexterity -> PPC -> Flexibility	0.256	2.198	0.028	Full Mediation	0.063	0.525
Ambidexterity -> PPC -> Process Innovation	0.028	0.260	0.795	No Mediation	-0.218	0.255

Table 5-12 PLS SEM Results (Indirect Effects With Control Variables)

Indirect Relationship	Std Beta	t-value	p-value	Outcome	Confidence Interval 2.5%	97.5%
Ambidexterity -> HRM -> Flexibility	-0.036	0.369	0.712	No Mediation	-0.240	0.149
Ambidexterity -> HRM -> Process Innovation	0.316	2.445	0.015	Full Mediation	0.087	0.581
Ambidexterity -> PPC -> Flexibility	0.318	2.332	0.02	Full Mediation	0.103	0.626
Ambidexterity -> PPC -> Process Innovation	0.008	0.061	0.952	No Mediation	-0.270	0.232

The results in Table 5-11 and 5-12 suggest that the adoption of human resource management practices does not have a mediating effect on the relationship between ambidexterity and operational flexibility, also supported by the lack of significant direct effect from human resource management and operational flexibility performance demonstrated earlier in both models with controls and without. However, the adoption of human resource management practices does indeed have a fully mediating effect between ambidexterity and process innovation performance, evidenced by the lack of direct effects between ambidexterity and process innovation performance concluded earlier, again in both models with and without controls.

Mixed results are also observed in the mediation analysis concerning the adoption of production planning and control management practices. In this instance, both models suggest the adoption of production planning and control does not have a mediating effect on the relationship between ambidexterity and process innovation performance, again also evidenced by the lack of significant direct effects of PPC on process innovation performance. However, the adoption of PPC practices does have a fully mediating effect between ambidexterity and operational flexibility performance.

Indeed, the relatively small sample size raises some concerns over the validity of fully mediating relationships given the chances of detecting a non-significant direct effect between endogenous and exogenous variables is more likely (Rucker et al. 2011). In addition, the path coefficients should also require further attention to ensure the effects calculated in the path model are indeed relevant. Thus, the following outlines the results of tests concerning the determination of statistical power to ensure the minimum 80% threshold has been reached, followed by tests concerning the coefficient of determination (R^2), predictive relevance (Q^2) and their corresponding effect sizes (f^2 and q^2) for both models with controls and without.

5.5.4 Post-Hoc Statistical Power Calculation

Having a relatively small sample size, a post-hoc statistical power calculation was also undertaken to verify whether the data holds ample statistical power. The power analysis was undertaken using the post-hoc statistical calculator for multiple regressions developed by Sober (2019). The results of this analysis are shown in Table 5-13 (on the next page) where the observed statistical power in both models with and without controls is well above the 80% recommended margin for PLS studies (Hair, Hult, et al. 2017).

Table 5-13 Post-Hoc Statistical Power Calculation on Dependant Variables

	Without Controls		**With Controls**	
	Operational Flexibility	Process Innovation	Operational Flexibility	Process Innovation
Number of Predictors	3	3	3	3
Observed R^2	0.299	0.283	0.344	0.256
Probability Level	0.05	0.05	0.05	0.05
Sample Size	50	50	50	50
Observed Statistical Power	**0.973**	**0.960**	**0.991**	**0.932**

Another method, as suggested by Hair, Hult, et al. (2017), also yields favourable results. Their approach, based on Cohen (1992), makes sample size recommendations with reference to the smallest R^2 value in the model, significance level adopted and the maximum number of arrows pointing towards any construct. In the model used in this thesis, the smallest R^2 is 0.256 (process innovation), the level of significance assumed is 5% and the maximum number of arrows pointing towards any construct is five. Thus, assuming a statistical power of 80% is required, the minimum recommended sample size would be 45 respondents. For a graphical representation of the power matrix used in this approach, readers are referred to Hair, Hult, et al. (2017) or Cohen (1992).

5.5.5 Coefficient of Determination (R^2) and Effect Size (f^2)

The coefficient of determination (R^2) is a measure of the predictive accuracy of the model (Hair, Hult, et al. 2017). The higher the R^2 value, the more variance can be explained by the exogenous variables in the model. The R^2 values in both models presented in this research are outlined in Table 5-14 (on the next page) along with the R^2 adjusted (to be discussed in section 5.5.7). This shows predictive accuracy of the endogenous variables in this model can be considered moderate to substantial (Henseler, Ringle & Sinkovics 2009; Peng & Lai 2012).

Table 5-14 Coefficient of Determination Scores

	Without Controls		With Controls	
Endogenous Variable	R^2	R^2 Adjusted	R^2	R^2 Adjusted
Human Resource Management	0.409	0.397	0.419	0.381
Production Planning and Control	0.358	0.345	0.438	0.401
Operational Flexibility Performance	0.342	0.299	0.411	0.344
Process Innovation Performance	0.326	0.283	0.332	0.256

Furthermore, the impact of a certain exogenous variable on endogenous variables can be assessed by way of assessing the difference in R^2 when that exogenous is removed from the model vs. when it is included. This is measured by what is known as the effect size denoted by f^2, the calculation for which is shown in Equation 5-1. In this instance, the calculations for f^2 were conducted within Smart PLS 3 (Ringle, Wende & Becker 2015). The resultant effect sizes of all combinations of endogenous variable and their respective exogenous variables is shown in Table 5-15 for the model without controls and Table 5-16 (on the next page) for the model with controls.

Equation 5-1 Effect Size (f^2)

$$f^2 = \frac{R^2_{included} - R^2_{excluded}}{1 - R^2_{included}}$$

Table 5-15 Effect Size (f2) for Model Path Relationships Without Controls

Relationship	**Effect Size (f^2)**	**Interpretation**
Ambidexterity → Operational Flexibility	0.046	Small
Ambidexterity → Process Innovation	0.005	None
Ambidexterity → Human Resource Management	0.693	Large
Human Resource Management → Operational Flexibility	0.002	None
Human Resource Management → Process Innovation	0.203	Moderate
Ambidexterity → Production Planning and Control	0.559	Large
Production Planning and Control → Operational Flexibility	0.173	Moderate
Production Planning and Control → Process Innovation	0.002	None

Table 5-16 Effect Size (f^2) for Model Path Relationships With Controls

Relationship	Effect Size (f^2)	Interpretation
Ambidexterity → Operational Flexibility	0.026	Small
Ambidexterity → Process Innovation	0.009	None
Ambidexterity → Human Resource Management	0.714	Large
Human Resource Management → Operational Flexibility	0.003	None
Human Resource Management → Process Innovation	0.199	Moderate
Ambidexterity → Production Planning and Control	0.722	Large
Production Planning and Control → Operational Flexibility	0.225	Moderate
Production Planning and Control → Process Innovation	0.000	None

Effect sizes ranging from 0.02, 0.15 and 0.35 represent small, moderate and large effect sizes, respectively (Henseler, Ringle & Sinkovics 2009). Thus, referring to the results in Table 5-15 and 16, there is a large effect size concerning the relationship between ambidexterity → HRM and ambidexterity → PPC whilst a moderate effect size is determined for the relationship between HRM → process innovation and PPC → operational flexibility. A small effect size was calculated for ambidexterity → operational flexibility, though a non-significant finding in this relationship (reported earlier) precludes us from further examining this effect. The remainder of the relationships held very little effect size, as come to be expected given their insignificant findings also reported earlier.

5.5.6 Predictive Relevance

Predictive relevance is measured using Stone-Geisser's Q^2 (Geisser 1974; Stone 1974). A Q^2 value greater than zero typically indicates the predictive relevance of a PLS SEM model (Hair, Hult, et al. 2017). A blindfolding procedure was undertaken within Smart PLS 3 (Ringle, Wende & Becker 2015) to determine Q^2 (based on an omission distance of seven), the results of which are shown in Table 5-17 (on the next page). As illustrated, the calculated Q^2 values from the blindfolding procedure for both models with and without controls are above zero and most (with the exception of process innovation performance) can be considered to have medium to large predictive relevance (where

0, 0.25 and 0.5 depict small, medium and large predictive relevance, respectively) (Hair et al. 2019).

Table 5-17 Predictive Relevance Scores

Endogenous Variable	**Q^2 Without Controls**	**Q^2 With Controls**
Human Resource Management	0.359	0.291
Production Planning and Control	0.318	0.324
Operational Flexibility Performance	0.234	0.261
Process Innovation Performance	0.207	0.127

It is also interesting to note that the predictive relevance of process innovation performance dropped by almost a factor of half when controls were introduced. Though, having still retained a predictive relevance score of above zero, the process innovation performance construct retains predictive relevance.

As in the calculation of the effect size for the coefficient of determination (f^2), the effect size for the predictive relevance can also be calculated. However, unlike the calculation of f^2, which was conducted within SmartPLS 3, the effect size for predictive relevance (q^2) was calculated manually using Equation 5-2 due to the lack of support in SmartPLS 3.

Equation 5-2 Effect Size (q^2)

$$q^2 = \frac{Q^2_{included} - Q^2_{excluded}}{1 - Q^2_{included}}$$

Here, the predictive relevance of an endogenous variable where all predicting variables are included was compared to the predictive relevance of an endogenous variable when a particular predictor was removed. Based on the same criteria for effect size concerning R^2 and the results of this analysis shown in Table 5-18 for the path model without controls and Table 5-19 for the path model with controls, conclusions regarding predictive relevance can be drawn.

Both models with and without controls seem to be consistent with regards to not detecting any predictive relevance to those hypothesised relationships that observed no significant effects. In fact, these relationships resulted in negative values for the effect size in predictive relevance. However, this is to be expected given the non-significant nature of the relationships to begin with (c.f. Matzler et al. 2015).

Interestingly, there was a noticeable difference in effect size outputs between the model with controls and without controls when it came to the relationship between the ambidexterity → production planning and control and production planning and control → operational flexibility. In this instance, the path model without controls observed a lesser predictive relevance than that of the model with controls. This can be attributed to the statistical significance of the control variables on operational flexibility and production planning and control.

Table 5-18 Effect Size (q2) for Model Path Relationships Without Controls

Relationship	**Effect Size (q^2)**	**Interpretation**
Ambidexterity → Operational Flexibility	-0.007	None
Ambidexterity → Process Innovation	-0.004	None
Ambidexterity → Human Resource Management	0.560	Large
Human Resource Management → Operational Flexibility	-0.021	None
Human Resource Management → Process Innovation	0.130	Small
Ambidexterity → Production Planning and Control	0.466	Moderate
Production Planning and Control → Operational Flexibility	0.128	Small
Production Planning and Control → Process Innovation	-0.038	None

Table 5-19 Effect Size (q^2) for Model Path Relationships With Controls

Relationship	Effect Size (q^2)	Interpretation
Ambidexterity → Operational Flexibility	-0.024	None
Ambidexterity → Process Innovation	-0.002	None
Ambidexterity → Human Resource Management	0.532	Large
Human Resource Management → Operational Flexibility	-0.019	None
Human Resource Management → Process Innovation	0.133	Small
Ambidexterity → Production Planning and Control	0.562	Large
Production Planning and Control → Operational Flexibility	0.180	Moderate
Production Planning and Control → Process Innovation	-0.030	None

5.5.7 Robustness Testing

An additional robustness test was conducted by systematically evaluating four separate path models shown in Figure 5-5[9]. For comparison purposes, each Model was also evaluated including control variables (models R1C – R4C shown in Table 5-21) and without control variables (models R1 – R4 shown in Table 5-20). In this instance, we base th discussion on the R^2 adjusted value which takes into consideration model complexity and sample size (Hair, Hult, et al. 2017). Generally speaking, the R^2 adjusted value will drop the value of R^2 according to the number of exogenous variables and the sample size (Hair, Hult, et al. 2017). Thus, it will help us in evaluating the impacts of non-significant constructs being applied to the model (inflating the R^2 value, as we have seen in Table 5-14) and hence allowing for greater substance in interpreting the results.

The evaluation procedure involves identical parameters for the calculation of path coefficients, significance, R^2 adjusted and Q^2 as applied earlier. That is, a regular PLS algorithm was adopted for the calculation of R^2 adjusted; a bootstrapping procedure based on 5000 subsamples, BCa confidence intervals, significance at 0.05 and two-tailed testing for the path model as well as a blindfolding technique with an omission distance of seven to calculate the Q^2 values.

[9] The model used for robustness testing takes into consideration all possible relationships between constructs. Thus, non-significant paths that were found during the initial assessment were also included for the sake of comparison. We did, however, also examine the relationship between HRM and PPC and found this to be not significant. Similarly, the relationship between operational flexibility and process innovation was also not significant, thus these relationships were omitted from the assessment.

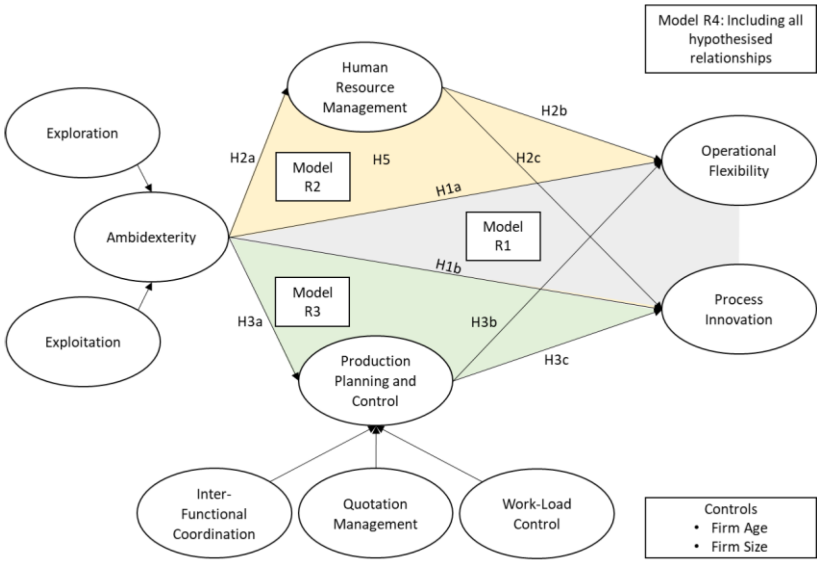


Figure 5-5 Robustness Testing Models

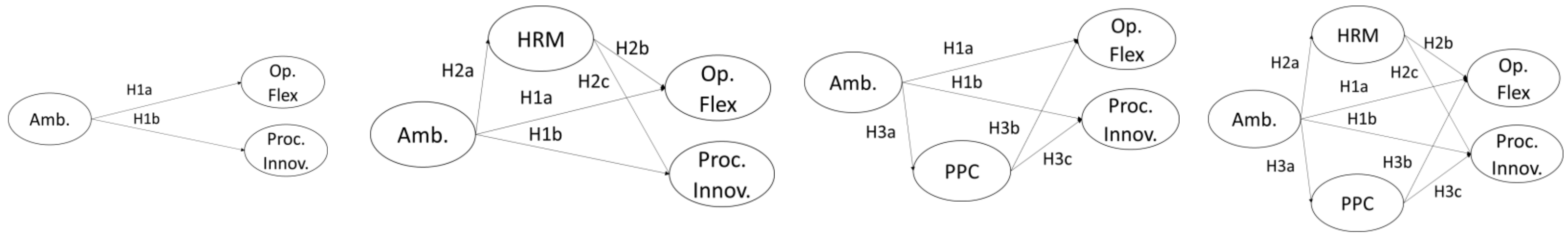
The results from model R1 and R1C suggest a significant and positive relationship between ambidexterity and both operational flexibility (H1a) and process innovation (H1b). This relationship holds for both models with and without controls, however, the model R1C demonstrates a significant drop in predictive relevance for the process innovation construct. This indicates, as was the case in the final model assessed earlier, the controls have a negative impact on the predictive relevance for the endogenous construct of process innovation. In addition, the R^2 adjusted values appear rather weak in both models R1 and R1C (<0.25) suggesting a low predictive accuracy (Hair, Hult, et al. 2017).

When adding the adoption of human resource management (HRM) practices in model R2 and R2C, we notice a significant and positive relationship between ambidexterity and HRM in both models R2 and R2C providing further support for H2a. In addition, we notice the direct relationship between ambidexterity and process innovation (H1b) is now non-significant given the significant relationship between HRM and process innovation (H2c) was introduced. Furthermore, we notice an increase in the R^2 adjusted and Q^2 values in model R2 and R2C for process innovation as well. In this instance, the R^2 adjusted value now has a small to moderate predictive accuracy (between 0.25 and 0.5), suggesting that HRM indeed adds to the predictive accuracy and predictive relevance of the process innovation construct. This also provides further support for the mediation analysis which suggests that HRM mediates the relationship between ambidexterity and process innovation evaluated in section 5.5.3. On the other hand, the operational flexibility construct seemed to be negatively impacted by the addition of HRM (H2b), observing a drop in both the R^2 adjusted and Q^2 values. This also provides further evidence to support rejecting our hypothesised positive relationship between HRM and operational flexibility.

Model R3 and R3C included the production planning and control (PPC) construct to model R1 and R1C. Again, as we have expected, we notice a significant and positive relationship between ambidexterity and PPC in both models R3 and R3C, providing further support for H3a. In addition, we notice an opposite effect to that of model R2 and R2C in the introduction of HRM. In this case, the introduction of PPC led to a now small-moderate increase in R^2 adjusted (between 0.25 and 0.5) as well as an increase in Q^2 for the endogenous construct of operational flexibility (H3b) in both models R3 and R3C. However, we also notice a decrease in R^2 adjusted and Q^2 for the endogenous construct of process innovation in models R3 and R3C. This also provides further evidence in rejecting our hypothesised significant relationship between PPC and process innovation (H3c). In a similar light, we also provide further support for the mediating role of PPC in the relationship between ambidexterity and operational flexibility investigated in section 5.5.3.

Finally, in the full model of R4 and R4C (identical to that under investigation in section 5.5), we find all the significant relationships associated with hypothesis 1a, 1b, 2a, 2c, 3a, and 3b hold. Hypothesis 2b and 3c remain unsupported. The R^2 adjusted values for the endogenous constructs of operational flexibility and process innovation level down slightly in Model R4 and R4C as compared to the singular direct effects of HRM and PPC in models R2, R2C, R3 and R3C, respectively. However, they still maintain a small to moderate predictive accuracy (between 0.25 and 0.5). Similarly, we observe the Q^2 values of the endogenous constructs of operational flexibility and process innovation to also level down slightly in models R4 and R4C. Though having been well above zero, we can deduce operational flexibility and process innovation to have good predictive relevance.

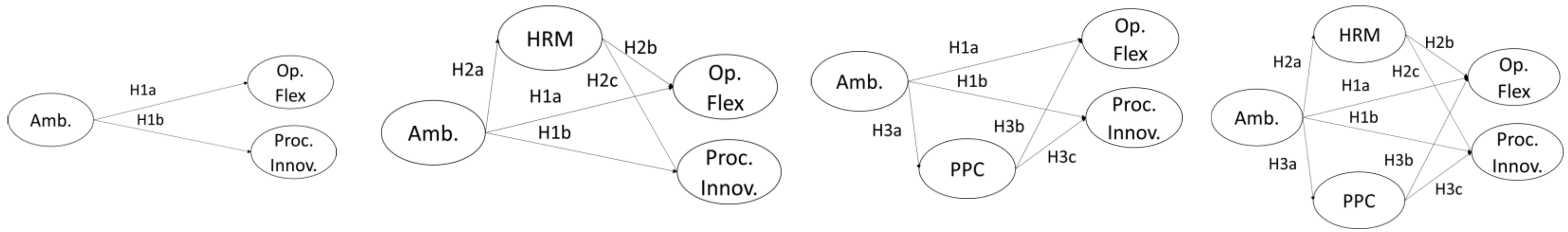
Table 5-20 Robustness Testing Results (Without Controls)



	Model R1			Model R2			Model R3			Model R4		
Hyp.	Std Beta	t-value	p-value	Std Beta	t-value	p-value	Std Beta	t-value	p-value	Std Beta	t-value	p-value
H1a	0.477	3.514	**0.000**	0.453	2.952	**0.003**	0.225	1.359	0.174	0.249	1.469	0.142
H1b	0.423	3.142	**0.002**	0.104	0.649	0.516	0.344	2.208	**0.027**	0.082	0.446	0.656
H2a				0.640	5.107	**0.000**				0.640	5.228	**0.000**
H2b				0.038	0.251	0.802				-0.044	0.279	0.780
H2c				0.498	3.512	**0.000**				0.489	3.254	**0.001**
H3a							0.599	4.306	**0.000**	0.599	4.441	**0.000**
H3b							0.421	3.195	**0.001**	0.428	2.947	**0.003**
H3c							0.132	0.891	0.373	0.046	0.269	0.788

	R^2 Adj.	Q^2	R^2 Adj.	Q^2	R^2 Adj.	Q^2	R^2 Adj.	Q^2
Op. Flex	0.211	0.151	0.195	0.136	0.313	0.250	0.299	0.234
Proc. Inn	0.161	0.122	0.296	0.237	0.155	0.104	0.283	0.207
HRM			0.397	0.359			0.397	0.359
PPC					0.345	0.318	0.345	0.318

Table 5-21 Robustness Testing Results (With Controls)



	Model R1C			Model R2C			Model R3C			Model R4C		
Hyp.	Std Beta	t-value	p-value	Std Beta	t-value	p-value	Std Beta	t-value	p-value	Std Beta	t-value	p-value
H1a	0.470	3.093	**0.002**	0.457	2.798	**0.005**	0.158	0.845	0.398	0.188	1.054	0.292
H1b	0.443	3.230	**0.001**	0.126	0.802	0.422	0.387	2.375	**0.018**	0.120	0.661	0.509
H2a				0.653	4.938	**0.000**				0.653	4.698	**0.000**
H2b				0.02	0.136	0.892				-0.055	0.379	0.705
H2c				0.482	3.506	**0.000**				0.484	3.14	**0.002**
H3a							0.646	4.744	**0.000**	0.646	4.698	**0.000**
H3b							0.483	3.498	**0.000**	0.492	3.257	**0.001**
H3c							0.087	0.567	0.571	0.012	0.063	0.950
	R^2 Adj.		Q^2	R^2 Adj.		Q^2	R^2 Adj.		Q^2	R^2 Adj.		Q^2
Op. Flex	0.231		0.141	0.214		0.128	0.356		0.275	0.344		0.261
Proc. Inn	0.143		0.026	0.273		0.153	0.128		0.011	0.256		0.127
HRM				0.381		0.291				0.381		0.291
PPC							0.401		0.324	0.401		0.324

5.6 Common Method Bias

Harman's single-factor test was conducted in order to test for the possibility of common method bias (Podsakoff & Organ 1986). This method assesses the extent to which one (single) factor accounts for the majority of the variance (Podsakoff et al. 2003). In order to test this, an unrotated principle component analysis using IBM SPSS Statistics 25 (IBM Corp. 2017) based on all items used in the model was undertaken. The results of this test suggest that 33.657% of variance can be accounted for by one factor, thus an indication that common method bias does not seem to be problematic in this research.

5.7 Summary of Results

We began this chapter with a detailed data examination process. Out of the initial 64 valid observations collected from the survey, 12 observations had more than 15% of the data missing and one further observation had failed to answer questions relating a key construct. A visual inspection of the remaining observations found one observation that appeared to be a case of "straight lining". In the interest of rigor, these 14 observations were removed from the sample, leaving a total of 50 observations for analysis.

A further data examination exercise was then undertaken at the variable level. Here, each variable was observed to meet the 10% threshold of missing values, thus no individual variables were removed from the analysis at this stage. Little's test (Little 1988) was also adopted to investigate the degree of randomness in the occurrence of missing values. The results concluded that the patterns of missing values were indeed random, thus mean-substitution was adopted as a missing value remedy.

Next, the distribution of the data itself was examined by means of boxplots and levels of skewness and kurtosis. Some outliers were detected in the exploration and exploitation constructs of the second-order formative construct of ambidexterity. Though, in this instance, the concerns were raised regarding extreme values with problem solving, improving quality and keeping existing customers happy. These concerns were nullified based on the core-characteristics of HVLV manufacturing and were deemed to be expected. No modifications of these constructs were undertaken.

Skewness and kurtosis of the data were also examined to ensure the data fit the ±3 skewness value threshold and the ±10 kurtosis value threshold. This analysis showed the skewness and kurtosis values of each individual item were well within their limits and no modifications to the data set were made based on this result.

An assessment of the measurement model was then undertaken where indicator loadings, internal consistency reliability, convergent validity and discriminant validity were assessed for reflective items, whilst convergent validity, collinearity and statistical significance were assessed for the second-order formative constructs of ambidexterity and production planning and control. One indicator (HRM6) was observed to have a substantially lower indicator loading relative others. Removal of this indicator was proven to improve the internal consistency reliability of the human resource management latent variable and was hence taken out of the model. The remainder of measures had good internal consistency reliability, convergent validity and discriminant validity. The reliability and validity of the second-order formative constructs was proven in the next step where the first order factors in the ambidexterity and production planning and control latent variable observed no issues with collinearity and good statistical significance and relevance.

An assessment of the structural model(s) revealed that six out of the eight hypotheses constructed in this thesis were supported. Those that were not included the link between human resource management and operational flexibility and the link between production planning and control and process innovation. A mediation analysis subsequently revealed that the hypothesis that were failed to be rejected (thus supported) also demonstrated significant indirect effects between ambidextrous capabilities and HVLV manufacturer performance. In particular, the adoption of production planning and control management practices was seen to fully mediate the relationship between ambidexterity and operational flexibility whilst the adoption of human resource management practices was observed to fully mediate the relationship between ambidexterity and process innovation. A post-hoc statistical power calculation and the resultant effect sizes calculated from the coefficient of determination (R^2) and predictive relevance (Q^2) also revealed the significance of the observed effects, which led us to support the hypothesis, are indeed meaningful and relevant.

Robustness testing was conducted to provide further clarification of the direct effects observed (or not observed) in the models tested earlier. The results of the robustness testing suggest that human resource management and process management are indeed crucial in explaining the variance in both process innovation by way of human resource management and operational flexibility by way of production planning and control.

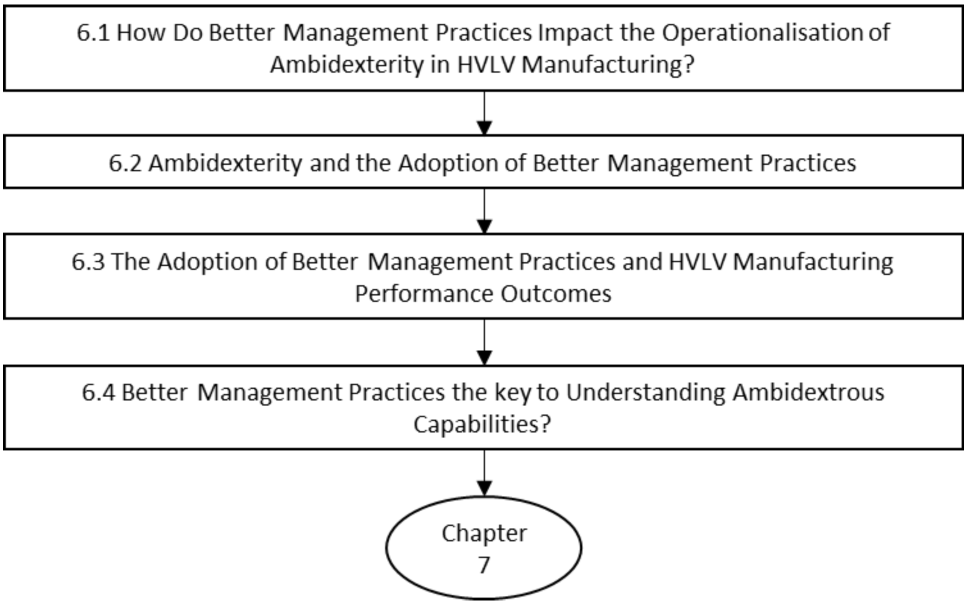
Finally, a test for common method bias was conducted using Harman's single factor test. An unrotated principle component analysis was undertaken and revealed 33.657% of the variance can be accounted for by one factor. In that, common method bias does not appear concerning in this research either.

Chapter 6 now provides a discussion of these results.

Chapter 6 Discussion of the Results

This chapter presents a discussion of the results presented in Chapter 5. Here, the research question of this thesis is revisited and the role of better management practices in operationalising ambidexterity in HVLV manufacturing is discussed. The outline of this chapter is shown in Figure 6-1.

Figure 6-1 Outline of Chapter 6



6.1 How Do Better Management Practices Impact the Operationalisation of Ambidexterity in HVLV Manufacturing?

"Our growth has far exceeded our ability to effectively organize and implement management systems… yet we have consistent and growing turnover and profit…"

Survey respondent (Director of a small HVLV manufacturer)

HVLV manufacturers, like any other organisation, are both a function of structure, processes and intentional design as well as a vague conceptualisation in the minds of the individuals working within it. Having centred our previous discussions on the notion of routines and capabilities - routines as carriers of knowledge and capabilities the architects of this knowledge - one gets a rather straightforward perception of how they combine to form certain organisational outcomes. As Abell, Felin & Foss (2008) stressed and Wilden, Devinney & Dowling (2016) continued to suggest, the link between everyday routines and capabilities is far more complex and presents itself as an ongoing concern for researchers and practitioners alike, not only in the dynamic interactions between (and inside) them, but also in their role in delivering favourable outcomes for organisations.

HVLV manufacturers, by virtue of their manufacturing strategy, are presented as highly flexible organisations – navigating themselves through the maze of a production system that appears more like a fluid and lively entity than a highly fine-tuned manufacturing machine. By the same token, it is important to keep in mind that there is a certain order in all of this chaos.

In each of the actions a HVLV manufacturing machinist, fabrication manager or director makes, there is an intentional decision to undertake this task, guided by the perception of their environment and their interactions within the broader organisational "system" consisting of people and other artefacts (including the likes of machinery and even office printers and telephones). The actions are also a function of past experience where, as individuals, we tend to apply the same framework to our actions if we have such ingrained experience in this action and the problem this action is trying to solve. There is always a recognisable pattern of behaviour, this is the reason why we are able to observe them in “real-life”.

Thus, in a sea of uncertainty we also see a stable platform from which we can make some inferences. But this sea is always changing, from the variations in customer demands to mega trends in technology and processes. On the basis of pure process studies, we are just along for the ride. This does bring about a certain contradiction, as Cohen (2007, pp. 781-2), cited in Howard-Grenville & Rerup (2016), mentions:

“*From one perspective … ‘one does not step into the same river twice.’ … From another perspective … ‘there is nothing new thing under the sun.’ For an established routine, the natural fluctuation of its surrounding environment guarantees that each performance is different, and yet, … it is the same*.”

Indeed, for the director of the small HVLV manufacturing enterprise quoted at the beginning of this section, good fortune may well be on the cards to explain their ongoing success, but the results of this research suggest there are much more observable routines (by way of management practices) that may have some explanatory power as well. Of course, the choice of survey methodology and the apparent realist lens that it seems to portray influences our ability to look inside routines and uncover more of the mystique surrounding their use in practice (more on this later), but it does still allow us to draw the fundamental assumptions behind their adoption given they have meaning in practice and are undertaken to achieve certain goals through actions. Though the unintended consequences of organising also play a role here, as we highlighted in Chapter 3, an investigation of contradictions, tensions and outcomes is still very much on the table, given an organisations’ choice (or not) to adopt these practices.

We now turn our attention back to the research objectives and hypotheses to discuss the findings outlined in Chapter 5.

6.2 Ambidexterity and the Adoption of Better Management Practices

The theory building process in Chapter 2 suggests the mechanisms that guide the transition from ambidextrous capabilities to the adoption of BMP are ones of synthesis and complementarity. The conceptualisation of ambidexterity in this thesis suggests the capability is one of leveraging the contradictions between exploration and exploitation. It isn't necessarily balance we are concerned with here, as is the case for HVLV manufacturing, they need to be able to maximise the opportunities associated with adopting both. Thus, higher levels of convergence (maximising exploitation and exploration) relates to greater ambidextrous capabilities. Given synthesis is achieved (and appropriate) one would expect the outcome to be greater adoption of BMP.

The results illustrated in the previous chapter tell this to be the case. Ambidexterity was strongly and significantly associated with the adoption of both human resource management practices and production planning and control management practices (as is the case for the strong effect size and significant *p*-statistics in both models containing controls and without controls).

The more popular stance on the link between capabilities and BMP in extant HVLV manufacturing literature is that associated with capability building *through* management practices. Here, as in Yang (2013), BMP (including HRM and PPC) affect the attainment of HVLV manufacturing performance, which in their case represent delivery, cost and quality goals, through the attainment of manufacturing capabilities which can be associated with ambidexterity, including flexibility and efficiency-related manufacturing capabilities. Similar arguments are also made in the now classic study of Dangayach & Deshmukh (2001) as well as those more general studies suggesting ambidextrous capabilities are key to linking manufacturing practices that leverage flexibility to some level of organisational performance outcomes (Patel, Terjesen & Li 2012; Tamayo-Torres, Gutierrez-Gutierrez & Ruiz-Moreno 2014). In the same light, ambidexterity literature is replete with studies on how ambidextrous capabilities can be built *through* management practices.

This thesis is not so concerned with capability building per se, the research is more geared towards operationalising capabilities i.e., how they translate to organisational performance outcomes. Along these lines, there have been research efforts that can substantiate the results obtained in this thesis, albeit scarce.

Matthews, Tan & Marzec (2015) presents one of the few studies that investigates this phenomenon. Through case-study evidence, they found that project-based organisations that pursued a strategy based on meeting cost, time and quality goals were more exploitative and hence adopted more exploitative management practices in relation to the traditional notions of process management and control. Other project-based organisations that adopted a strategy based on flexibility and innovation tended to be more exploratory and refrained from developing internal capabilities. Clearly, however, one is at the expense of the other, in this instance, which also prompted the authors to stress the synergistic effects of exploitative practices in reducing costs and increasing control on exploration, and vice-versa. A more recent survey-based study by Tamayo-Torres et al. (2017), that builds on the previous study of Matthews, Tan & Marzec (2015), suggests that firms operating in more dynamic environments actually increase the importance of the ambidexterity and BMP link, suggesting that ambidexterity drives improvements in manufacturing performance through engaging the typical sand cone model where quality drives speed, speed drives flexibility and flexibility drives cost.

This study, however, does not make such explicit assumptions about cumulative capabilities. Unlike previous studies, this thesis investigates the degree of adoption regarding specific and structured management practices – thus placing focus on the impact of what HVLV manufacturers actually do, which then translates into manufacturing performance outcomes. In the most general sense, the results demonstrate that ambidextrous HVLV manufacturers are indeed better managed. But this, it seems, is only the tip of the iceberg.

It would appear that HVLV manufacturers holding ambidextrous capabilities also seem to avoid the pitfalls associated when the latent contradictory demands of exploitation and exploration are made salient through, perhaps, certain project characteristics or when the order book size begins to grow. Having to operate in an environment that is in a constant state of flux would suggest managers should hold the capability to recognise and leverage competing demands (Smith & Lewis 2011) towards what some would label "getting the job done"(Osterwalder & Pigneur 2010). It is interesting then, to observe the adoption of structured management practices such as HRM and (in particular) PPC when ambidextrous capabilities are well developed – given the intuitive focus on "control" runs counter to the more ingrained need for flexibility.

HVLV manufacturers are, by definition, flexible organisations – indeed their very design is a testament to this. Having been well established in the exploratory sense through problem solving, innovative manufacturing methods and so on, literature would often cite the danger in being forever exploratory (March 1991). Thus, the challenge, for HVLV manufacturers is to maintain a certain level of efficiency and control – perhaps an explanation of why the ambidextrous manufacturers in our sample took on the task of adopting these PPC management practices.

In the specific sense of adopting effective HRM practices, our results also support extant literature that suggest ambidextrous capabilities are synonymous with gaining, retaining and developing talent. For the HVLV manufacturing environment, then, this appears to be no exception. Employees, and in particular those on the shop floor, are the life blood of HVLV manufacturers. They possess the skills, knowledge and talent to address the demanding requirements of disparate customer needs on a constant basis. This occurs even with smaller organisations, where one survey respondent expressed concerns mentioning:

"...sometimes there is not scope to keep talent in a cut throat industry. A business like ours servicing predominantly primary producers cannot afford to keep talent employed at all costs. Margins are tight, and we have learnt from personal experience that paying a good worker too handsomely can be detrimental".

We see those organisations that can leverage ambidexterity are indeed adopting these practices. This also seems to run counter to the recent study by Petroni, Zammori & Marolla (2017) where they suggest MTO SMEs that operate under extreme levels of customisation and one-off production do not seem to place too much focus on the adoption of HRM practices in general. Such firms, however, were seen to depend deeply on tacit knowledge that is held as leverage to justify a worker's position in the company.

The workers themselves were happy enough to be left alone, thus presumably the HRM practices were geared towards retainment at the expense of others.

Capabilities are embedded in skills and the transfer of tacit knowledge amongst members of an organisation. Whilst the companies described by Petroni, Zammori & Marolla (2017) as having low adoption rates in BMP are those associated with the higher end of the customisation spectrum, the fact tradesmanship and innovative capacity are embedded in individuals doesn't mean those capabilities are fostered at a higher level. Without the dissemination of knowledge through routines, themselves a function of tacit-knowledge, there is little chance capabilities at the firm-level will inherit the same capabilities as the individuals with those capabilities inside them. Thus, it would be reasonable to assume those organisations described by the authors were not ambidextrous to begin with. Indeed, the authors mention that efficiency gains and cost reduction was not a large concern for these organisations. In either case, our results in this space also help explain some of this phenomenon concerning the adoption of BMP in a more general sense.

6.3 The Adoption of Better Management Practices and HVLV Manufacturing Performance Outcomes

The results demonstrated that the adoption of BMP did have a significant and positive impact on HVLV manufacturer performance, though some of the hypotheses were not supported. In particular it was found that whilst PPC had a significant and positive impact on operational flexibility, it did not have the same impact on process innovation performance. Contrary to this, the adoption of HRM practices was observed to have a significant impact on process innovation performance, though did not have a significant impact on operational flexibility (in fact, the standardised beta coefficient was negative). This was a surprising result.

HRM practices (by way of acquiring, retaining and dealing with poor performance) have a long and rich history in both manufacturing flexibility (Ahmad & Schroeder 2003; Kathuria & Partovi 1999) and innovation literature (Haneda & Ito 2018). The overarching logic in mass-scale BMP studies would appear to suggest hiring the right people with the right skills is critical in any manufacturing environment (Bloom et al. 2017; Bloom & Van Reenen 2007). The same studies also suggest incentivising to attract talent, implementing a performance-based rewards system and dealing with poor performance is going to be critical in any organisational context.

Our results line-up with others in general manufacturing literature with regards to the relationship between HRM and process innovation performance (Agarwal, Brown, et al. 2014). Better employees with complementary skills and creative output appear as central to HVLV manufacturers as they are in other manufacturing environments. What did not quite line up with extant literature comes from the non-significant relationship between HRM and manufacturing flexibility performance. Given HRM's stature as "general purpose" by way of their applicability across a vast array of industrial sectors, HRM would then prove crucial in helping organisations to both exploit existing resources towards competitive parity in todays' markets and exploring new opportunities in the future (c.f. Pisano 2017). The results in this thesis, however, tell a different story.

Part of the reasoning behind our lack of significant relationship between HRM and operational flexibility can be attributed to the flexibility paradox outlined earlier in this thesis and further discussed in Katic & Agarwal (2018). The paradox would suggest that the more flexible a HVLV manufacturer is by way of design and the level of customisation offered, the less flexibility is actually observed in the manufacturing system. Notionally, it is harder to retain flexibility if a higher backlog of customised jobs is waiting in dispatch. At some point, the manufacturing system simply can't cope, and operational flexibility is thus reduced. Paradoxically, by the same token, operational flexibility is easier to achieve if the uncertainty stemming from the demand side is reduced i.e., if the manufacturer is opting to build-to-print (BTP) rather than engineer-to-order (ETO).

Indeed, HRM would be more critical in ETO manufacturers to achieve the same level of flexibility than that of BTP manufacturers where the skill level requirements are lessened. Petroni, Zammori & Marolla (2017) labelled such manufacturers that held BTP operations, often relied on repeat business and did not have specific HRM requirements as "old fashioned". For them, the competitive criterion is gains in efficiency and variation reduction to simplify the manufacturing process and appease the requirements of a small number of "reliable" customers. Thus, it is plausible to suspect the degree of uncertainty with relation to undertaking design engineering work and the skill associated with this would have a bearing on this relationship. Whilst a multi-group analysis (Hair, Sarstedt, et al. 2017) would reveal some insights here, the relatively small sample size precludes us from further investigating this and generating any reliable results, thus also a promising area of future research.

In the sense of production planning and control (PPC) and HVLV manufacturer performance, the results help validate the claims made by the workload control (WLC) school in the importance of the adoption of a structured, comprehensive and appropriate PPC approach to HVLV manufacturing environments (Hendry, Huang & Stevenson 2013; Silva, Stevenson & Thurer 2015; Thurer et al. 2012).

As hypothesised, the counterintuitive notions of restricting and regulating order release, effective quotation management and coordination efforts between functions and suppliers are certainly crucial towards achieving manufacturing flexibility – as the various case studies and simulation studies described in the theory building and literature review Chapters attested to. However, counter to the hypothesised claims in PPC also facilitating process-based innovations, the results was something different than expected.

Given the centrality of PPC to HVLV manufacturing success, the hypothesis was based on the synergistic effects of control and flexibility. Emerging evidence suggests that process control mechanisms also have a positive impact on innovation via exploration (Snehvrat et al. 2018) and as argued extensively in this thesis, routinised patterns of behaviour as knowledge carriers are the basis from which new knowledge can be formed. It would appear, in this instance, PPC routines concerning integration and coordination, quotation and estimation activities as well as effective workload control may well not incur the freedom for variation within routines towards forces for change and improvement. A more plausible explanation can also lie in the manner in which these PPC routines are executed. Adopting a systematised PPC methodology in a HVLV manufacturing enterprise is still a nascent phenomenon. PPC in a HVLV manufacturing enterprise is an expensive and time-consuming activity where the applicability of enterprise resource planning systems and software in this environment is still saturated in complexities (Aslan, Stevenson & Hendry 2015). Most manufacturers are having to adapt existing platforms and make do with the deficiencies often associated with pre-production planning and management activities (Adrodegari et al. 2015). In addition, the relevance and impetus of process innovations begins with a strategic decision to undertake this activity. To assume the increased flexibility and standardisation associated with the adoption of PPC would allow HVLV manufacturing managers more time for strategic decision making may be a naïve notion as "lack of time" is often a major cause of stunted growth (Bloom et al. 2018). Nonetheless, this also presents itself as an interesting endeavour for future research as well.

6.4 Better Management Practices the Key to Understanding Ambidextrous Capabilities?

The goal in this thesis was to understand the roots of ambidextrous capabilities in organisations. In particular, the research was narrowed down on a highly volatile and uncertain environment of HVLV manufacturing and proposed the notion of better management practices as the mechanisms through which ambidextrous capabilities are put into action towards organisational performance outcomes. In this case we conceptualised the goal of HVLV manufacturing as the simultaneous pursuit of operational flexibility (by way of producing a wide variety of products) whilst consistently meeting the stringent demands of today's customers in delivery and cost goals (via process innovation). Thus, the research pursuit in understanding how HVLV manufacturers operationalise ambidexterity is founded on the ideal that observed impacts of ambidextrous capabilities and BMP should result in an understanding of how HVLV manufacturers operate and are able to legitimise themselves.

Ambidexterity is a dynamic capability, helping firms in sensing opportunities, seizing the value of these opportunities and reconfiguring the organisation to suit. Thus, the results also complement those in recent dynamic capabilities literature regarding the indirect effects of "operational" capabilities in the link between dynamic capabilities and organisational performance (Wu, Melnyk & Flynn 2010). These studies view the role of dynamic capabilities as altering (or reconfiguring) the existing routines in organisations to match the dynamics of the external environment. A key distinction between this research and those in dynamic capabilities in general, is that whilst the results can see similarities between dynamic capabilities theory and ambidexterity, the conceptualisation of dynamic capabilities is extended further in recognising that whilst they are indeed complementary by way of objectives, they are also fundamentally different in means.

Ambidexterity, as a higher order dynamic capability, can be enacted in a multitude of ways and impact the organisation at different levels. By adopting the routines-based view of organisation and extending this ideology to include the emergent, generative and conflicting properties of routines, this research is also able to help in shedding some light on the inner workings of operational capabilities by investigating the adoption of BMP. Environmental dynamism seems to also be a key area of concern in both dynamic capabilities and ambidexterity literature where the results appear somewhat fragmented and inconclusive. The HVLV manufacturing lens is a prime example of this environment, as such the results also inform extant literature here.

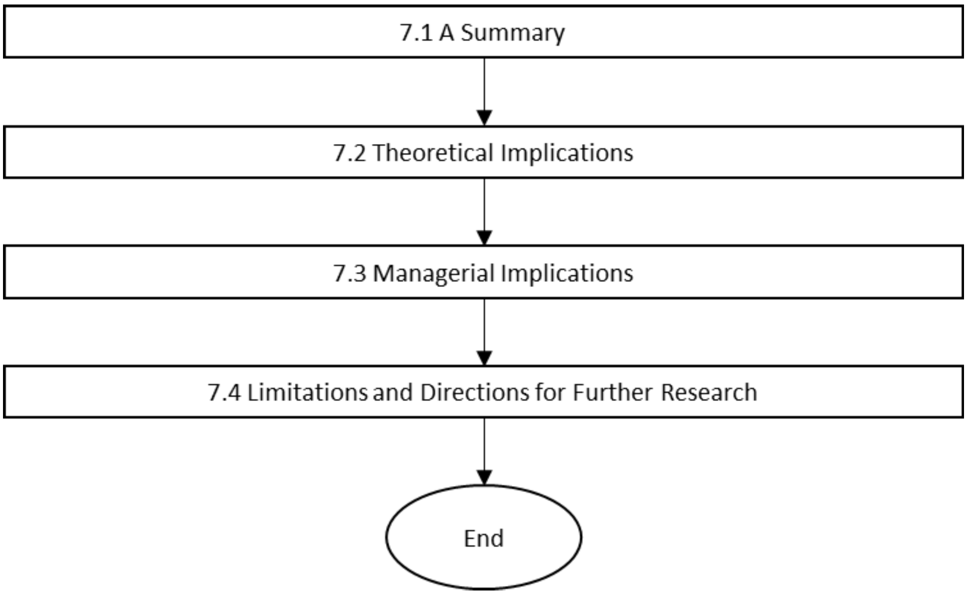
As expected, this research is able to verify the fact that ambidextrous capabilities, on their own, are not sufficient – they are enacted through BMP which ultimately impact HVLV manufacturer performance. However, their impact on performance is not consistent. Somewhat counter to the claims by Cao, Gedajlovic & Zhang (2009), the results suggest that HVLV manufacturers as highly resource constrained (Slomp, Bokhorst & Germs 2009) can thrive in maximising the tensions that coexist in the form of exploration and exploitation. They seem to adopt a conceptualisation of tensions as mutually enhancing that guides their decision to adopt certain management practices. These management practices, however, impact the overarching performance of HVLV manufacturers in different ways – HRM in facilitating exploration and PPC in facilitating exploitation.

This more fine-grained conceptualisation also moves beyond extant literature in the more contemporary debate regarding the role routines (or operational capabilities) play in facilitating synergism by way of consolidating the latent tensions of exploration and exploitation when they become salient in the act of organising. Thus, this research also provides credibility to both the role of the capabilities deployment process in linking ambidexterity to BMP and to the routines deployment process in linking BMP to HVLV manufacturer outcomes.

Chapter 7 Conclusions and Implications

This chapter provides a conclusion for this thesis. A summary of the research is first presented, followed by an outline of the theoretical and managerial implications. Finally, this thesis ends with a discussion of the limitations and directions for further research.

Figure 7-1 Outline of Chapter 7



7.1 A Summary

At the beginning of this research endeavour, a fundamental question that is persistently plaguing both ambidexterity and HVLV manufacturing literature was articulated. There seemed to be a wealth of knowledge on how to achieve organisational ambidexterity and the role of structure, processes and individuals in this ultimate goal. However, there remained and untapped need to understand how organisations actually operationalise this simultaneous pursuit of exploration and exploitation. The emerging understanding of ambidexterity as a (dynamic) capability provided some guidance in that such a view elucidated that ambidexterity is not, in itself, a source of competitive advantage, rather it is the resource reconfigurations that stem from this capability that prove critical to organisational performance outcomes. Thus, capabilities and the management routines that constitute them are important.

At the same time, an evolving trend in the age-old tradition of better management practices (BMP) was identified, where almost intuitive everyday management practices were recently proven to be a major factor in manufacturer performance outcomes. With regards to this research, it presented a significant opportunity to realise the role of routines in understanding how organisations operationalise ambidexterity. Although, BMP only appear useful in context. The research focus was then narrowed on an organisational context known as HVLV manufacturing where the challenges in understanding this phenomenon are compounded by the inherent dynamism and volatility of a manufacturing strategy in which the customer is effectively given full control over their operations. Here, leveraging uncertainty towards synergistic outcomes is key.

Having grounded the objectives of this thesis in understanding how organisations operationalise ambidexterity and the role of BMP in the HVLV manufacturing context, an extensive literature review and theory building exercise was conducted. The literature on HVLV manufacturing and BMP revealed a cohesive and well-founded discussion on the role of BMP in achieving HVLV manufacturing performance outcomes. However, the implications seemed to be contradictory and oftentimes inconclusive when higher customisation environments were introduced. In this instance, the contradictions inherent in letting the customer into the production system from the beginning, and at the same time having to remain competitive in the short term, proved challenging. When investigating literature on HVLV manufacturing and ambidexterity, however, there appeared to be some light at the end of the tunnel.

Whilst not explicitly referring to ambidexterity *per se*, there was evidence of studies that investigated similar organisational tensions in, for instance, flexibility vs. innovation and control vs. stability. Here, coordination was key, and the resolution was in separating out exploratory and exploitative activities – something akin to structural ambidexterity. However, literature in this domain also recognised that the drive for flexibility was the same urge that lead to standardisation. Emerging trends concerning mass customisation in HVLV manufacturing purported to help in this dilemma, though it was found they too suffer from the same contingencies associated with fundamentally reducing the instances of variation through customer input and effectively laying waste to the HVLV manufacturers' capabilities that make them what they are in the first place. Better management practices, as routines that HVLV manufacturers actually undertake in the realisation of a customised product, appear more promising here, though their role in operationalising ambidexterity in this environment remains to be told.

Next, with the aims of uncovering the mechanisms that link ambidextrous capabilities to organisational outcomes in HVLV manufacturing, a theory building exercise was undertaken that looked deeper into the inner workings of this relationship between capabilities and organisational performance. Through adopting a routines-based lens, it is here that we realise the discrepancy in our understanding of operationalising ambidexterity is not a simple case of understanding direct (and hierarchical) relationships between capabilities and routines, but also in the often latent contradictions of organising that are hidden in the meaning behind the adoption of routines themselves. In this case, literature was also seemingly lacking as in the HVLV manufacturing environment, the meaning behind the adoption of certain BMP seem to result in uncertain organisational outcomes.

Accumulating the gaps in extant knowledge concerning 1) the operationalisation of ambidexterity; 2) the role of routines in translating ambidextrous capabilities to organisational outcomes and 3) the HVLV manufacturing dilemma in leveraging their flexibility towards ambidextrous outcomes, the research question for this thesis was formulated as:

How do better management practices (as routinised patterns of behaviour) impact the operationalisation of ambidexterity in HVLV manufacturing?

In order to investigate this question, three research objectives were derived:

1. Investigate the impact of ambidextrous capabilities on the adoption of better management practices
2. Investigate the impact of better management practice adoption on HVLV manufacturer performance outcomes and finally,
3. Investigate the combined impact of ambidextrous capabilities and better management practice adoption on HVLV manufacturer performance outcomes.

A conceptual framework was then developed based on the underlying research questions and objectives. During the theory building exercise, human resource management (HRM) and production planning and control (PPC) management practices were revealed as key BMP in this thesis.

A research design centred on a combination of theoretical perspectives was then developed. Ultimately, a deductive-based survey methodology was selected in order uncover the influence of BMP in the operationalisation of ambidexterity in HVLV manufacturing. A relatively small sample size that resulted from this survey effort meant that much of the survey questions initially intended as part of this research were excluded (this also fed into the selection of PPC and HRM practices mentioned earlier).

The online survey was ultimately emailed to 838 HVLV manufacturers where 73 responses were collected, leaving a response rate of 9%. After accounting for HVLV manufacturers with less than five employees, erroneous response patterns and missing values, a total of 50 responses remained.

Data analysis was then conducted using both IBM SPSS 25 for the evaluation of skewness, kurtosis, outliers and common method bias whilst SmartPLS 3 was used for the evaluation of measures and hypothesis testing based on a two-step process (the evaluation of the measurement model and the evaluation of the structural model).

The evaluation of the distribution revealed no major issues with skewness, kurtosis or outliers. Similarly, the evaluation of common method bias, stemming from the effects of self-reporting, were inconclusive and reveals common method bias does not pose a significant problem in this research.

The measurement model demonstrated good reliability and validity of the measures used in the research model with minimal modification (bar the removal of one item for the sake of internal consistency reliability). The results from the measurement model assessment also demonstrated the efficacy of building ambidexterity and PPC as second-order formative constructs. The evaluation of the structural model(s), however, revealed an interesting result.

Two different structural models were assessed – one with the direct effects of controls and the other without controls. The results of both models were consistent in suggesting that contra to our beliefs concerning the role of BMP (PPC and HRM) as the conduit from which ambidextrous capabilities impact HVLV manufacturer performance, only partial support for this was found.

Even though ambidexterity did not have a significant impact on HVLV manufacturing performance outcomes (by way of operational flexibility and process innovation), as was indeed the hypothesised result, PPC did not have a significant impact on process innovation and HRM did not have a significant impact on operational flexibility. However, PPC was observed to fully mediate the relationship between ambidexterity and operational flexibility and HRM was observed to fully mediate the relationship between ambidexterity and process innovation. Both of these results were also verified in further robustness testing.

Returning to the research question, it would seem the path from holding ambidextrous capabilities to making use of them is not a straightforward process for HVLV manufacturers. Those manufacturers that observe higher levels of ambidextrous capabilities tend to adopt HRM and PPC as better management practices. However, these BMP do not help HVLV manufacturers in achieving their goals in delivering customised products better, faster and cheaper in the same way. Adopting PPC management practices increases operational flexibility in being able to produce a wide variety of customised products effectively, though does not seem to aid in undertaking process innovations. On the opposite side, HRM practices appear to help HVLV manufactures in achieving process innovations though do not seem to help in achieving operational flexibility. In either case, both are necessary in achieving HVLV manufacturing goals, though both prove insufficient on their own.

This research has begun to shed some light on the inner workings of HVLV manufacturers. Bringing BMP to the forefront of the discussion has proved fruitful, not only in the face value of understanding their impact on HVLV manufacturer performance, but in the realisation that they prove pivotal in understanding how HVLV manufacturers, as flexible organisations, can remain flexible organisations. Though the restrictions bestowed upon this research in terms of the sample size and methodology adopted preclude us from making generalisations about these findings, they do seem to suggest some important implications for both theory and practice, discussed next.

7.2 Theoretical Implications

The theoretical implications of this thesis span both the broader ambidexterity literature as well as HVLV manufacturing literature.

Firstly, there is a well-defined gap in our understanding of how organisations operationalise ambidexterity. The majority of research efforts in this space would seek to explain how ambidextrous capabilities are built *through* the adoption of BMP. This thesis, however, is concerned with the link between ambidextrous capabilities and BMP (where BMP subsequently impact organisational performance outcomes). Thus, it is concerned with ambidextrous capability deployment, rather than necessarily capability building.

In this respect, we contribute to extant ambidexterity literature by explicating the role of BMP as both *explanans* and *explananda* for capability deployment and organisational performance. In addition, we also contribute to the larger dynamic capabilities literature, where the role of routinised patterns of behaviour in executing capabilities towards organisational performance remains uncertain.

By adopting a routines-based lens, we demonstrate that merely holding dynamic capabilities is not sufficient, routines matter, and in these routines lies latent characteristics that can impact organisational performance differently. It would seem that the intended impacts on exploratory and exploitative performance of dynamic capabilities (such as ambidexterity) is dictated by the characteristic of the routines actually doing the work.

Secondly, from the HVLV manufacturing point of view, this research presents itself as one of few that investigates this crucial divide in HVLV manufacturing by exploring the role of ambidextrous capabilities and BMP in understanding how they can begin to leverage their inherent flexibility to their advantage without having to sacrifice their unique capabilities in manufacturing a high-variety of customised goods. In this case, we bring forward two such mechanisms that help in this regard.

One of the main discussions centred on this dilemma revolve around the implementation of effective coordination, sales and estimation and workload control. Whilst literature would suggest these management practices to be crucial for HVLV manufacturer performance, it would appear they are only effective in one respect i.e., helping the organisation increase their ability to produce a wide variety of products. In addition, we also highlight the contradictory role of human resource management practices in leveraging HVLV manufacturing capabilities as, contrary to universalistic world-class manufacturing studies, the adoption of these management practices can impact HVLV manufacturer performance differently as well.

Secondly, we contribute to HVLV manufacturing literature concerning manufacturing flexibility by highlighting the dangers of holding an inherently flexible enterprise. The results would suggest that flexibility does not necessarily breed flexibility as the performance impacts of this flexibility are governed by the actions HVLV manufacturers actually take in building a highly customised product. We demonstrate that HVLV manufacturers can leverage their unique capabilities and retain competitive parity by doing what they're already capable of, just better. Leading us towards the managerial implications of this research.

7.3 Managerial Implications

Because this research is centred on HVLV manufacturing and the subsequent adoption of management practices and organisational outcomes, the viewpoint is fundamentally practice-based. This thesis studies organisations that are constantly under severe strain and part of the intention is to provide practical advice on how HVLV manufacturing owners, directors and indeed middle management and floor staff are better able to leverage their capabilities in real-time. In this vein, and according to the results, we can suggest the following.

Firstly, HVLV manufacturing ambidextrous capabilities drive the adoption of BMP. Whether this occurs intuitively as part of their increased capabilities in problem solving and divergent or creative thinking is yet to be determined. Though, what can be suggested is that managers in HVLV manufacturing organisations cannot afford to rest on their laurels when it comes to combatting the tensions and contradictions that will inevitably arise every time a job arrives through their doors. Maximising these tensions towards synergistic outcomes is crucial in their pursuit of long-term competitive parity by way of better management practices.

Secondly, the adoption of BMP does not come out of thin air. It is a result of continuous capability building and deployment. Skills, knowledge, experience and perception matter – if the organisation is not capable of synthesising all this knowledge and work towards a complementary integration of exploration and exploitation, then the chances of making use out of routines in the sense of BMP are slim. Managers are thus urged to build a credible foundation that helps nurture the translation of ambidextrous capabilities into workable BMP. Though our results don't explicitly suggest this given our survey methodology, the extant literature on the subject recommends managers can achieve this, for instance, by building ambidextrous capabilities within themselves.

Thirdly, PPC and HRM have seen increased attention from researchers. Yet, it would appear their contradictory affects have been somewhat taken from granted. In the sense of PPC, the classic “job shop problem” and “lead-time syndrome” have been plaguing literature for many decades. Here, HVLV manufacturers have been searching for ways to improve visibility in their processes and somehow make sense of all the chaos in a meaningful and systematic matter. However, we urge managers to carefully consider the *modus operandi* governing any efforts to leverage PPC in their favour. Whilst the results suggest it is invaluable in helping manufacturers achieve operational flexibility, it does so from only one side of the HVLV manufacturing equation – the other side of ongoing process innovation is not impacted. It is an exploitative routine, thus helping the organisation do things right. It does not, however, help the organisation do the right things.

On the other hand, HRM also seems to have contradictory effects. Opposite to the adoption of PPC, HRM is seen as inherently exploratory routines in their significant impact on process innovation outcomes and lack of significant impact on operational flexibility. Whilst our managerial recommendations in this respect would suggest selective use of these routines when innovation is in order, we suspect there is more to this story in that there appears to be more heterogeneity in HVLV manufacturing than extant literature leads us to believe. Whilst these claims cannot be substantiated with the evidence so far, we can certainly attest to the fact that HRM may see decreased relevance in HVLV manufacturers associated more with repeat business than those that conduct design and engineering activities more often.

7.4 Limitations and Directions for Future Research

It is important to keep in mind that the managerial suggestions mentioned above are formulated based on evidence from this research, which is not without its limitations.

Firstly, the most obvious limitation is that in relation to the relatively low sample size. This has significantly constrained the ability to generalise the results across various HVLV manufacturing domains. In addition, it has also limited the possibility of conducting more advanced statistical inference techniques that involve models concerning an entire suite of BMP, as was the original intention. Even though statistical power has been proven to an extent in Chapter 5, readers should observe caution in that smaller samples also tend to overestimate certain effects and at the same time leave the results more prone to influence from the distribution of data. Every attempt was made to increase the reliability and validity of the results as much as practicable (as seen in the second-order constructs of PPC and ambidexterity) and were able to simplify the model in the aim of drawing some reasonable conclusions. However, it is noted this inherently limited the ability to draw a more fine-grained picture of how ambidexterity is operationalised in HVLV manufacturing.

Secondly, although efforts were made to reduce common method bias as much as practicable in the design and delivery of the survey instrument as well as in the choice of splitting up the performance measures and using two separate (rather than one complete) performance constructs, only one key decision maker per HVLV manufacturer was surveyed. As is the case, ambidexterity occurs at all levels of organisation and its impact on one level is felt throughout the others as well. To be able to investigate the operationalising of ambidexterity in HVLV environments, and in order to reduce the likelihood of common method variance, further research should be conducted that investigates this phenomenon at multiple levels. In addition, this is fundamentally a cross-sectional study looking at one single point in time. Further research should also undertake a longitudinal study that looks at the evolution of ambidexterity, BMP and HVLV manufacturer performance. This should observe the inherent dynamics associated with their relationships and make more conclusive recommendations based on more detailed evidence.

Thirdly, and along similar lines, the conceptualisation of ambidexterity in this thesis is only geared towards one possible approach i.e., maximising contradictions. Further research should also be conducted to test the model in times of trade-off, given this will provide further opportunities for statistical inference and increase our understanding of BMP adoption and provide a more contingent view on the ambidexterity and HVLV manufacturing performance link.

Fourthly, and perhaps on a more philosophical front, our approach to reason is constrained by the methodology used to undertake this research project. The survey methodology bestows us as observers in a world where a particular reality exists. Predictions about reality are made and tested to see if this reality needs to be altered or not. This precludes us from observing other realities that may exist elsewhere and limits the findings towards a discourse and rhetoric that lines itself up with that of literature and the inferences we can draw from that. Although explicit efforts to reduce the impact of this were made by undertaking an analysis through multiple theoretical lenses, the research is still limited concerning the understanding of how individuals actually navigate HVLV manufacturing life and all the contradictions and complexities that come with it. Further research should also take the notion of process and time seriously by investigating how individuals go about conducting the act of organising. This will certainly improve the extant understanding of routine behaviour beyond adoption, as we have done so here.

Fifth, and from a more theoretical perspective, whilst the focus of this thesis is on HVLV manufacturing, there is certainly room to test the role of BMP in operationalising ambidexterity in other organisational contexts. BMP are context driven, though the fundamental logic guiding their adoption remains similar amongst other organisational environments. Adopting another contingency to the equation will also help in solidifying the impact of routines in the ambidextrous capability deployment process studied in this thesis.

Sixth, the observed heterogeneity in HVLV manufacturers was much higher than literature led us to believe. HVLV manufacturers, whilst collated into two main groups concerning engineer-to-order and make-to-order, there are intricate nuances associated at the micro-level regarding their operations and strategic intent that we propose also seem to have an impact on the operationalisation of ambidexterity as well as the adoption and dissemination of BMP. Further research is certainly recommended in going deeper into these intricacies between varying levels of uncertainty.

Lastly, we can attest to the fact that our approach in studying BMP is limited by the specific focus on only PPC and HRM. Though, perhaps among the more important in a

HVLV environment when it comes to leveraging the uncertainty stemming from such a manufacturing strategy, the literature review revealed a larger suite of practices that can indeed prove useful in this regard. Given also the importance of complementarity in dynamic capabilities literature, a more holistic approach based on a larger sample of BMP appears well worthwhile for future research.

Appendices

Appendix 1. Content Validity Survey

A Pre-Test Survey on Better Management Practices in High-Variety, Low-Volume Manufacturing

Introduction

Dear Participant,

We are developing a survey on the impact of both operations and innovation centred management capabilities on the performance of High-Variety, Low-Volume (HVLV) manufacturers - a manufacturing strategy centred on the production of a wide variety of customised products. In an effort to collect high-quality data, we are requesting your involvement as an expert judge in the preliminary assessment of our survey items.

Here, you will find a pre-test questionnaire which aims to assess whether the questions we propose in our final questionnaire are important (or not) in the understanding of estimation and sales, production planning and control, procurement, quality management, human resource management and engineering change management in the context of HVLV manufacturing.

The survey should take around 5 minutes to complete. Remember, there are no right or wrong answers, we are only interested in your attitude towards the questions related to each management practice label. This pre-test questionnaire is anonymous and the results will be used to improve the final questionnaire.

Thank you for participating in this preliminary testing procedure. If you have any questions regarding the research, please don't hesitate to ask.

Mile Katic (PhD Candidate) e: mile.katic@uts.edu.au
Dilek Cetindamar Kozanoglu (Associate Professor, FEIT, UTS)
Renu Agarwal (Associate Professor, UTS Business)

A Pre-Test Survey on Better Management Practices in High-Variety, Low-Volume Manufacturing

Section A - Adoption of Management Practices

This section seeks to assess how essential each survey item (question) is to the understanding of its management practice label.

For example, if the management practice label isQuality Management and the item is "We undertake quality control" - ask yourself, how important is the knowledge gained from this item to the understanding of Quality Management? You would then rank this importance on a scale of 1-5 (1 being not important and 5 being very important to the understanding of quality management).

* 1. Are you, or have you been, an academic, manufacturing industry professional or both?

- ◯ I am (or have been) an academic
- ◯ I am (or have been) a manufacturing industry professional
- ◯ I am (or have) worked as both

* 2. How long have you worked as a manufacturing industry professional and/or academic?

- ◯ Less than 5 years
- ◯ 5-10 years
- ◯ 11-15 years
- ◯ 16-20 years
- ◯ More than 20 years

* 3. How important is the knowledge/ability captured by the following items to the*understanding* of **Estimating and Sales**?

Think about the decisions you make when receiving a tender request, making cost and lead time estimations and putting them together in a quotation to send to the customer

	Not Important	Slightly Important	Moderately Important	Important	Very Important	Unsure
We keep track of and monitor all quotations (both won and lost) in an easy access database	○	○	○	○	○	○
We have a keen understanding of our competitors and employ a systematic quotation control system in order to help guide cost and lead time estimations for customer enquiries (for example, a strike-rate matrix)	○	○	○	○	○	○
We actively help customers meet their goals rather than just providing customers' wants	○	○	○	○	○	○
There is a high degree of coordination between all departments to ensure we set realistic due-dates for customer enquiries	○	○	○	○	○	○
Capacity and resource availability information is readily available to both manufacturing and sales departments when responding to customer enquiries	○	○	○	○	○	○
There is a high degree of coordination between our organisation and our suppliers when we respond to customer enquiries	○	○	○	○	○	○

* 4. How important is the knowledge/ability captured by the following items to the*understanding* of **Human Resource Management**?

Think about the activities you perform when making staffing decisions as well as those that help foster an environment that enable your workers' the ability, motivation and opportunity to perform

	Not Important	Slightly Important	Moderately Important	Important	Very Important	Unsure
Senior managers are evaluated and held accountable for the strength of the talent pool they actively build	◯	◯	◯	◯	◯	◯
We strive to outperform the competitors by providing ambitious stretch targets with clear performance related accountability and rewards	◯	◯	◯	◯	◯	◯
We move poor performers out of the company or to less critical roles as soon as a weakness is identified	◯	◯	◯	◯	◯	◯
We actively identify, develop and promote our top performers	◯	◯	◯	◯	◯	◯
We provide a unique value proposition above our competitors to encourage talented people to join our company	◯	◯	◯	◯	◯	◯
We do whatever it takes to retain our talent	◯	◯	◯	◯	◯	◯

* 6. How important is the knowledge/ability captured by the following items to the*understanding* of **Production Planning and Control**?

Think about the planning and control processes you undertake when you have won the quotation and commence production

	Not Important	Slightly Important	Moderately Important	Important	Very Important	Unsure
We implement a systematic method of workload control	○	○	○	○	○	○
We employ a pre-shop floor pooling and release system to improve flow in manufacturing operations	○	○	○	○	○	○
We have a systematic method of bottleneck detection and reduction	○	○	○	○	○	○
Job priorities are clearly understood by everyone on the shop floor	○	○	○	○	○	○
We rigorously pursue quick change over and set-up times for our machines and strive to improve them	○	○	○	○	○	○
We structure our manufacturing practices and shop-floor layout based on the identification of common product families	○	○	○	○	○	○

A Pre-Test Survey on Better Management Practices in High-Variety, Low-Volume Manufacturing

Finished!

The questionnaire finishes here. Thank you for your time and your valuable contribution to our research. If you would like to clarify any of your responses in this survey please do so in the comment box below.

9. Comments

Appendix 2. Questionnaire Invitation Letter

A Survey on Innovation in High-Variety, Low-Volume Manufacturing – Towards Competitive Customisation

Dear Participant,

As we are approaching one of the busiest seasons of the year, it would be quite easy to assume one of the main things on your mind would be to clear the order book and get as many jobs out the door as quickly (and efficiently) as possible. Whilst undeniably an important part of job-shop success, it doesn't tell us the whole story – you still have to explore new opportunities towards long-term growth whilst leveraging the flexibility that makes your organisation what it is in the first place. When jobs vary from customer to customer, attempting to exploit your existing assets towards greater efficiency and exploring new opportunities at the same time becomes particularly difficult to achieve – no matter what time of year it is.

This nation-wide survey, part of my PhD research project being conducted at the University of Technology Sydney, aims to understand the impact of day-to-day operations (deemed "better" management practices) on the ability to innovate and improve operational efficiency at the same time, as well as how this effects overall organisational performance. The question, in this instance, is how do some basic management principles impact the ability of a job-shop to simultaneously improve efficiency and innovate.

By participating in this research project, you will be eligible to receive an individual participant report allowing you to benchmark your organisational capabilities and performance against others. We also offer discounted entry to the Australasian Conference on Information Systems – a conference focused on organisational resilience and sustainability through digital transformation held at UTS.

The survey can be completed by anyone with a keen understanding of the operations and general strategic objectives of the organisation. It is divided into 4 sections (A-D) and should take around 15 minutes to complete.

All data will be treated with absolute confidentiality and no identifiable company data (including names and other company specific comments) will appear on any reports stemming from this research. The survey participation is voluntary and you may withdraw at any time.

Click the button below to start the survey. Should you have any questions regarding the research or the survey, please don't hesitate to ask.

Thank you for your participation and contribution!

Mile Katic* (PhD Candidate), Associate Prof. Dilek Cetindamar Kozanoglu*, Associate Prof. Renu Agarwal**

Appendix 3. Complete Questionnaire

A Survey on Better Management Practices and High-Variety, Low-Volume Manufacturing Excellence – Towards Competitive Customisation

Introduction

Dear Participant,

This survey is part of a broader PhD research project being conducted at the University of Technology Sydney. The overall aim of this research project is to:

1. **Better understand how day-to-day operational activities (considered "better" management practices) impact organisational performance of High-Variety, Low-Volume (HVLV) manufacturers – a manufacturing strategy centred on producing a wide range of customised products – and,**
2. **How the ability to innovate and simultaneously improve operational efficiency impacts this link**

The information you provide will help us in better understanding the role these two capabilities (improving operational efficiency and innovation) play in achieving greater competitiveness through a customisation-based manufacturing strategy in Australia.

All information gathered herein will be used for the purposes of this research project as well as other research projects in the future. In addition to this (and in accordance with UTS policies and good research practice) all data collected as part of this survey will be treated with absolute confidentiality. No identifiable unit-level company data (including names and other company-specific comments) will appear on any reports stemming from this research. The survey participation is voluntary and you may withdraw at any time.

The survey is divided in 4 sections (A-D) and should take around 20 minutes to complete.

All respondents who complete the survey and provide contact information will receive:

1. **Individual participant reports which will benchmark their organisational capabilities and performance with similar organisations as well as,**
2. **$250 off entry to the Australasian Conference on Information Systems – a conference focused on organisational resilience and sustainability through digital transformation held at UTS**

Thank you for participating in this research project.

Mile Katic[1], Associate Prof. Dilek Cetindamar Kozanoglu[1], Associate Prof. Renu Agarwal[2]

[1] School of Information, Systems and Modelling, Faculty of Engineering and IT, UTS.

Email: mile.katic@uts.edu.au
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[2] Management Discipline Group, UTS Business.

This research meets the requirements of the National Statement on Ethical Conduct in Human Research (2007) and has been approved by UTS HREC ref. no: ETH18-2426.

A Survey on Better Management Practices and High-Variety, Low-Volume Manufacturing Excellence – Towards Competitive Customisation

Survey Instructions

Please place a response for each question in this survey.

There is an N/A option should you feel a particular question does not fit your organisation - in this instance there is a comments section at the end of the survey if you would like to clarify your response.

If you would like to "save" your responses and go back to the survey and complete it later you can do so. The survey automatically saves all responses once you click "next page". Should you need to go back to it later, simply close the survey and reopen the link when you are ready to recommence.

Only one response per manufacturing organisation is permitted. The survey can be conducted by anyone in the organisation with knowledge of the day-to-day operations as well as the strategic trajectory and organisational performance. This would typically include the likes of owners, directors, general managers and other key decision makers.

Thank you for taking part in this research project.

A Survey on Better Management Practices and High-Variety, Low-Volume Manufacturing Excellence – Towards Competitive Customisation

Section A - Basic Organisational Characteristics

This section focuses on generic background information about your organisation.

* 1. What is your role in the company?

- ◯ CEO, Owner, Director
- ◯ General Manager
- ◯ Middle Management
- ◯ Project Manager/Engineer
- ◯ Foreman
- ◯ Other (please specify)

* 2. How long have you worked in this organisation?

- ◯ Less than 5 years
- ◯ 5-10 years
- ◯ 11-15 years
- ◯ 16-20 years
- ◯ More than 20 years

* 3. Do you have any of these tertiary qualifications? Please tick all that apply

- ☐ Bachelor's Degree or International Equivalent
- ☐ Master's Degree (other than MBA)
- ☐ PhD
- ☐ MBA
- ☐ No Tertiary Qualifications
- ☐ Other tertiary qualifications (please specify)

* 4. How many employees does your organisation have?

- ◯ 1-4
- ◯ 5-19
- ◯ 20-99
- ◯ 100-199
- ◯ 200 and above

* 5. How long has the organisation been operational

- ◯ Less than 5 years
- ◯ 5-10 years
- ◯ 11-15 years
- ◯ 16-20 years
- ◯ More than 20 years

* 6. What was the Turnover of the organisation in 2017?

- ◯ Under $50,000
- ◯ Between $50,000 and $200,000
- ◯ Between $200,000 and $2 million
- ◯ More than $2 million

* 7. Which of these industries do you primarily service? (select all that apply)

- ☐ Agricultural Machinery and Equipment Manufacturing
- ☐ Aircraft Manufacturing and Repair Services
- ☐ Automotive Electrical Component Manufacturing
- ☐ Boat Building and Repair Services
- ☐ Boiler, Tank and other Heavy Gauge Metal Container Manufacturing
- ☐ Communication Equipment Manufacturing
- ☐ Electrical Cable and Wire Manufacturing
- ☐ Fixed Space Heating, Cooling and Ventilation Equipment Manufacturing
- ☐ Iron and Steel Forging
- ☐ Lifting and Material Handling Equipment Manufacturing
- ☐ Machine Tool and Parts Manufacturing
- ☐ Mining and Construction Machinery Manufacturing
- ☐ Motor Vehicle Body and Trailer Manufacturing
- ☐ Motor Vehicle Manufacturing
- ☐ Prefabricated Metal Building Manufacturing
- ☐ Pump and Compressor Manufacturing
- ☐ Sheet Metal Products Manufacturing (except Metal Structural and Container Products)
- ☐ Ship building and Repair Services
- ☐ Structural Steel Fabrication
- ☐ White ware Appliance Manufacturing
- ☐ Other (please list if the primary industry being served is not listed)

* 8. 8. Which of the following statements best describes your organisations' products? Please select one response

- ◯ Each order is for a different product, made to the specific requirements of the customer
- ◯ All (or the majority of) products are bespoke but a few are made on a repeat basis
- ◯ We have some bespoke products and some standard products
- ◯ Most products are standard; there is little difference between customer requirements
- ◯ All products are standard; orders are fulfilled from inventory

* 9. Based on your organisations' current status, what is **the scope of responsibility** the organisation takes when realising a customer order? (Select all that apply)

- ☐ We are responsible for designing the product (includes basic idea for the product and rough set of drawings)
- ☐ We are responsible for setting the specifications (this includes detailed "shop" drawings for manufacture and all technical requirements including material specifications)
- ☐ We are responsible for purchasing the required materials for production

* 10. Which of these activities do you typically undertake**after you have received a customers' order?** (Select all that apply)

- ☐ Delivery
- ☐ Assembly
- ☐ Processing
- ☐ Purchasing
- ☐ Routing *(This refers to shop-floor work routing)*
- ☐ Specification *(This refers to a detailed set of production drawings that list both technical requirements and which materials to use)*
- ☐ Design *(This refers to the basic idea of the product including a rough set of drawings)*

* 11. How important are the following competitive priorities to your organisation? Please rank the strategic importance of each from 1 (not important) to 5 (very important)

	Not Important	Slightly Important	Moderately Important	Important	Very Important
Cost	○	○	○	○	○
Delivery (speed)	○	○	○	○	○
Dependability	○	○	○	○	○
Flexibility	○	○	○	○	○
Customisation	○	○	○	○	○
Service	○	○	○	○	○
Innovation	○	○	○	○	○
Sustainability	○	○	○	○	○
Social Responsibility	○	○	○	○	○

A Survey on Better Management Practices and High-Variety, Low-Volume Manufacturing Excellence – Towards Competitive Customisation

Section B - Adoption of Management Practices

This section seeks to understand the extent you adopt each of these day-to-day management practices. Remember, there are no right or wrong answers here, we are only interested in your attitude towards each management practice.

You can close the window and return to the survey at any time - just make sure you click "Next" at the bottom of every page to save your responses.

* 12. Do you agree with the following statement concerning**quality management** activities?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	N/A
We use statistical techniques (for example, SPC) to improve our processes and reduce variation	○	○	○	○	○	○
We adopt 5S principles (sort, straighten, shine, standardise and sustain)	○	○	○	○	○	○
All employees have access to quality-related and productivity performance information	○	○	○	○	○	○
We employ a formal continuous improvement program	○	○	○	○	○	○
We undertake quality control	○	○	○	○	○	○

* 13. Do you agree with the following statement concerning**maintenance** activities?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	N/A
We dedicate a portion of every day solely to maintenance	○	○	○	○	○	○
We apply a host of maintenance optimisation techniques with the use of statistics and/or Reliability Centred Maintenance	○	○	○	○	○	○
We stay on the leading edge of technology in our industry	○	○	○	○	○	○
We actively develop proprietary equipment	○	○	○	○	○	○

Section B - Adoption of Better Management Practices

* 14. Do you agree with the following statement concerning **human resource management** activities?

	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree	N/A
Senior managers are evaluated and held accountable for the strength of the talent pool they actively build	◯	◯	◯	◯	◯	◯
We adopt an appropriate performance-based rewards and accountability system linked to organisational targets	◯	◯	◯	◯	◯	◯
We adopt different strategies (remove, reallocate and/or develop employees) to manage our under-performers	◯	◯	◯	◯	◯	◯
We actively identify, develop and promote our top performers	◯	◯	◯	◯	◯	◯
We provide a unique value proposition above our competitors to encourage talented people to join our company	◯	◯	◯	◯	◯	◯
We do whatever it takes to retain our talent	◯	◯	◯	◯	◯	◯

* 15. Do you agree with the following statement concerning**change management** activities?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	N/A
We adopt online, rapid and up-to-date communication across all stakeholders involved in engineering changes	○	○	○	○	○	○
We leverage partnerships with suppliers and customers in order to make effective resource allocation decisions (including staffing, capacity planning and the like) during engineering change	○	○	○	○	○	○
We leverage partnerships with suppliers and customers in order to detect any disruptions arising in the future	○	○	○	○	○	○
We see change as an important learning opportunity	○	○	○	○	○	○
We use various engineering design techniques to reduce the number of emergent changes in product design (these can involve combinations of Quality Function Deployment, Failure Mode and Effect Analysis and others).	○	○	○	○	○	○

Section B - Adoption of Better Management Practices

* 16. Do you agree with the following statement concerning **sales and estimation** activities?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	N/A
We keep track of and monitor all quotations (both won and lost) in an easy access database	○	○	○	○	○	○
We have a keen understanding of our competitors and employ a systematic quotation control system in order to help guide cost and lead time estimations for customer enquiries (for example, a strike-rate matrix)	○	○	○	○	○	○
We understand our customers' objectives	○	○	○	○	○	○
There is a high degree of coordination between all departments to ensure we set realistic due-dates for customer enquiries	○	○	○	○	○	○
Capacity and resource availability information is readily available to both manufacturing and sales departments when responding to customer enquiries	○	○	○	○	○	○
There is a high degree of coordination between our organisation and our suppliers when we respond to customer enquiries	○	○	○	○	○	○

* 17. Do you agree with the following statement concerning **new product and process design** activities?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	N/A
We use design for manufacturing and assembly methods	○	○	○	○	○	○
We use Computer Aided Manufacturing (CAM)	○	○	○	○	○	○
We have created new ways to coordinate design and manufacturing issues	○	○	○	○	○	○
Product designers and manufacturing staff have equal status in NPD projects	○	○	○	○	○	○
We practice job rotation between design and manufacturing engineering	○	○	○	○	○	○
Manufacturing sign-off is required for jobs that require design work	○	○	○	○	○	○
Our product designers make use of manufacturability guideline/checklists	○	○	○	○	○	○
We develop dedicated technologies for specific product families/customer segments	○	○	○	○	○	○

A Survey on Better Management Practices and High-Variety, Low-Volume Manufacturing Excellence – Towards Competitive Customisation

Section B - Adoption of Better Management Practices

* 18. Do you agree with the following statement concerning **production planning and control** activities?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	N/A
We implement a systematic method of workload control	◯	◯	◯	◯	◯	◯
We employ a pre-shop floor pooling and release system to improve flow in manufacturing operations	◯	◯	◯	◯	◯	◯
We have a systematic method of bottleneck detection and reduction	◯	◯	◯	◯	◯	◯
Job priorities are clearly understood by everyone on the shop floor	◯	◯	◯	◯	◯	◯
We rigorously pursue quick change over and set-up times for our machines and strive to improve them	◯	◯	◯	◯	◯	◯
We structure our manufacturing practices and shop-floor layout based on the identification of common product families	◯	◯	◯	◯	◯	◯

* 19. Do you agree with the following statement concerning**procurement** activities?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	N/A
We have a fast and easy to use ordering system	◯	◯	◯	◯	◯	◯
We employ an inventory management system	◯	◯	◯	◯	◯	◯
The people ordering items from suppliers have extensive manufacturing/design experience	◯	◯	◯	◯	◯	◯
We share sensitive information (for example, production plans, capacity and cost) with our major suppliers	◯	◯	◯	◯	◯	◯
We maintain strong relationships with a small number of high quality suppliers	◯	◯	◯	◯	◯	◯

Section C - Ambidextrous Capabilities

This section focuses on your organisations ability to innovate and improve operational efficiency at the same time. Please answer this question to the best of your knowledge.

* 20. Based on your organizations' orientation during the past 3 years, how much do you agree with the following statement?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
We look for novel technological ideas by thinking outside the box	◯	◯	◯	◯	◯
We base our success on our ability to explore new technologies	◯	◯	◯	◯	◯
We create products and/or services that are innovative to the firm	◯	◯	◯	◯	◯
We look for creative ways to satisfy our customer needs	◯	◯	◯	◯	◯
We aggressively venture into new market segments	◯	◯	◯	◯	◯
We actively target new customer groups	◯	◯	◯	◯	◯
We commit to improving quality and lowering costs	◯	◯	◯	◯	◯
We strive to continuously improve the reliability of our products and/or services	◯	◯	◯	◯	◯
We place focus on increasing the level of automation in our operations	◯	◯	◯	◯	◯
We constantly survey the customer satisfaction levels of our existing customer base	◯	◯	◯	◯	◯
We fine-tune what we offer to keep our current customer satisfied	◯	◯	◯	◯	◯
We place focus on penetrating more deeply into our existing customer base	◯	◯	◯	◯	◯

A Survey on Better Management Practices and High-Variety, Low-Volume Manufacturing Excellence – Towards Competitive Customisation

Section D - Organisational Performance

This is the final section of the survey! Here, we are seeking to understand your organisational performance (relative to your main competitor) on operational performance, market-related performance and innovation performance. Please answer this question to the best of your knowledge.

* 21. Please assess *your* firms **process flexibility performance** against your main competitor(s)

	Much Worse	Somewhat Worse	About the same	Somewhat Better	Much Better
Ability to customise products	○	○	○	○	○
Ability to adjust production volumes	○	○	○	○	○
Ability to respond to changes in delivery requirements	○	○	○	○	○
Ability to produce a range of products	○	○	○	○	○

* 22. Please assess *your* firms **cost efficiency performance** against your main competitor(s)

	Much Worse	Somewhat Worse	About the same	Somewhat Better	Much Better
Unit cost	○	○	○	○	○
Total manufacturing overhead cost	○	○	○	○	○
Productivity	○	○	○	○	○

* 23. Please assess *your* firms **market performance** against your main competitor(s)

	Much Worse	Somewhat Worse	About the same	Somewhat Better	Much Better
Profitability	○	○	○	○	○
Market share of major product/product line	○	○	○	○	○
Unit growth rate in sales	○	○	○	○	○

* 24. Please assess *your* firms **product innovation performance** against your main competitor(s)

	Much Worse	Somewhat Worse	About the same	Somewhat Better	Much Better
The level of newness (novelty) of new products	◯	◯	◯	◯	◯
The use of the latest technological innovation in new product development	◯	◯	◯	◯	◯
The speed of new product development	◯	◯	◯	◯	◯
The number of new products introduced to the market	◯	◯	◯	◯	◯
The number of new products that is first-to-market (early market entrants)	◯	◯	◯	◯	◯

* 25. Please assess *your* firms **process innovation performance** against your main competitor(s)

	Much Worse	Somewhat Worse	About the same	Somewhat Better	Much Better
The technological competitiveness	◯	◯	◯	◯	◯
The updated-ness or novelty of technology used in processes	◯	◯	◯	◯	◯
The speed of adoption of the latest technological innovations in processes	◯	◯	◯	◯	◯
The rate of change in processes, techniques and technology	◯	◯	◯	◯	◯

Finished!

The questionnaire finishes here. Thank you for your time and your valuable contribution to our research. If you would like to clarify any of your responses in this survey please do so in the comment box below.

Please provide your contact details on the following page if you would like to receive an executive summary outlining the results of this research as well as receive a a promo code for a $250 discounted entry to the ACIS conferences held at UTS. We also plan to follow-up this survey by studying individual cases – if you are interested in participating in the second stage of this research, please indicate so below.

26. Comments

* 27. Do you wish to receive an executive summary of the results, promo-code for the ACIS conference discounted entry and/or participate in the second stage of this research project?

☐ Yes ☐ No

Appendix 4. Ethics Approval Letters

Ethics Approval Letter for Initial Questionnaire

Mile Katic

From:	research.ethics@uts.edu.au
Sent:	Monday, 11 June 2018 4:42 PM
To:	Mile Katic; Dilek Cetindamar Kozanoglu
Cc:	Camila Cremonese; Sofia Haidar
Subject:	Your ethics application has been approved as low risk - ETH18-2426

Dear Applicant

Your local research office has reviewed your application titled, "Managing the contradictions between customisation and flexibility in high-variety, low-volume manufacturing", and agreed that the application meets the requirements of the National Statement on Ethical Conduct in Human Research (2007). I am pleased to inform you that ethics approval has now been granted.

Your approval number is UTS HREC REF NO. ETH18-2426.
You should consider this your official letter of approval. If you require a hardcopy please contact your local research office.

Approval will be for a period of five (5) years from the date of this correspondence subject to the provision of annual ethics reports to your local research office.

Your approval number must be included in all participant material and advertisements. Any advertisements on the UTS Staff Connect without an approval number will be removed.

Please note that the ethical conduct of research is an on-going process. The National Statement on Ethical Conduct in Human Research (2007) requires us to obtain reports about the progress of the research, and in particular about any changes to the research which may have ethical implications. You will be contacted when it is time to complete your first report.

Please refer to the AVCC guidelines relating to the storage of data, which require that data be kept for a minimum of 5 years after publication of research. However, in NSW, longer retention requirements are required for research on human subjects with potential long-term effects, research with long-term environmental effects, or research considered of national or international significance, importance, or controversy. If the data from this research project falls into one of these categories, contact University Records for advice on long-term retention.

To access this application, please follow the URLs below:
* if accessing within the UTS network: https://rm.uts.edu.au
* if accessing outside of UTS network: https://vpn.uts.edu.au , and click on " RM6 – Production " after logging in.

If you have any queries about this approval, or require any amendments to your approval in future, please do not hesitate to contact your local research office or Research.Ethics@uts.edu.au.

REF: 12a

Ethics Approval Letter for Final Questionnaire

Mile Katic

From:	research.ethics@uts.edu.au
Sent:	Sunday, 11 November 2018 4:13 PM
To:	Mile Katic; Dilek Cetindamar Kozanoglu; Research Ethics
Cc:	Adra Anthoney; Elizabeth Ng; Laura McLean; Renee Estrella; Sofia Haidar
Subject:	Your ethics application has been approved as low risk - ETH18-3137

Dear Applicant

UTS HREC REF NO. ETH18-3137

Your local research office has reviewed the amendment application for your project titled, "Managing the contradictions between customisation and flexibility in high-variety, low-volume manufacturing", and agreed that the amendments meet the requirements of the National Statement on Ethical Conduct In Human Research (2007). I am pleased to inform you that your amendment has been approved as follows:

""

This amendment is subject to the standard conditions outlined in your original letter of approval.
You are reminded that this letter constitutes ethics approval only. This research project must also be undertaken in accordance with all UTS policies and guidelines including the Research Management Policy (http://www.gsu.uts.edu.au/policies/research-management-policy.html).

You should consider this your official letter of approval. If you require a hardcopy please contact your local research office.

To access this application, please follow the URLs below:
* if accessing within the UTS network: https://rm.uts.edu.au
* if accessing outside of UTS network: https://vpn.uts.edu.au , and click on " RM6 – Production " after logging in.

If you have any queries about this approval, or require any amendments to your approval in the future, please do not hesitate to contact your local research office or Research.Ethics@uts.edu.au.

REF: REF 12e

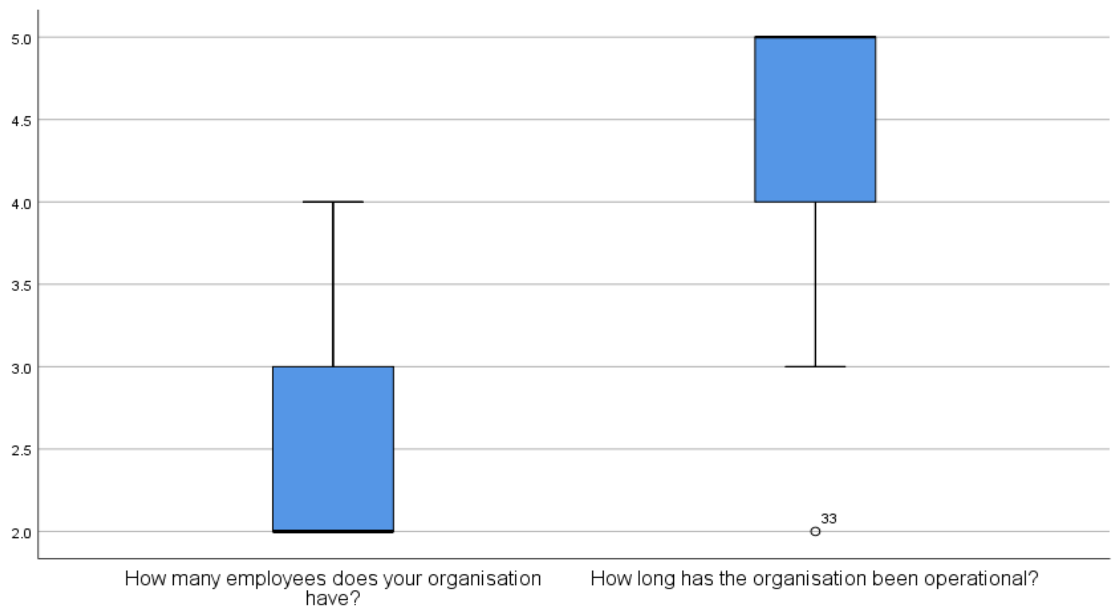
Appendix 5. Missing Data and Data Distribution

Item	Valid	Mean	Std. Deviation	Missing (No.)	Missing (%)	Skewness	Kurtosis
Size	50	2.4600	0.57888	0	0	0.819	-0.283
Age	50	4.5600	0.78662	0	0	-1.647	1.658
Explore1	50	3.7000	0.90914	0	0	-1.052	0.930
Explore2	50	3.1400	1.04998	0	0	-0.621	-0.316
Explore3	50	3.6400	1.02539	0	0	-0.868	0.849
Explore4	50	3.8400	0.91160	0	0	-1.522	2.853
Explore5	50	2.9800	0.99980	0	0	0.041	-0.398
Explore6	50	3.5600	0.90711	0	0	-1.040	1.203
Exploit1	50	4.0800	0.66517	0	0	-0.956	2.628
Exploit2	50	4.1800	0.71969	0	0	-1.654	6.686
Exploit3	50	3.3800	1.00793	0	0	-0.467	-0.265
Exploit4	50	3.0600	0.97750	0	0	-0.124	-0.785
Exploit5	50	3.9200	0.80407	0	0	-1.814	5.669
Exploit6	50	3.7400	0.87622	0	0	-0.593	0.798
PPC1	48	3.6667	0.97486	2	4	-0.421	-0.733
PPC3	45	3.2222	1.16558	5	10	-0.185	-0.913
PPC4	50	3.9600	0.94675	0	0	-0.820	-0.025
Sales1	50	3.9200	0.94415	0	0	-0.593	-0.441
Sales2	48	3.1458	1.09135	2	4	-0.096	-0.660
Sales3	50	4.4600	0.64555	0	0	-0.794	-0.361
Sales4	49	4.0408	1.09847	1	2	-1.263	1.051
Sales5	46	3.8696	1.24023	4	8	-0.984	-0.026
Sales6	49	4.0612	0.98759	1	2	-1.344	2.177
HRM1	47	3.0638	1.05097	3	6	-0.015	-0.487
HRM2	48	3.0833	1.04847	2	4	0.059	-0.784
HRM3	50	3.6400	0.92051	0	0	-0.513	0.269
HRM4	50	3.6600	1.08063	0	0	-0.887	0.444
HRM5	50	3.4600	0.88548	0	0	-0.333	0.185
HRM6	50	3.7800	0.93219	0	0	-0.639	0.445
Perf_Flex1	50	3.9800	0.79514	0	0	-0.217	-0.739
Perf_Flex2	50	3.8200	0.80026	0	0	-0.156	-0.485
Perf_Flex3	50	3.9600	0.83201	0	0	-0.809	1.725

Item	Valid	Mean	Std. Deviation	Missing (No.)	Missing (%)	Skewness	Kurtosis
Perf_Flex4	50	4.0200	0.76904	0	0	-0.035	-1.281
Perf_Innov_Proc1	50	3.4400	0.73290	0	0	0.054	-0.171
Perf_Innov_Proc2	50	3.3000	0.90914	0	0	0.034	-0.043
Perf_Innov_Proc3	50	3.1800	0.84973	0	0	0.056	0.210
Perf_Innov_Proc4	50	3.3400	0.79821	0	0	0.301	-0.187

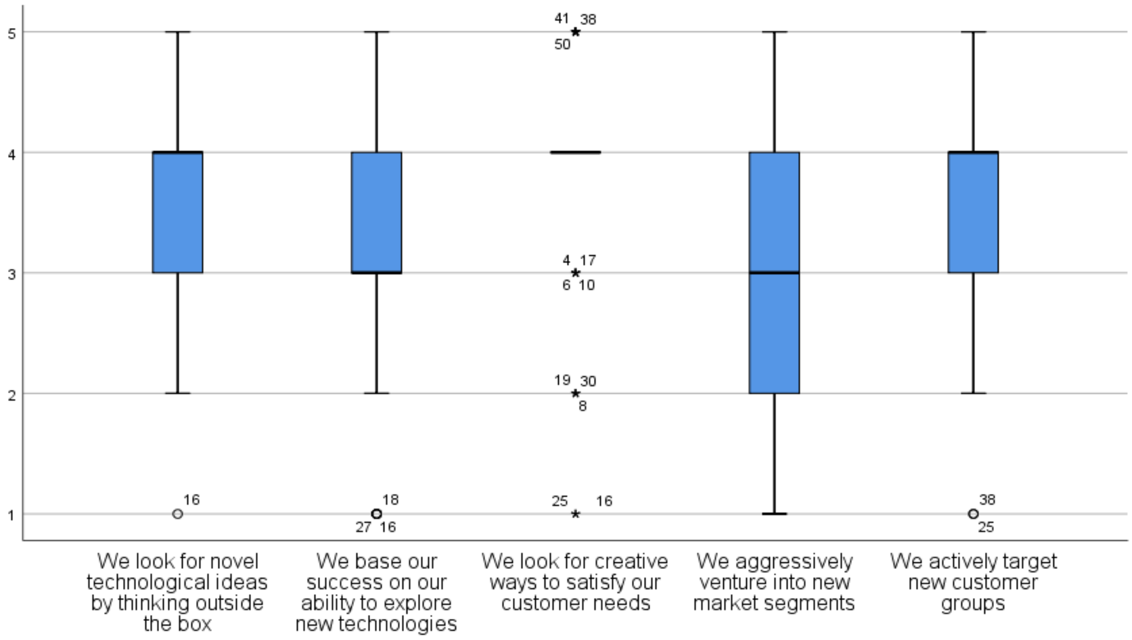
Appendix 6. Outlier Detection using Box Plots

Box Plot for the Control Variables of HVLV Manufacturer Age and Size

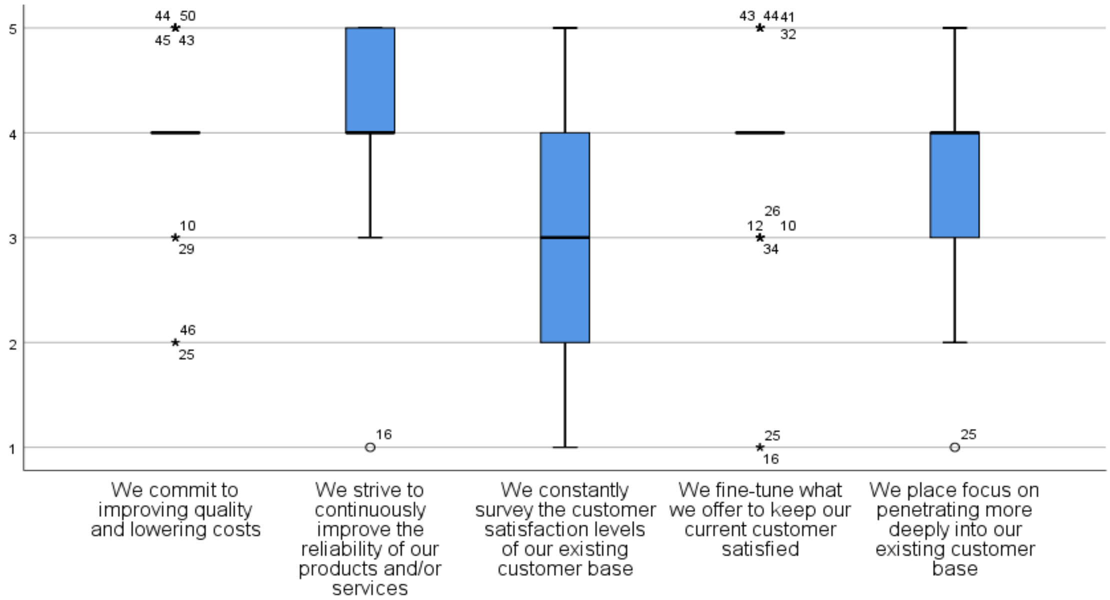


Note: 2, 3 and 4 on the y-axis denote 5-19, 20-99 and 100-199 employees for Age whilst 2,3,4 and 5 on the y-axis denote 5-10, 11-15, 16-20 and > 20 years for Size, respectively.

Box Plot for the Exploration Construct



Box Plot for the Exploitation Construct



Appendix 7. HVLV Manufacturer Profile

		Scope of Responsibility			Activities Undertaken After Receipt of Customer Order						
No.	Custom*	Design	Specifications	Purchasing	Deliver	Assembly	Processing	Purchasing	Routing	Specification	Design
1	1.00			•	•	•	•	•		•	
2	1.00			•	•	•	•	•		•	•
3	1.00			•	•	•	•	•	•		
4	1.00			•	•	•	•	•	•		
5	1.00			•	•	•	•	•	•	•	
6	1.00		•		•	•	•	•		•	
7	1.00		•		•	•	•	•	•	•	
8	1.00		•		•	•	•	•	•	•	
9	1.00		•		•	•	•	•	•	•	
10	1.00		•		•	•	•	•	•	•	•
11	1.00		•		•	•	•	•	•	•	•
12	1.00		•		•	•	•	•	•	•	•
13	1.00		•	•	•	•	•	•		•	
14	1.00		•	•	•	•	•	•		•	
15	1.00		•	•	•	•	•	•	•	•	
16	1.00		•	•	•	•	•	•	•	•	
17	1.00	•			•	•	•	•			•
18	1.00	•	•	•	•	•	•	•	•	•	•
19	1.00	•	•	•	•	•	•	•	•	•	•
20	2.00			•			•				
21	2.00			•		•	•	•		•	•
22	2.00			•		•	•	•	•	•	
23	2.00			•	•	•	•	•			
24	2.00			•	•	•	•	•	•		•
25	2.00			•	•	•	•	•	•	•	•

		Scope of Responsibility			Activities Undertaken After Receipt of Customer Order						
No.	Custom*	Design	Specifications	Purchasing	Deliver	Assembly	Processing	Purchasing	Routing	Specification	Design
26	2.00			•	•	•	•	•	•	•	•
27	2.00		•		•	•		•	•	•	
28	2.00		•		•	•	•	•	•	•	•
29	2.00		•	•					•	•	
30	2.00		•	•	•	•	•	•	•	•	
31	2.00	•		•	•	•		•			•
32	2.00	•	•		•	•	•	•	•		•
33	2.00	•	•	•						•	•
34	2.00	•	•	•		•	•	•	•	•	•
35	2.00	•	•	•	•	•	•	•	•	•	•
36	2.00	•	•	•	•	•	•	•	•	•	•
37	2.00	•	•	•	•	•	•	•	•	•	•
38	3.00			•						•	•
39	3.00			•			•	•	•		
40	3.00		•		•		•	•	•	•	•
41	3.00		•		•	•	•	•	•	•	
42	3.00		•		•	•	•	•	•	•	•
43	3.00		•	•			•				
44	3.00	•	•	•		•	•	•		•	•
45	3.00	•	•	•	•	•	•		•		•
46	3.00	•	•	•	•	•	•	•	•	•	•
47	3.00	•	•	•	•	•	•	•	•	•	•
48	3.00	•	•	•	•	•	•	•	•	•	•
49	4.00		•				•	•	•	•	•
50	4.00		•	•	•	•	•	•	•	•	•

*The levels of customisation are described in section 5.2.3. Higher values denote those manufacturers offering less customisation.

Appendix 8. Heterotrait-Monotrait (HTMT) Test Results

	Age	Coordination	HRM	Quotation Management	Size	Workload Control	Exploitation	Exploration	Operational Flexibility	Process Innovation
Age										
Coordination	0.128									
HRM	0.106	0.516								
Quotation Management	0.279	0.872	0.595							
Size	0.05	0.116	0.245	0.172						
Workload Control	0.176	0.644	0.582	0.941	0.107					
Exploitation	0.137	0.688	0.808	0.738	0.104	0.638				
Exploration	0.179	0.614	0.65	0.498	0.248	0.447	0.82			
Operational Flexibility	0.162	0.564	0.384	0.679	0.304	0.447	0.452	0.546		
Process Innovation	0.105	0.294	0.649	0.471	0.016	0.314	0.414	0.471	0.383	

Appendix 9. PLS SEM Results Summary (Direct Relationships)

PLS SEM Results Summary (With Control Variables)

									Confidence Interval	
Hyp.	Relationship	Std Beta	Std Error	T value	P value	Outcome	f2	q2	2.5%	97.5%
H1a	Ambidexterity → Operational Flexibility	0.188	0.179	1.054	0.292	Supported	0.026	-0.024	-0.201	0.486
H1b	Ambidexterity → Process Innovation	0.12	0.181	0.661	0.509	Supported	0.009	-0.002	-0.253	0.461
H2a	Ambidexterity → Human Resource Management	0.653	0.138	4.698	0.000	Supported	0.714	0.532	0.312	0.833
H2b	Human Resource Management → Operational Flexibility	-0.055	0.144	0.379	0.705	Not Supp.	0.003	-0.019	-0.345	0.222
H2c	Human Resource Management → Process Innovation	0.484	0.154	3.14	0.002	Supported	0.199	0.133	0.185	0.796
H3a	Ambidexterity → Production Planning and Control	0.646	0.138	4.698	0.000	Supported	0.722	0.562	0.307	0.842
H3b	Production Planning and Control → Operational Flexibility	0.492	0.151	3.257	0.001	Supported	0.225	0.180	0.218	0.810
H3c	Production Planning and Control → Process Innovation	0.012	0.189	0.063	0.950	Not Supp.	0.000	-0.030	-0.381	0.341

							Confidence Interval	
Relationship	Std Beta	Std Error	T value	P value	Outcome	f2	q2	2.5%	97.5%
Age -> HRM	0.101	0.115	0.879	0.380	Not Sign.	0.017	-0.016	-0.131	0.330
Age -> PPC	0.261	0.146	1.791	0.073	Not Sign.	0.119	0.030	-0.050	0.524
Age -> Operational Flexibility	-0.037	0.111	0.336	0.737	Not Sign.	0.002	-0.011	-0.264	0.178
Age -> Process Innovation	0.076	0.122	0.623	0.533	Not Sign.	0.007	-0.037	-0.173	0.313
Size -> HRM	0.005	0.128	0.038	0.970	Not Sign.	0.000	-0.079	-0.252	0.260
Size -> PPC	-0.130	0.105	1.238	0.216	Not Sign.	0.030	-0.010	0.325	0.080
Size -> Operational Flexibility	0.263	0.105	2.542	0.011	Significant	0.116	0.050	0.073	0.479
Size -> Process Innovation	-0.034	0.125	0.275	0.784	Not Sign.	0.002	-0.049	-0.250	0.246

PLS SEM Results Summary (Without Control Variables)

Hyp.	Relationship	Std Beta	Std Error	T value	P value	Outcome	f2	q2	Confidence Interval 2.5%	97.5%
H1a	Ambidexterity → Operational Flexibility	0.249	0.169	1.469	0.142	Supported	0.046	-0.007	-0.092	0.559
H1b	Ambidexterity → Process Innovation	0.082	0.184	0.446	0.656	Supported	0.005	-0.004	-0.295	0.413
H2a	Ambidexterity → Human Resource Management	0.640	0.122	5.228	0.000	Supported	0.693	0.560	0.307	0.798
H2b	Human Resource Management → Operational Flexibility	-0.044	0.157	0.279	0.780	Not Supp.	0.002	-0.021	-0.356	0.243
H2c	Human Resource Management → Process Innovation	0.489	0.150	3.254	0.001	Supported	0.203	0.130	0.213	0.793
H3a	Ambidexterity → Production Planning and Control	0.599	0.135	4.441	0.000	Supported	0.559	0.466	0.256	0.807
H3b	Production Planning and Control → Operational Flexibility	0.428	0.145	2.947	0.003	Supported	0.173	0.128	0.134	0.702
H3c	Production Planning and Control → Process Innovation	0.046	0.172	0.269	0.788	Not Supp.	0.002	-0.038	-0.318	0.372

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