

Navigating Complexities:
A Grounded Theory of Competitive
Manufacturing Capabilities Development for
High Value Manufacturing SMEs

Obiajulu Ngadaonye Egbunike

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

Centre for Advanced Manufacturing Systems at Cardiff
Cardiff Business School, Cardiff University

October 2019

Abstract

The overall aims of this study are twofold: the first is to develop a new and practical theory which explains some of the dynamics that stimulate the development of competitive manufacturing capabilities in High Value Manufacturing (HVM) SMEs in Wales. This task was accomplished through an exploratory study that increased our understanding of the concept of competitive manufacturing capabilities. Secondly, our aim was to pursue this task using the Grounded Theory Methodology (GTM), a rarely used methodology in Operations Management research. Based on this methodology, the research involved a combination of methods administered to an initial sample of 13 organisations; 11 HVM SMEs and 2 academic support institutes, followed by a more detailed case study of a selection of 4 SMEs, out of the initial population of 13. Findings from the study included the core capability, Navigating Complexities, of which Balancing Complexities, Smart/Informed Prospecting, Sensing and Organisational Resonance were shown to be key dynamics. Other major findings include 4 closely related categories; Cross Functional Intellectual Benchmarking, Socioeconomic Complexities, Technological Complexities and Situational Knowledge Stretching, each with their own sub - dynamics. While these findings do not claim to provide the only solution available for improving competitive manufacturing capabilities, the framework presented in this thesis will help HVM SMEs better understand some of the actions they need to take to ensure they embed proven methods for enhancing their competitiveness. It will also help other interested stakeholders within the wider innovation ecosystem better understand their roles and responsibilities in supporting these SMEs to success.

Acknowledgements

My utmost and most sincere gratitude is to my supervisors, Professor Mohamed Naim and Dr Laura Purvis. Over the last 12 years, their motivation, insights, guidance and seemingly endless supply of patience has been invaluable to my academic pursuits as well as my career. I have been privileged to have such a committed team of supervisors who never failed to demonstrate their enthusiasm for the progress of this research. I could not have imagined having better supervisors as without their support and encouragement, I would not have completed this research.

Further thanks are due to members of the Logistics and Operations Management (LOM) team at Cardiff Business School as well as the ASTUTE project team (2010 – 2015), who not only made Cardiff Business School a vibrant and exciting place to work, but a place where all members of staff were happy to support each other in the pursuit of their goals. In this regard, a further thanks goes to Andrew Hopkins, Andrew Potter, Andy Davies, Daniel Eyers, Claire Biggs, Jacqueline Marsh, Rebecca Travers and Jon Gosling who all at one point, contributed something, or provided some advice towards this PhD. You guys made CARBS the place to be and a memorable part of my life.

A debt of gratitude is also due to the many company managers who gave up their time, sometimes on very short notice, to be involved in this study. Without their kind assistance, this research would not be possible.

Dedication

This work is dedicated firstly, to my parents - Professor & Mrs G.N Egbunike, who have steadfastly believed that I can achieve whatever I set out to do. They made great sacrifices to get me started on the road of lifelong learning and never waned in their support, even when it seemed like I was 'falling by the wayside'.

Secondly, to my siblings, Ike and Isioma, who egged me on with questions such as, "haven't you finished that thing yet?", and "this is taking forever...when on earth will you be done...?". It is done now!

Lastly, and most importantly, to my wife Nkem and our three children, Zoe, Kamsi and Kaima. Your unfailing support all these years have been invaluable. Indeed, you have all been my pillars of strength and my biggest sources of inspiration.

Contents

List of Figures	ix
List of Tables	x
Table of Abbreviations	xi
Chapter 1: Introduction	1
1.1 Chapter Overview.....	1
1.2 Background of Research.....	2
1.2.1 Context of Research.....	5
1.2.2 Policy Intervention.....	8
1.3 Research questions.....	10
1.4 Personal Motivation.....	12
1.5 Structure of the Thesis.....	15
1.6 Chapter Summary.....	18
Chapter 2: Minor Literature Review	20
2.1 Introduction.....	20
2.2 Background: Manufacturing Capabilities.....	21
2.3 Review methodology and classification.....	23
2.4 Article Classification Results.....	29
2.4.1 Research Paradigms.....	29
2.4.2 Dominant Research Design.....	33
2.4.3 Research Methods.....	35
2.4.4 Content Analysis of Research into the Management of Manufacturing Capabilities.....	36
2.4.4.1 Technology Focus.....	36
2.4.4.2 People / Attitudes Focus.....	36
2.4.4.3 Process / Organisation focus.....	38
2.5 Discussion.....	42
2.6 Chapter Reflections.....	43
Chapter 3: Research Design and Methodological Considerations	46
3.1 Introduction.....	46
3.2 The Researcher as a multicultural subject.....	48
3.3 Reflexivity in Management Research: Personal Considerations.....	50
3.4 Research Philosophy.....	53
3.4.1 Fundamentals of the Positivist Approach.....	57
3.4.2 Fundamentals of the Interpretivist Approach.....	58
3.4.3 Fundamentals of the Pragmatist Approach.....	59

3.4.4	Fundamentals of the Realist Approach.....	60
3.4.4.1	Choice of the Critical Realist research approach and its justification	61
3.4.5	Behind the veil: The ‘concreteness’ of the OM field and its philosophical perspectives.....	61
3.5	Deductive and Inductive Approaches to Research.....	63
3.6	Research Strategy.....	65
3.6.1	Adoption of a Qualitative approach.....	65
3.6.2	Action Research.....	67
3.6.3	Ethnography.....	68
3.6.4	Case Studies.....	69
3.6.5	Grounded Theory.....	70
3.6.5.1	History and Origins of GTM.....	72
3.6.5.2	Choice of GTM Approach.....	74
3.6.5.3	GTM Process.....	75
3.7	Data Collection Tools - Qualitative Interviews.....	81
3.7.1	Unstructured Interviews.....	82
3.7.2	Semi-Structured Interviews.....	85
3.8	Ethical Issues and Considerations.....	87
3.8.1	Informed Consent.....	87
3.8.2	Anonymity and Confidentiality.....	88
3.8.3	Other ethical considerations.....	89
3.9	Chapter Summary.....	90
Chapter 4:	Data Collection and Analysis – Phase 1	92
4.1	Introduction.....	92
4.2	Theoretical Sampling: Site Selection and Access	93
4.3	The Case Study Units of Analysis.....	96
4.3.1	Company A	96
4.3.2	Company B	98
4.3.3	Company C	99
4.3.4	Company D	101
4.3.5	Company E	103
4.3.6	Company F	105
4.3.7	Company G	107
4.3.8	Company H.....	109
4.3.9	Company I	112
4.3.10	Company J.....	114

4.3.11	Company K.....	116
4.3.12	Company L	117
4.3.13	Summary of findings.....	118
4.4	Preliminary Interviews and Data Analysis: Phase 1.....	118
4.4.1	Coding.....	121
4.4.2	Block Groupings.....	121
4.4.3	Initial Data Clustering: First Pass.....	127
4.5	Open Coding.....	130
4.5.1	Coding Activity.....	131
4.5.2	Core Categories.....	135
4.6	Chapter Summary.....	141
Chapter 5: Data Collection and Analysis – Phase 2.....		143
5.1	Introduction.....	143
5.2	Construction of Thematic Categories.....	144
5.2.1	Introducing “Navigating complexities”.....	145
5.2.2	Introducing “Proprietary process and technology development”	160
5.2.3	Introducing “Cross functional intellectual benchmarking”.....	170
5.2.4	Introducing “Knowledge formation”.....	178
5.3	Discussion.....	187
5.4	Chapter Summary.....	189
Chapter 6: Major Literature Review.....		191
6.1	Introduction.....	191
6.2	Recap: Journey of an HVM entrepreneur.....	193
6.3	Complexity: Introduction and Definitions.....	197
6.4	Understanding Complexity: Theories and Frameworks.....	206
6.4.1	Social Complexity.....	207
6.4.2	Technological Complexity.....	209
6.5	Resource Based View of Firms.....	210
6.6	Dynamic Capabilities.....	213
6.6.1	Routines and Capabilities.....	219
6.6.2	Models of Dynamic Capabilities.....	220
6.7	Chapter Summary.....	221
Chapter 7: Theoretical Framework Development.....		223
7.1	Introduction.....	223
7.2	The Grounded Theory: Emerging Issues in Competitive Manufacturing Capabilities Development.....	224

7.2.1	The Framework.....	228
7.2.1.1	Develop, Improve & Sustain Competitive Manufacturing Capabilities.	229
7.2.1.2	Navigating Complexities.....	230
7.2.1.3	Cross Functional Intellectual Benchmarking.....	232
7.2.1.4	Situational Knowledge Extension.....	233
7.3	Theory Linkages.....	233
7.3.1	The Moderating Factors.....	233
7.3.2	Advanced Manufacturing Technologies (AMT).....	235
7.3.3	Collaborative R&D Partnerships.....	238
7.3.4	Navigating Complexities.....	243
7.3.4.1	Balancing Complexities	246
7.3.4.2	Smart/informed prospecting.....	247
7.3.4.3	Sensing.....	248
7.3.4.4	Organisational Resonance.....	249
7.3.5	Situational Knowledge Stretching.....	250
7.3.5.1	Knowledge Sorting and Coding.....	253
7.3.5.2	Evidential Knowledge Mapping.....	254
7.3.5.3	Creativity.....	256
7.3.6	Cross Functional Intellectual Benchmarking.....	257
7.3.6.1	Advanced/Specialist Education.....	261
7.3.6.2	Mentorship and Coaching.....	264
7.3.6.3	Cross Functional Co-ordination.....	265
7.3.7	Proprietary Process & Technology Development.....	266
7.3.7.1	Advanced Technology [Management] Platforms.....	267
7.4	Chapter Summary.....	270
Chapter 8: Conclusions and Recommendations.....		272
8.1	Introduction.....	272
8.2	Grounded Theory Conclusions.....	272
8.3	Integrating the grounded theory into the literature.....	277
8.4	The substantive theory and its theoretical contribution.....	280
8.5	Methodological contribution.....	284
8.6	Evaluating the Grounded Theory.....	285
8.7	Implications of study.....	287
8.7.1	Implications for Practitioners.....	287
8.7.2	Implications for Research and Academia.....	289
8.8	Limitations of Study.....	290

8.9	Recommendations and Future Directions.....	291
References		296
Appendices		330

List of Figures

Figure 1.1: Thesis Structure.....	16
Figure 2.1: Selection Process for 104 reviewed papers.....	27
Figure 2.2: Flow-chart of procedures for qualitative content analysis.....	37
Figure 2.3: Content analysis results and emerging themes from manufacturing capabilities research.....	41
Figure 3.1: Research framework.....	47
Figure 3.2: Model of Study Process – Factors affecting outcomes.....	50
Figure 3.3: Subjective - Objective debate within Social Science.....	56
Figure 3.4: Overview of the adopted Grounded Theory process.....	79
Figure 3.5: Research position and coding progression.....	81
Figure 3.6: Interview strategies - breakdown of interview approach.....	84
Figure 4.1: Research position & coding process of the Grounded Theory Method.....	93
Figure 4.2: Constant Comparison method of data analysis.....	
Figure 4.3: Example of conceptualised model of communications.....	125
Figure 4.4: Conceptualised framework from Block Coding stage.....	129
Figure 4.5: Coding structure tree for Core Category Development.....	139
Figure 5.1: Research position & coding process of the Grounded Theory Method.....	144
Figure 5.2: Initial conceptualisation of Negotiating Complexities core category.....	159
Figure 5.3: Coding tree and theme changes based on case study findings.....	186
Figure 5.4: Initial Conceptualisation of relationship between HVM, collaborators and market opportunities.....	188
Figure 6.1: The Full House of Project Complexity.....	205
Figure 6.2: Conceptual Framework for Manufacturing Complexity.....	207
Figure 6.3: Research model of Dynamic Capabilities.....	218
Figure 6.4: Model of Dynamic Capabilities.....	219
Figure 7.1: Current Stage of Research Project.....	224
Figure 7.2: The end-to-end research framework including the Grounded Theory of Navigating Complexities.....	225
Figure 7.3: Model of Emergent theory of Navigating Complexities.....	227
Figure 8.1: Emergent theory of Navigating Complexities.....	273

List of Tables

Table 2.1: Literature reviews vs systematic reviews.....	25
Table 2.2: Year of publication	28
Table 2.3: Most cited journals.....	29
Table 2.4: Research paradigm classification framework.....	30
Table 2.5: Research perspectives.....	31
Table 2.6: Dominant Research Paradigms in Manufacturing Capabilities Research.....	32
Table 2.7: Research design in manufacturing capability research	33
Table 2.8: Research Methods in Manufacturing Capability Research.....	35
Table 3.1: Reflexivity Considerations.....	52
Table 3.2: Comparison of the two schools of Grounded Theory.....	75
Table 4.1: High level block codes combination from all 13 companies.....	128
Table 4.2: Examples of initial open codes generated from transcript (line by line coding).....	132
Table 4.3: Examples of initial open codes generated from transcript (line by line coding).....	134
Table 4.4: Codes generated from Company A's interview script (line by line coding)	136
Table 4.5: Summary of Coding, Analysis and Interpretation processes.....	140
Table 5.1: Navigating Complexities.....	147
Table 5.2: Fitbit example: Navigating Complexities.....	154
Table 5.3: Navigating complexities low level categories.....	159
Table 5.4: Proprietary Process and Technology Development.....	162
Table 5.5: Proprietary process and technology development low level categories.....	170
Table 5.6: Benchmarking.....	171
Table 5.7: Benchmarking low level categories.....	178
Table 5.8: Knowledge Formation	179
Table 5.9: Knowledge formation low level categories.....	185
Table 6.1: Main definitions of Dynamic Capabilities.....	215
Table 8.1: Summary of core categories, explanations and building blocks.....	275
Table 8.2: Tabular representation of Whetten's (1989) framework.....	278
Table 8.3: Table of research propositions.....	292

Table of abbreviations

Abbreviation	Description
AMT	Advanced Manufacturing Technology
ASTUTE	Advanced Sustainable Manufacturing Technologies Project
EurOMA	European Operations Management Association
GT	Grounded Theory
GTM	Grounded Theory Methodology
HRM	Human Resource Management
HVM	High Value Manufacturing
IQ	Intelligence Quotient
MedTech	Medical Technology
NHS	National Health Service
NPD	New Product Development
OECD	Organisation for Economic Co-operation and Development
OM	Operations Management
PPTD	Proprietary Process and Technology Development
RBV	Resource Based View
SME	Small and Medium Enterprises
UK	United Kingdom
VRIN	Valuable, Rare, Inimitable and Non-substitutable

Chapter 1: Introduction

1.1 Chapter Overview

This chapter introduces an overview of the purpose, context and motivation for this research. The aims which are twofold, are also introduced. Firstly, the aim is to develop a new and practical theory that increases our understanding of competitive manufacturing capabilities in High Value Manufacturing (HVM) small and medium enterprises (SMEs) as well as explain some of the dynamics that stimulate their development and evolution. This study was conceptualised due to a noticeable absence of basic frameworks to support the practical development of competitive capabilities in HVM enterprises. Having worked with these HVM enterprises for a few years, the need to develop such a useful framework was required. This task was therefore accomplished through an exploratory grounded theory study that increased the practical understanding of the concept of competitive manufacturing capabilities. In addition, the second aim was to establish a methodological contribution, once again, through the use of the Grounded Theory methodology (GTM), a rarely used methodology in operations management research. The use of this methodology is in response to the calls from various scholars, who have emphasized the need for a more mature Operations Management field through the exploration of concepts, using different methods and methodologies.

Following this well-orchestrated qualitative study, an emergent grounded theory of *Navigating Complexities* was introduced. This theory explained some of the complex social processes inherent within HVM SMEs regarding their pursuit of sustainable competitive advantage and was defined as “*exploratory operations and dynamics within socially permitted boundaries designed to locate a balance or equilibrium between complex and unpredictable socioeconomic, as well as technological systems towards the identification of solutions which provide relief to certain needs*”. Interestingly, findings from the research activities identified interdisciplinary issues which went beyond just operations management but delved into knowledge management, organisational behaviour, economics and strategic management amongst other disciplines

Having provided a brief introduction, the remaining chapter begins with a short discussion of the background to the study, following which the context of the study is discussed. The research question, as well as its derivative sub questions, are then presented, highlighting their background and choice therein. A further exposition into the aims are then highlighted,

following which my personal motivations are discussed in some detail. Lastly, the structure of the thesis is described, providing a summary for each of the eight chapters. This chapter ends with a conclusion.

1.2 Background of Research

Organisations of all sizes face growing challenges from an increasingly complex, dynamic and unpredictable world. Indeed, the proliferation of new and advanced technologies, demands for personalised products and services from clients, changing requirements from policy makers and regulatory organisations as well as rapidly changing social, cultural and economic landscapes have fuelled the race for organisations to survive and better still, to thrive amidst these complexities. The need therefore for these organisations to continually observe and assess these trends while strategising accordingly is of critical importance. Some of these strategies for example, include the continuing recruitment and development of people with higher and more advanced skills, the acquisition of advanced technology infrastructure, the development of, and participation in, innovation networks remain some of the top priorities of these organisations. More importantly however, is the need to remain sensitive to changes external to the organisation and in constant touch with their current and potential clientele – these are at the forefront of most organisational strategies.

The evolution into a knowledge managed, high technology world has impacted greatly on all sectors in all locations, especially the wider manufacturing sector, which has brought global economies to the verge of economic stagnation (see Atkinson et al., 2012; Berry, 2015; Berry, 2016). This wider manufacturing sector, in which my focus lies, has experienced some of the greatest shifts especially as the process of manufacturing goods has evolved from craftsmanship to highly organized and advanced factory systems. These factory systems, the focus of various studies, include the move away from mechanized powered systems to the ongoing and futuristic trends which incorporate advanced manufacturing technologies and innovative business processes (see for example, Mital et al. 1999; Ridgway et al., 2013; Gosling et al., 2014; Esmailian et al., 2016; Eyers et al., 2018)

Nowhere else are these challenges more felt than in many SMEs. Defined by the European Commission (2016) as “...enterprises which employ fewer than 250 persons and which have an annual turnover not exceeding EUR 50 million, and/or an annual balance sheet total not exceeding EUR 43 million”, extensive research activities have been carried out in various subject areas due to the importance of these SMEs to the local, national and global

economies. Many findings indicate that along with resource, skills and financial concerns which are often their most publicized challenges, other challenges faced by these organisations include those concerned with their supply chains (Vaaland and Heide, 2007; Bourlakis et al., 2014; Rezaei et al., 2015), exports and internationalisation (Neupert et al. 2006; Lloyd-Reason et al., 2009; Pickernell et al., 2016), technology adoption (Jones et al., 2003) and of course, a combination of some of the above (Lee et al. 2012). Considering the well-known UK statistics which indicate that “small businesses accounted for 99.3% of all private sector businesses at the start of 2018 and 99.9% were small or medium-sized” and “total employment in SMEs was 16.3 million; 60% of all private sector employment...” (FSB, 2019) the need to find, develop and implement solutions which help develop strong organisational architectures to support the navigation of challenges and development of sustainable growth is necessary. This is important because the statistics clearly indicate also, that SMEs are the backbone of the UK economy (DBIS, 2012; Sadler-Smith et al, 1998)

The research reported in this thesis seeks to develop a practical theory which is grounded in data, following the unravelling of some of the complexities surrounding competitive manufacturing capabilities (sometimes referred to as manufacturing related capabilities) in High Value manufacturing (HVM) SMEs. The need to understand this characteristic or concept of being an HVM firm is of great importance to varying stakeholders. These HVM organisations, according to Martinez et al (2008), are defined as those that do not compete primarily on cost but instead, deliver value for one or more of their stakeholder groups through contracting capability, delivering product and/or service innovation, establishing process excellence, achieving high brand recognition and/or contributing to a sustainable society. While other definitions, such as those provided by Livesey (2006), expand on this definition, various scholars have explored the concept in more detail and from different standpoints (MacBryde et al. 2010; MacBryde et al. 2013; Piorkowski et al. 2013; Huaccho Huatuco et al. 2019; Huq et al. 2020). While these studies each bring different insights into the HVM concept, there are opportunities for new exploratory studies following the findings from Benedettini et al (2010) who argue that HVM is not a destination but a race between nations and firms who seek greater control and profitability from their efforts towards sustainable production.

My particular interests therefore involve developing an understanding of which capabilities are important to these HVM enterprises to enable them acquire and maintain market competitiveness; how these capabilities are identified and developed as well as the dynamics involved in their operations – what activities they get involved in, whether on a regular or periodic basis. To achieve these objectives, the Grounded Theory methodology

(GTM) is used. GTM is defined as “a systematic, inductive, and comparative approach in which the researcher undergoes an iterative process of moving back and forth between empirical data and emerging analysis which makes the collected data progressively more focused and the analysis successively more theoretical” (Bryant and Charmaz, 2007). It is also known to be a well-structured method to develop the strategies for systematically gathering and analysing interview data (Strauss and Corbin, 1998). This will be discussed further in Chapter 3, Section 3.6.5.

The regional and sectoral focus of this endeavour explore the HVM enterprises operating within the life sciences sector located in Wales which includes disciplines surrounding biosciences, biotechnology, healthcare and pharmaceuticals. The focus on this particular sector is due to the growing interest from both the local, regional and national governments as well as the huge investments allocated to the sector. For example, the Wales Life Sciences Investment Fund, a dedicated equity fund, has a target investment value of £100 million for investment in life-sciences businesses located in, or to be located in Wales (Welsh Audit Office, 2016). Other than that, many of these organisations are often termed HVM enterprises due to certain facts; they apply leading edge technical knowledge and expertise to the development of products as well as mostly compete on value rather than cost.

As mentioned earlier, this endeavour which is exploratory in nature, is achieved through a grounded theory approach, where data is collected, analysed, assessed and synthesized, all in a well-orchestrated manner, to generate a theory grounded in data. The purpose of this chapter therefore, is to highlight and discuss the background to, as well as the need for, this research based on the personal and professional experiences of the researcher over mostly an 8-year period. Having worked as a Research Associate and Project Officer on both the Welsh Manufacturing Institute (WMI)¹ feasibility study as well as the Advanced Sustainable Manufacturing Technologies Project (ASTUTE)² projects respectively, detailed

¹ With the aim of revitalising the Welsh economy through its once flourishing manufacturing sector, a 6-month exploratory project was carried out to test the feasibility of a Welsh Manufacturing Institute (WMI) towards providing a central resource to coordinate a pan-Wales collaboration between industry and the academic institutions. Part of the methodology involved semi structured face-to-face interviews with 16 senior academics and heads of manufacturing related institutes. After these interviews, R&D facility tours were undertaken across the different Welsh Universities to identify the extent of their preparedness to develop collaborative R&D partnerships with industrial partners – which many were already undertaking. and 2 face-to-face interviews with the Chairman of the Welsh manufacturing Forum.

Available at: https://research.cardiff.ac.uk/converis/portal/detail/Project/2277786?auxfun=&lang=en_GB [Accessed 19th August 2019]

² The ASTUTE project (2010 – 2015) was a £27 million project, with £14 million coming from the Convergence funding of the European Regional Development Fund (ERDF) through the Welsh European Funding Office

interactions with members of academia, industry practitioners as well as policy officials highlighted the need for such an endeavour to provide all interested stakeholders with practical tools for sustainable growth through the development of competitive manufacturing capabilities. On this basis, contextual research interests were developed and discussed with colleagues before the research was undertaken.

1.2.1 Context of Research

Without seeking to trivialise the rich and diverse history surrounding the growth and subsequent decline of manufacturing in Wales, as well as its contribution to the industrialisation of both the local and national economies, the next few paragraphs provide a succinct and high-level background into both the high and low points of the regional economy of Wales. It is believed that this exposition is necessary so as to provide the context for the discussions which follow towards identifying and clearly staging the research aims and questions. Having been the seedbed of the industrial revolution and a major part of the manufacturing landscape of the UK (Parhi, 2013), the development of industry in South Wales has been based to a large extent on its raw materials, acquired from its natural resources (Minchinton, 2013; Pugh et al., 2018). This economic development eventually evolved into manufacturing and services sectors once recognised on a global level as leaders in manufacturing innovation and enterprise (Cooke, 2003)

This region which lies on the periphery of Europe has had a long history of industrial and manufacturing prowess reaching back nearly 400 years to when the first commercial copper smelting industry began. At various times since then, it has been the centre of world copper smelting, has had the largest iron making town in the world and has been a major source of steam coal entering international markets (Humphreys, 1976). Following these successes, Wales developed impressive, highly specialized centres of manufacture especially in iron and copper which played a major role on the British economic scene (Minchinton, 2013). Arguably, it was many years after, in preceding decades that these early successes as well as the highly specialised manufacturing methods and processes proved

(WEFO). Specifically, the aim of ASTUTE was to enable the manufacturing industry in West Wales and the Valleys to grow by adopting more advanced technologies. To achieve this, ASTUTE brought together a unique combination of science, engineering and business expertise and resources all the Welsh Higher Education Institutes to focus on the challenges faced by businesses in the Wales Convergence region. Using conservative estimates, ASTUTE's work created economic impact of over £200m and exceeded all other targets set at the start of the project.

Available at: <https://www.cardiff.ac.uk/camsac/research/projects/astute-2020> [Accessed 19th August 2019]

to be possible hindrance to the further growth and development of its regional economy. The complete reliance on its natural endowments which enriched a lethargic economic structure hindered identification of growing global trends pointing to locally grown industries. This discussion will be highlighted in the coming paragraphs.

In later years and at various other times, the success of the region was based on its ability to attract foreign direct investments (FDI). This is according to Edwards et al. (2001), who argued that “the attraction of manufacturing investment from overseas was the main focus of regional development policy in Wales for much of the 1970s and 1980s”, as well as McNabb and Munday (2017) who also argued, “accounts of the role of inward investment in Wales have been broadly positive, with research pointing to effects in terms of new jobs, higher exports and spillovers of new knowledge and techniques to indigenous firms”. McNabb and Munday (2017) highlighted further:

“Foreign manufacturing has a long history in Wales...by 1974 foreign owned manufacturing employed an estimated 53,000 people. North American firms dominated foreign inward investment into Wales until the 1970s. The quantity of European and Japanese manufacturing investments in the Welsh total increased sharply in the 1980s. There was a shake-out in Welsh manufacturing after 1980 and, by 1984, foreign owned manufacturing employment had fallen to around 40,000, but rose steadily after this reaching an estimated 75,000 by 1996...Wales is estimated to have secured almost 1500 overseas inward investment products between 1984 and 2007, with an estimated £13.5bn of planned capital investment, and almost 100,000 planned new jobs and 70,000 safeguarded jobs...”

In the period after 1978 however, a widespread decline across all sectors and decline in service sector employment deepened due the effects of a deepening economic recession (Morris, 1987). The effect of this industrial recession in Wales during the 1980’s was massive, the primary contributor being job loss through establishment closure (Westhead, 1988). Furthermore, Westhead (1988) reported that, “103, 574 manufacturing redundancies were reported in wales over the 1980 – 1984 period, and 70% of these could be claimed to have occurred through the closure of manufacturing establishments”. All was not lost however because with slightly contrary reports, Cooke (2003) stated that from 1983 – 1993, Wales continued to attract between 15% and 20% of inward investment into the UK despite having only 5% of the UK’s population.

Once again, the fortunes of the Welsh economy were to be negatively impacted upon during the period commencing the late 1990s as well as 2008. The 1990s brought about the increasing acceptance of economic globalisation where a rapid increase cross-border movement of goods, services and capital, powered by advancements in technology took hold. Between 1998 and 2008, 31,000 jobs were lost as companies moved to Central and Eastern Europe, Southeast Asia and China to take advantage of lower labour costs, growing markets and an increase in skill levels (Evans et al., 2008). The House of Commons Welsh Affairs Committee also concluded:

“The decline in manufacturing can be attributed in part to globalisation...globalisation has created a ‘culture of uncertainty’ in manufacturing: as global companies chase increased profits they are moving their production facilities to China, Eastern Europe and India where labour is so much cheaper”

Regarding the years following 2008, The Welsh European Funding Office (2013) reported:

“...the 2008/2009 recession was relatively deep in Wales as private sector output fell by more than 12% compared with a decline of approximately 8% in the UK. These data show that, like the UK, output in Wales has not, at the time of writing, returned to levels recorded in 2008...it is clear that the economy of West Wales and the Valleys has been damaged by the recession but it is unclear to what extent or when it will recover some or all of the losses or declines in output that have been incurred”

In summary, Wales comparative disadvantage was not simply in terms of industries and occupations, but also in the type and ownership of establishments prevalent in Wales, and the resultant nature of work. These factors played a major part in creating an economy with low value added, low earnings and low rates of participation, as well as an unemployment rate habitually below the UK average (Jones, 2000). Furthermore, Cooke (2001) gave reason for this as Wales having a weak innovation environment. These occurrences therefore prompted Williams et al (1992) and later, Munday et al (1995) to question the long-term benefits of, for example, Japanese investments in the UK which featured low value-added functions which could better be characterised as ‘warehouses’ rather than factories. Morris (1995) provided a historical end-to-end overview of the situation in Wales highlighting the aforementioned issues from the gradual ‘de-skilling’ of the region to the industrial

restructuring drive. He however opened up his thesis with a quote from Douglas Coupland³, who summed up the arguments by describing the term McJob, as;

“a low-pay, low-prestige, low-dignity, no-future job in the service sector. Frequently considered a satisfying career choice by people who have never held one.”

Within the context of all of the above, a sizeable portion of industrial Wales became derelict and devoid of a hitherto globally acknowledged manufacturing conglomerate, resulting in huge job losses and an increasing social decline. It was not uncommon therefore, for many to accept the decision to grant Objective 1⁴ status to parts of Wales, bestowing upon these parts a badge of failure, an explicit recognition that Wales had become one of the poorest parts of Europe (Hill, 2000)

1.2.2 Policy Intervention

Following the overall regional and economic experiences above, the Welsh state of affairs came down to two basic problems suffered by Wales. Morgan (1996) suggested that firstly, a past reliance on a narrow industrial base owing to its factor endowments such as land, labour as well as natural resources and secondly, a reliance on such industries meant that the country had a low technological base. Jones (2000) also highlighted this plight by stating that regional policy and industrial development bestowed upon Wales a structure ill-suited to change and one where much control resided outside its economic borders (referring to the ‘subsidiary’ economy, where much of the decision making and control was with the parent organisations located in their home countries). The need therefore to enact policies and measures to facilitate the creation of opportunities for sustainable development, including opportunities for employment, upskilling the population as well as creating economic value was, and still is, necessary. This is due to the fact that traditional regional policy has had little effect on the generally low innovation levels in South Wales compared to other regions of the EU and despite its past manufacturing strengths (Huggins, 1996).

³ Douglas Coupland, author of 1991 international bestseller *Generation X: Tales for an Accelerated Culture*. This book popularized the term Generation X, “a label attributed to people born during the 1960s and 1970s. Members of Generation X are often described as cynical or disaffected... This generation has an increased understanding of technology, having grown up during the age of computers” (The Business Dictionary, available at: <http://www.businessdictionary.com/definition/Generation-X.html> [Accessed 21st June 2017]).

⁴ The Objective 1 programme is a European Union regeneration initiative that operates within European regions of most need and supports the development of regions that are significantly falling behind the rest of Europe, whose per capita GDP is less than 75% of the EU average.

To demonstrate this, a number of detailed studies have tried to assess the levels of success various local and EU interventions have wrought in the Welsh region. For example, Edwards et al. (2007) evaluated the role of EU structural funds in upgrading and enhancing SME innovation in the disadvantaged regions of Wales. Following a sample of Welsh manufacturing SMEs their conclusions indicated that EU policy has failed to come to terms with the important social characteristics and complexities of innovative processes especially when they allow mechanistic approaches to innovation across different regions and enterprises. Similarly, Pugh et al (2018) analysed the use of European Union Structural Funds to support the development of innovation policy in Wales between years 2000 and 2006. With a focus that specifically examined the Technium programme⁵ they concluded that one of the major reasons for its failure included not only the lack of the strategic direction and management of the programme, but a failure to consider the demand from the local businesses in line with the best practices from successful incubator programmes around the world.

To emerge from this plight, various regional, national and even international governing bodies proposed extensive support for the development of, and focus on, home grown advanced manufacturing start-ups and enterprises as well as an adequate support system to sustain the innovation and entrepreneurial drive. Due to their advanced science and engineering capabilities, universities and other publicly funded institutions were recruited into collaborative partnerships to support this drive to promote high value enterprise development. In the past for example, the Welsh Development Agency prompted numerous initiatives intended to benefit and promote local firms as well as provide SMEs with supportive and efficient infrastructure (Huggins, 1996). According to Todtling (1998) also,

“Many regions including Wales have developed technology policy concepts or innovation plans and have become active in supporting technology transfer and innovation activities. Often, these concepts included the strengthening of particular industrial clusters in the region...due to the relatively strong and proactive role of respective organisations in wales, innovation partners are frequently public or

⁵ The Technium Programme was an initiative from the Welsh Assembly Government to nurture the development of the knowledge economy in Wales through a network of inter-related support centres where innovative companies could reach their potential in a supportive environment. (see Abbey et al. 2008; Davies and Abbey 2007)

semi-public support organisations (government institutions, training organisations, universities).”

With these budding partnerships however, the intervention of universities and their academics was still not seen to be adequate enough. Years after, it was still suggested by scholars, that with the abundance of scholarly facilities and practitioners in Wales, there is no adequate or equal engagement between these scholars, industry and policy. Morgan (2002) argued that the higher education in Wales has been prevented, hitherto, from playing a full role in solving the major problems endemic to the Welsh economy. This has been attributed to the structure of the sector as well as its funding arrangements. Other scholars such as Wells et al (2009) stated that although individual academics may have been involved with industry in a fragmented manner, it was hardly an example of a framework for engagement or cohesive use of the world class expertise available for the region.

1.3 Research questions

The research questions for this study were developed over a period of time and were based on a combination of the following:

- The author’s prior experience as a Research Associate at Cardiff Business School, over a period of 6 months. During this period, I engaged with a wide range of stakeholders including academics, industry practitioners and policy makers towards the delivery of the WMI feasibility study
- The author’s prior experience as a Researcher & Project Officer at Cardiff Business School, over a period of 60 months on the ASTUTE project. The responsibilities of the position involved working directly with SMEs and start-ups towards supporting their growth through the adoption of both soft and hard advanced technologies into their organisations.

It was initially anticipated that this PhD study would explore either, or both, of these two choices: (1) the adoption and impact of advanced technologies on manufacturing SMEs in Wales or (2) technology transfer and the absorptive capacity of small to medium manufacturing firms in Wales. These choices were considered in detail as per the theme of the ASTUTE project which provided the impetus for the pursuance of the PhD study. In addition, a qualitative ‘Action Research’ approach was favoured for either of these studies, towards understanding the processes behind the respective concepts as well as the benefits and improvements achieved therein. Following extensive interactions with multiple

SMEs, entrepreneurs, academics and policy makers however, it became evident that the adoption of advanced technologies, the implementation of technology transfer initiatives or indeed, the exploration of absorptive capacity processes were only 'minor' concerns, which contributed to a wider need or challenge within the SME, start-up and innovation ecosystem in Wales.

The identification and development of the research questions therefore followed the tenets of the chosen methodology of the study, which was Grounded Theory. One of the key characteristics of the traditional version of this methodology proposed that the research be approached without narrow research questions or hypotheses common in other research designs. Glaser and Strauss (1967) advised that the research problem must 'emerge' and suggested further in Glaser (1998) that for a problem to be of relevance, it must be generated from those for whom it is significant.

This thesis therefore addresses the following research question which was generated wholly from extended discussions with relevant stakeholders:

- Regarding competitive manufacturing capabilities, what is/are the main concern(s) of HVM SMEs and entrepreneurs working in the innovation and start-up ecosystem in Wales?
 - How are these main concerns resolved, developed and managed?
 - What activities are undertaken by these HVM SMEs, to continually remain relevant, not just locally, but globally as well?

Following more detailed consultations with the stakeholders over the course of the ASTUTE project delivery, the focus of the questions above took shape within the area of competitive manufacturing capabilities and its link to the competitiveness of the firms. The wider research needs therefore involved the strategic identification, acquisition, sustenance and evolution of competitive manufacturing related capabilities.

These initial questions were 'measured' against some criteria suggested by experienced GT researchers. Locke (2001) for example, argued that "the kinds of issues appropriate for study are those that are relevant and problematic in the social situation", while Birks and Mills (2010) suggest that research questions should be broadly stated and in terms that reflect a problem-centred perspective of those experiencing or living the problematic phenomenon. They sound a note of warning, "avoid locking yourself into a specific topic of study as this will hinder your application of grounded theory methods...".

Having considered the challenges faced by the Welsh manufacturing ecosystem as well as the investment drive from both private and public sector stakeholders, the questions above were considered to be timely and relevant for the situation.

1.4 Personal Motivation

While I have highlighted the professional, environmental and socio-political reasons for my interest in seeking to understand the issues relating to the competitiveness of Welsh HVM SMEs, I believe that my personal motivations are also part of the driving force in my wanting to pursue and acquire the PhD.

Having joined the Logistics and Operations Management (LOM) group in Cardiff Business School as a Research Associate in January 2008, I was intrigued by the wide range of expertise within the group as well as the depth of knowledge that existed amongst the members of staff. I joined this group on a funded project⁶ which sought to develop new and practical knowledge that had the potential to revitalise the UK manufacturing sector. It was later I came to learn that LOM had one of the largest and most academically diverse groups of Operations Management academics in any university in the UK. Their specialities and backgrounds covered a wide range of disciplines; engineering, social sciences, retail, transportation, information technology, healthcare and behavioural sciences. What excited me more about this group was that their research activities mostly had practical implications for both public and private sector organisations. Research activities undertaken by LOM researchers were often done in collaboration with industry partners, thereby providing immense contributions and benefits to not only the Welsh region but also the UK and even internationally. Coming from industry, having worked globally for an international organisation, I found this exciting. Being the child of an accomplished academic, my opinion of them was completely different from what I was experiencing. And I liked this experience.

During my interactive sessions with different literature in the course of my work, I was also impacted by a few articles which shaped my desire to not only pursue a PhD, but to do so with a difference. In their paper titled ‘Too much theory, not enough understanding’,

⁶ The Cardiff University Innovative Manufacturing Research Centre (CUIMRC) was a 5 year, £3.5m Engineering & Physical Sciences Research Council (EPSRC) funded project whose objective was “to provide a focal point for UK manufacturing industry to understand why they must change their businesses along sustainable lines, what strategic directions they require, what this will mean to them operationally and how they should go about implementation”.

Available at: <https://gow.epsrc.ukri.org/NGBOViewGrant.aspx?GrantRef=GR/S75505/01>

Schmenner et al. (2009) for example reassessed the role of theory in Operations Management. Several statements made an impact on me. According to them:

- “If our discipline cannot guide managers into how to deal with issues that currently buffet modern businesses, what is its legitimacy?”
- “Real-life problems and puzzling new phenomena in particular seldom map onto specific paradigmatic domains and thus, trying to understand a novel phenomenon using existing paradigms is akin to trying to play a new game with the old rules”

In another uncompromisingly direct argument, Alvesson and Sandberg (2013) in a paper titled “Has management studies lost its way? Ideas for more imaginative and innovative research”, argued that despite the huge increase in the number of management articles published in the last three decades, a serious shortage of high-impact research in management studies prevailed. The authors gave their reasons as the near total dominance of incremental gap-spotting research in management research, leading to a dearth of influential theories. According to them, of course, this occurrence was due to factors such as institutional conditions, professional norms within the management field and researchers’ identity conditions, which put together, compelled the ‘publish or perish’ mantra. To put management studies back on track however, they suggested the following: revising institutional conditions, rethinking professional norms and cultivating a more scholarly identity: from gap – spotter to path – (up)setter. Having read numerous journal papers, as well as attended meetings and seminars in the course of my work as a Research Associate, I recognised their arguments, as I had sometimes wondered about the usefulness of certain research activities and outputs. Very often, the question, ‘have you identified any gaps in the literature?’ were taken as the sole basis of research endeavours and my retort, to myself, was often, ‘why are you not identifying problems with organisations and their operations or processes or supply chains or...?’ These types of research will be more interesting.

By far their most important recommendation, which impacted upon my decisions to pursue the research degree, albeit with a ‘twist’, was their final suggestions, which emphasized the ‘need to consider alternative methodologies for theory development’. As a means to follow through with the use of alternative methodologies, they suggested the use of problematization as a methodology for assumption-challenging studies (Alvesson and Sandberg 2011). Needless to say, Mats Alvesson and Jorgen Sandberg published other papers⁷ which I considered very instructive to my research endeavours

⁷ See for example, Alvesson and Sandberg. 2014; Sandberg and Alvesson. 2011; Alvesson. 2013.

The third paper which I found to be quite creative, instructive and very motivational was from Delamont (2005) who creatively identified the “dilemmas, directions and distractions in educational research”. A major deviation from the mainstream Operations and General Management literature, this paper took the form of an allegory in which Delamont likened the directions researchers took in their daily activities within the universities to the imagined exits from a safe comfortable city, identified in James Elroy Flecker’s poem *The Gates of Damascus*.

In this analysis, Damascus was likened to a safe ivory tower, the university where opportunities to read, teach and reflect were the norm. The challenge however was that as educational researchers, the safety of Damascus could not be permanent because researchers had to leave by one of the four gates into the harsh and unpredictable outside world. To me, this mirrored the situation in which I found myself especially as a Project Officer on the ASTUTE project. In the course of my work with LOM, I had understood that the universities were potentially more than places of teaching and research only – but could be places that developed sustainable solutions for the outside world.

These four gates included the Aleppo Gate to engage in honourable trade, where researchers sold their products for a good price. This spoke of customer-contractor research to tackle relatively straightforward practical, questions. The Mecca Gate led to the researcher assuming the life of a pilgrim signifying that those that take that gate are motivated not by money but by their identity in the research world; what education is, what its purposes are and why it matters. This had a personal meaning to me because as mentioned earlier, I grew up in an academic household where intellectual discussions and expectations were the norm, rather than lackadaisical pursuits or financial frivolities. At that age, I preferred the financial frivolities which were not forthcoming.

The Lebanon Gate signified exploration – which exposes researchers to the risk of losing their epistemological certainties, standpoints and foundations. The last gate, the Baghdad Gate, was one that no researcher chose because it led into the desert where they found themselves alone and without meaning. In these situations, research programs did not work out and researchers fell into depression and terror.

These papers, along with others too numerous to mention, provided the impetus for my daring to be different with this PhD approach. Following my work experience, supporting the growth of Welsh based HVM SMEs, I decided to explore an issue on the agenda of every SME – the identification and advancement of their competitive capabilities.

1.5 Structure of the Thesis

The eight chapters in this thesis are illustrated in Figure 1.1. A more detailed description of the individual chapters is provided below

Chapter 1: Introduction - This chapter serves as the introduction to this study by highlighting the background to the research endeavour. The emergent substantive theory of navigating complexities as well as the context in which it is set are briefly explained. The principles of the methodology applied in this study are also discussed, thereby demonstrating some of the novelty in the approach

- **Egbunike, O.** and Biggs, C. 2014. Towards revitalizing Welsh Manufacturing: The role of Welsh Universities. Proceedings: *International Conference on Sustainable Design and Manufacturing*, Cardiff. April 2014

Chapter 2: Literature Review Part 1 - The second chapter presents a purposefully minimal literature review, in keeping with the research method. This chapter focuses on manufacturing capabilities and the broad methodologies used to understand them. This review was conducted prior to the research process in order to set the scene for the exploratory study. A complete and more detailed review which informed this chapter is published in:

- **Egbunike, O.**, Purvis, L. & Naim, M.M. 2017. A Systematic Review of Manufacturing Capabilities Research. *Production Planning & Control*, 29:16, 1349-1366
- **Egbunike, O.**, Naim, M. & Purvis, L (2014) The philosophies of manufacturing capabilities research: A 30-year systematic review. 18TH International Working Seminar on Production Economics, Innsbruck, Austria. 24 – 28 February 2014

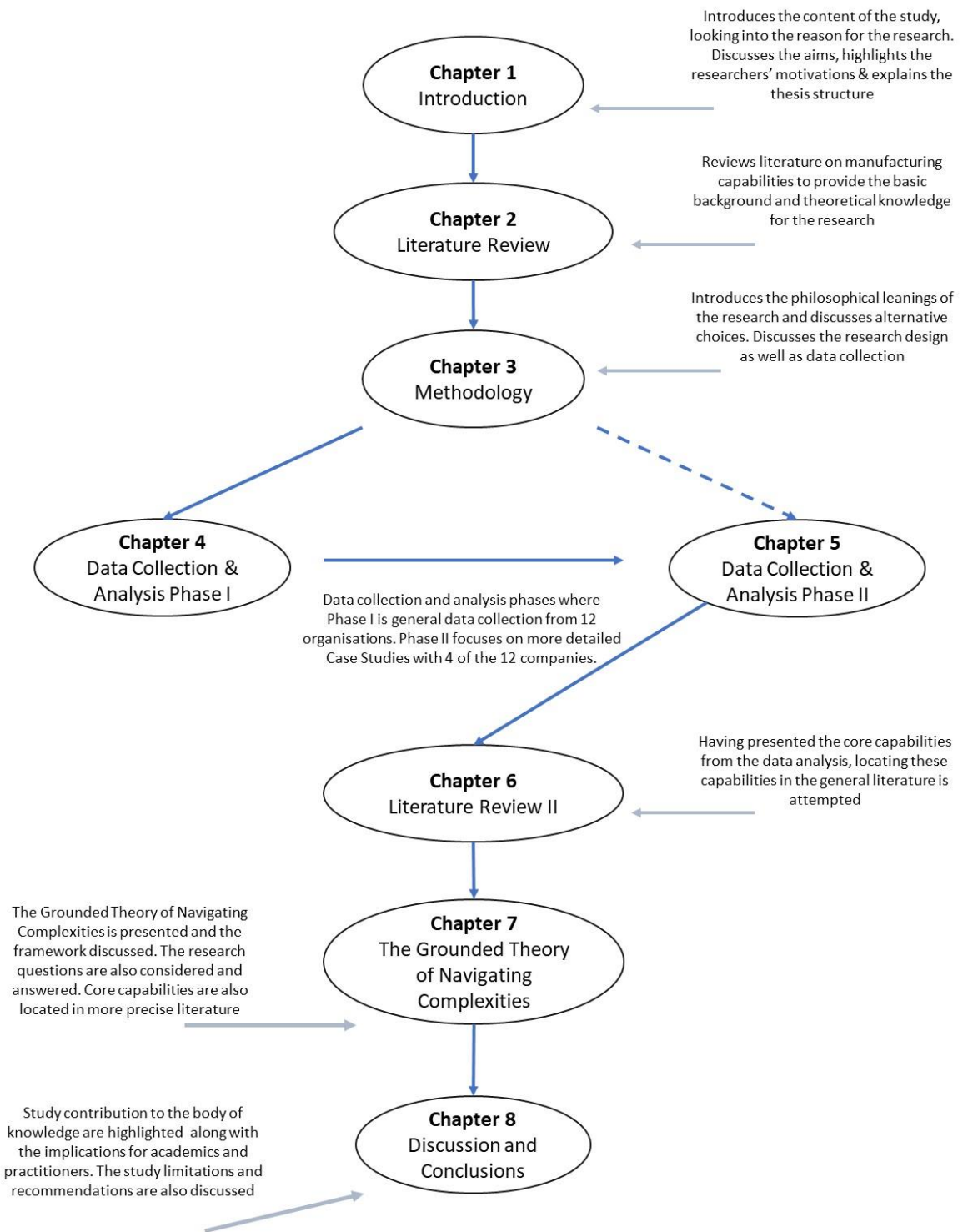


Figure 1.1: Thesis Structure

Chapter 3: Methodology – The methodology chapter discusses the research design for this study and discusses the ontological and epistemological choices in which the research is positioned. In addition to these, the procedures used to analyse and synthesize the results from the data are outlined and discussed.

- **Egbunike, O.,** Naim, M.M and Purvis, L. 2014. Philosophies of Manufacturing Capability Research. Proceedings: *The Eighteenth International Working Series on Production Economics*, Innsbruck, Austria. February 2014

Chapter 4: Data Collection and Analysis Phase 1 – This chapter describes the first stage of the Grounded Theory enquiry process where eleven (11) organisations were queried using the Grounded Theory methods. Data was collected and analysed resulting in the first stage of data saturation. The initial findings were discussed at length both at an international conference as well as a local gathering of academics who all provided constructive feedback. The complete reference is shown below:

- **Egbunike, O.,** Naim, M.M and Purvis, L. 2015. The Process of Identifying Manufacturing Related Capabilities in Advanced Technology Firms for Enhanced Competitive Advantage. Proceedings: *European Operations Management Association*, Neuchatel, Switzerland. June 2015

Chapter 5: Data Collection and Analysis Phase 2 – This chapter builds on the outcomes from chapter 4 by engaging further with a select number of respondents from the original pool of 11 organisations. A Case Study approach, which shines the light on 4 organisations, is favoured in this chapter where the Grounded Theory methods are once again observed, to generate and analyse data. The beginnings of an emergent substantive theory are identified.

Chapter 6: Literature Review Part 2 – A focused literature review is presented in this chapter. Unlike the initial review in Part 1, this literature review focuses on the areas that have been identified as the major constituents of the emergent theory.

Chapter 7: The Grounded Theory – This chapter presents the findings of the overall study as constructed through the data gathering, analysis and interpretation. This interpretation which could be considered to possess both subjective and objective aspects is located within the existing research and presented.

Chapter 8: Discussion and Conclusion – This discussion and conclusion chapter details the contributions of the study as well as the limitations and implication for management learning and strategic adoption. The research questions are answered in this chapter.

Conclusions drawn from the results of the research will also be highlighted and a possible future agenda proposed.

1.6 Chapter Summary

This chapter has introduced the overview of the research, which describes its purpose and the aims behind it. The research outcome, Navigating Complexities, is also introduced briefly. Following this, the research context, research questions, personal motivations as well as the thesis structure are also highlighted. Going forward, the next chapter explores manufacturing capabilities towards understanding the content of that research field. The review also highlights the philosophical leanings of the studies assessed towards providing an understanding of how our understanding of the field is shaped.

Chapter 2: Minor Literature Review

2.1 Introduction

Although it is not the intention of this thesis to join the debate concerning the review of literature and its relevance with the tenets of GT, it nonetheless has to be noted. Issues surrounding the review of literature prior to commencing Grounded Theory studies have generated a huge amount of scholarly discourse (see for example Dunne, 2011; Mcghee et al., 2007; Christiansen, 2011) since the theory was proposed by Glaser and Strauss (1967). This is because while the thorough review of existing literature is mandatory in most research endeavours before commencing any activities, Glaser and Strauss (1967) argued vehemently against this. According to them, “an effective strategy is, at first, literally to ignore the literature of theory and fact on the area understudy, in order to assure that the emergence of categories will not be contaminated by concepts more suited to different areas”. To further emphasize this, Glaser (2004) emphasized this once again. The rationale behind this principle is to prevent preconceived ideas from being imported into the GT research and unconsciously imposing them on the discovery process. While some researchers have adopted the tenets of the original founders of GT and have adhered to this (Holton, 2007; Charmaz, 2006), others have argued that it is impossible to enter a field of endeavour without an idea of what is to be expected. Various researchers suggest the unworkability of this method, especially for PhD students and early researchers, and put forward their arguments. Hoda et al. (2011) for example, suggest that keeping the review to a minimum and reading just enough to understand the basic facts and terminologies in order to converse logically with participants is necessary. Dunne (2011) also argues amongst other things, that a minor review helps to contextualise the study as well as reveal how the phenomenon has been studied to date. These two reasons, amongst many others have necessitated the following review, which is very brief, but insightful.

This chapter details the findings of a scoping review conducted to explore what literature on manufacturing capabilities was conducted over a period of 30+ years, specifically between 1980 and 2014, and how it was conducted, with reference to the different philosophical perspectives. The aim was to assess the extent to which our knowledge of this field had developed through the application of varying philosophies encapsulating elements such as research ontologies, epistemologies, designs, methodologies and methods. Several databases were therefore interrogated using key word searches, resulting in 104 papers

identified and selected using strict inclusion parameters. The literature identified covered both the engineering and management domains, which indicated a breadth of ontological and epistemological stances. The findings highlighted the dominance of the positivist paradigm, suggesting the need for a more balanced and informed approach in philosophical, and more specifically, methodological selection by engineering and management scholars. A substantive missing philosophical element was the adoption of more interpretive research approaches, such as a Grounded Theory (GT) and Action Research (AR) approaches, which the totality of this PhD research thesis addresses.

It is important to note also that this chapter introduces what has been published in a journal (Production Planning and Control), as well as what has been presented internationally (Seminar on Production Economics). The initial review activities were undertaken solely for the purpose of the PhD research but found to be publishable, hence the full citations below:

- Obi Egbunike, Laura Purvis & Mohamed. M. Naim (2018) A systematic review of research into the management of manufacturing capabilities, *Production Planning & Control*, 29:16, 1349-1366
- Egbunike, O., Naim, M. & Purvis, L (2014) The philosophies of manufacturing capabilities research: A 30-year systematic review. 18TH International Working Seminar on Production Economics, Innsbruck, Austria. 24 – 28 February 2014

2.2 Background: Manufacturing Capabilities

The scholarly context for this review was anchored in studies from researchers such as Wheelwright (1984) who argued that manufacturing capabilities which can be used as competitive weapons, play a major role in an organizations desire to attain competitive advantage. Terjesen et al. (2011) also argued that superior manufacturing capabilities have long been associated with high performance in firms and have been recognized as sources of competitive advantage. Furthermore, Narasimhan and Schoenherr (2013) investigated competitive manufacturing capabilities by focusing on their progression and development over time and emphasised how this can influence improvements in manufacturing performance. This sustainable competitive advantage for firms is therefore said to result from building core capabilities or competencies (Prahalad and Hemel, 1990; Hayes, 1985) where these capabilities are conceptualized as the efficiency with which a firm transforms

available inputs into outputs (Dutta et al., 2005) or refer to the exploitation of specific practices to attain performance gains (Dabhilkar and Bengtsson, 2008). That said, various researchers have suggested many different manufacturing capabilities which work toward supporting these production related goals. Vickery et al (1993) for example, developed a list of 31 components of production competence based on a literature review.

Although the previous researchers made references to what these capabilities are, further definitions provided more insights into what actually makes up these capabilities. The term 'capability' was first of all, introduced into the manufacturing strategy literature from general management following the development of the 'resource-based view' of the firm (Corbett and Claridge, 2002). According to Swink and Hegarty (1998) and Boyer and Lewis (2002), manufacturing capabilities are fundamental proficiencies in manufacturing that enable firms to achieve production related goals involving such matters as cost control, time/throughput speed, volume, delivery dependability and quality that conform to specifications. Others define it as "the strength or proficiency of a bundle of interrelated routines for performing specific tasks" (Peng et al., 2008) or "the ability to perform and sustain a set of routines which may be regarded as highly structured set of habitual reactions linking organisation members to one another and to the environment" Nelson and Winter (1982). In other literature, capabilities are known to be a business unit's intended or realized operational strengths, a definition which provides the basis for linking business strategies to operational ones (Swink and Hegarty, 1998).

Indicative from these studies was the fact that capabilities are made up on particular bundles of routines with which the organisation dispenses its value to its customers. This therefore, highlighted the fact that just possessing manufacturing capabilities, whether technical, processes or organisational, will not automatically translate into competitive advantage. Instead, the performance outcomes were dependent on how they were leveraged, both within and outside the organisations reach afterall, Eisenhardt and Martin (2000) emphasized the dynamism of capabilities when they stated that firms must continually reconfigure their internal and external competencies to enable them adopt to changing technological environments. Given therefore, the importance of this concept to the success of organisations and indeed, the spill over effects on the long-term economic growth and resilience, the increasing focus of this topic in operations and supply chain management is not surprising. What is surprising however, is the absence of scholarship into *how* manufacturing capabilities research has been conducted from various methodological perspectives. With the amorphous and multidisciplinary nature of manufacturing research

and practice as well as the speed with which the sector is evolving, what methods and methodologies have been employed and what is the reasoning behind them?

These discussions around the methods and methodologies are not new to operations management research. Various scholars have dissected, theorised and proposed previously under-utilised methods and methodologies towards developing arguments for the increase in certain methods and methodologies over others (see Meredith et al, 1989; Flynn et al, 1990; McCutcheon and Meredith, 1993; Westbrook, 1995; Meredith, 1998; Wacker, 1998; Coughlan and Coughlan, 2002; Forza, 2002; Voss et al, 2002 amongst others). If their advice is followed, as well as that of Kuhn (1970), whose suggestion affirming the need for researchers to propose more encompassing theories to find solutions to new challenges, the need for operations management researchers to understand their methodological past and present in order to move forward is called for.

As such, the objective of the study was to investigate how research in manufacturing capabilities has been conducted and what the main areas of interest have been. The application of varying philosophies involving ontologies, epistemologies, methodologies and designs were therefore assessed towards synthesizing and refining the knowledge currently existing in the field. Following this, a future agenda was proposed.

2.3 Review methodology and classification

In order to construct a typology of existing research, a systematic review was adopted for this exercise. This systematic review, according to Wright et al. (2007) is defined as “a review of the evidence on a clearly formulated question that uses systematic and explicit methods to identify, select and critically appraise relevant primary research, and to extract and analyse data from the studies that are included in the review”. They were first developed for, and used in medical sciences as part of the search for better evidence base for policy-making and clinical practice and later on adopted by other academic disciplines over the years (Tranfield et al, 2003).

Although a few reasons were identified for our choice of a systematic review over the conventional literature review (see Table 2.1) the following were the major determinants:

- To adopt an objective and rigorous approach in order to minimize bias and ensure replicability.
- Due to the large quantities of information published about manufacturing capabilities research, the need to reduce this to a manageable number and still retain the quality of outputs was necessary. This, according to Mulrow (1994) is one of the advantages of systematic reviews. According to him, “through critical exploration, evaluation and synthesis, the systematic review separates the insignificant, unsound, or redundant deadwood...from the salient and critical studies that are worth of reflection”.

For these reasons and more, other studies in operations management have recommended and used this method to review literature (see for example, Thome et al., 2016; Matthews and Marzec, 2012; Alexander et al., 2014)

To commence the systematic review activities therefore, the process recommended by Tranfield et al. (2003) for was adopted, which involved the planning, execution, reporting of the results. During the planning stage, the objectives of the research were re-iterated, following which the data sources were discussed. As part of this stage also, the choice was made to limit the sources to only peer-reviewed journal articles because these were considered to be validated as well as to have the highest impacts in their fields (Podsakoff et al., 2005). Having made this choice, especially for the sake of rigour, conference papers, textbooks, contributions to edited books, dissertations, newspaper articles were excluded. In addition to the earlier advice from Podsakoff et al (2005) this identified also, with David and Han’s (2004) approach to ensuring that only quality papers are considered in the review.

Following these decisions, key words were then selected to include, “manufacturing capabilit*”, “manufacturing competenc*”, “production capabilit*” or “production competenc*”. This was done, given the different names and meanings researchers may have used to identify the same subject including manufacturing capability or capabilities, manufacturing competence or competencies and so on. The exact meanings were later on identified during the screening process and those that did not meet the criteria were excluded.

These key word searches were then put through several databases including ABI/Inform Global ProQuest, EBSCO, SCOPUS, Web of Knowledge and Google Scholar. These databases were chosen as they were considered to be the most comprehensive of peer-

reviewed journals for business and management studies, as well as the social sciences. During the search, where possible, for example in the SCOPUS database, further limitations were placed on the articles to be retrieved by limiting the selection criteria to articles with only the keywords in ‘title, abstract and keywords’, language options to ‘English’ and paper type to ‘peer reviewed’. These actions served to streamline the possible hits generated from these databases to papers that met the strictest requirements for the review.

Literature Review	Methodological Stage	Systematic review
Introduces context and current thinking, often without a specific question, is general and covers several aspects of a topic	Focus of review	Uses a precise question to produce evidence to underpin a piece of research. A stand-alone piece of research, it should be conducted prior to undertaking further research, particularly in higher degree theses.
Finds papers through a fairly random process, usually searching only a few databases. Use of grey literature common, but not usually systematic.	Methods for data collection	Searches of several specified databases using precise search terms; a similar systematic search of grey literature sometimes included, depending on the question.
Papers are read, ‘take home’ messages used in the review.	Methods for data extraction	Data extraction tool used to identify precise pieces of information; two or more researchers undertake data extraction
Anything up to 150 papers or more.	Number of papers included in review	Usually less than 50 papers; often fewer than 10.
Prose paper, occasionally supported with diagrams.	Methods for data presentation	PRISMA/CONSORT or similar chart/table of included papers.

Table 2.1: Literature reviews vs systematic reviews (Robinson and Lowe, 2015)

For ease of categorization, easy access and manipulation, all identified papers were exported into EndNote with necessary information such as abstracts, keywords and citation included. Following this activity, the search for articles that met the initial criteria began. Replications of papers that appeared more than once, due to their presence in multiple databases, were deleted and a significant reduction in papers was observed. With a more manageable database of papers (628), the abstract, introduction and discussion and/or conclusion sections of all papers were read to ascertain their relevance to this study. Some papers were excluded once again, because their research topics were peripheral to this study and they did not meet the inclusion and / or exclusion criteria which included:

1. Does this paper contribute to the development and understanding of manufacturing capabilities in the operations and supply chain management field? This was

particularly relevant in terms of the inclusion / exclusion criteria for papers identified in engineering journals. If no managerial implications were discussed, and the article only specifically addressed manufacturing capabilities from a technical perspective (specific tools, techniques, etc.), these articles were not included.

2. Can the method / methodologies employed be identified? Indeed, this was a very important criteria, due to the objective of this study, which was to identify the philosophies behind the chosen methodologies.

In total, 104 papers were selected from 52 journals, and read in full (see Figure 2.1 for selection and filtration process). To aid this process, an extraction form (see Appendix D) as well as an excel spreadsheet (see Appendices E, F) were used, in addition to the EndNote software. The excel sheet was especially helpful due to its ease of sharing and ability to incorporate numerous comments and suggestions.

Following the initial assessment of the papers after reading in full and categorizing, an initial overview of these papers is highlighted in Tables 2.2 and 2.3. In relation to the content analysis, one of the main challenges consisted was ensuring inter coder reliability. According to Duriau et al. (2007) by involving two other researchers into the content analysis, validity and reliability is believed to be highly enhanced. For this study, random selections were cross checked and confirmed in pairs by this researcher, alongside the two others

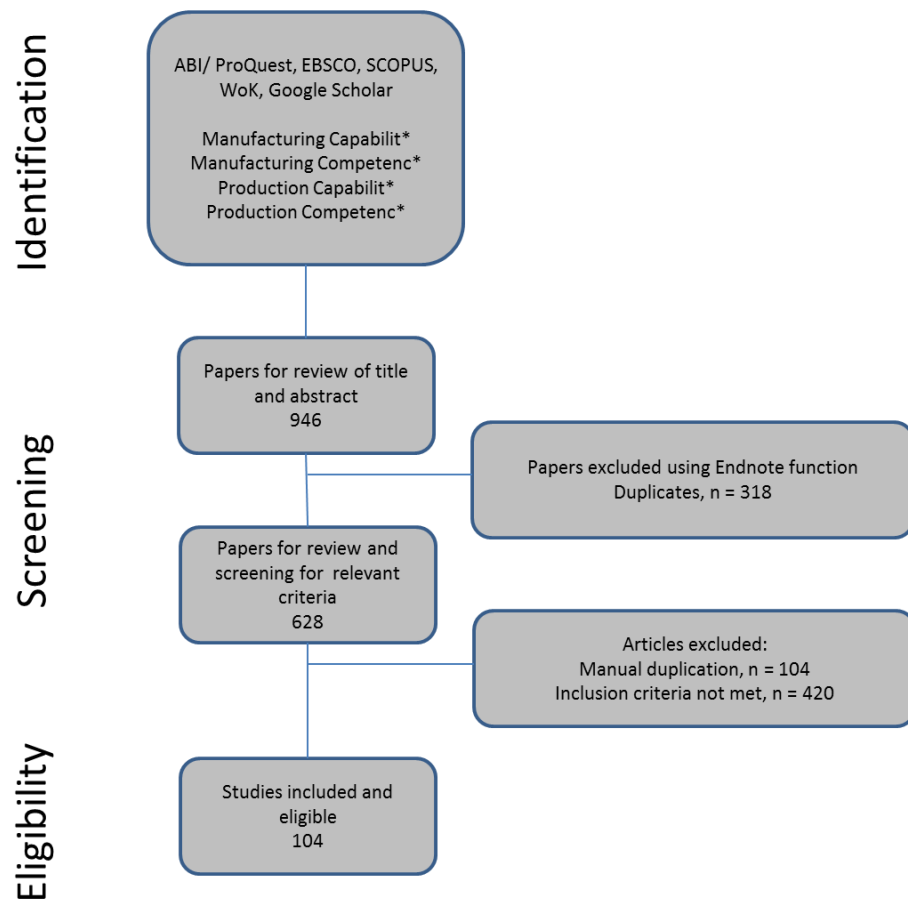


Figure 2.1 Selection Process for 104 reviewed papers

The first stage of our analysis was to determine the frequencies in publication years, having initially selected our start year to be 1980 (Table 2.2). The first identified paper was by Whybark (1987), who had developed a trade-off argument for manufacturing capabilities by arguing that management must set priorities on those manufacturing competencies most important for success in the market. After 1987 however, research on manufacturing capabilities has seen a steady increase in published papers, and is expected to continue to do so. A simple extrapolation of the number of papers identified between 2011 to date suggests that the interest in manufacturing capabilities will equal if not exceed the volume of research of the last decade. This further strengthens the justification for this present study which posits that operations management researchers need to ensure that going forward, their research activities will need to employ a wide array of methodologies.

Year of Publication	<i>Frequency</i>
1980 – 1990	3
1991 – 2000	25
2001 – 2010	57
2011 – Date	18

Table 2.2: Year of publication

With regards to the most cited journals, Table 2.3 shows the different journals containing relevant search results, ranked by the number of papers that matched the inclusion criteria. A total of 12 journals were identified that contained two or more relevant papers. These journals were then classified based on the headings found in the Academic Journal Quality Guide (Harvey et al., 2010) and the ISI Web of Knowledge (2014). For example, the International Journal of Production Economics was classified as an Operations & Technology Management journal in the Academic Journal Quality Guide, while ISI Web of Knowledge classified it as both Operations Research & Management Science and Engineering. As such, distinguishing between the two classifications, journals were then grouped according to discipline, namely Operations and Technology Management (OTM), Engineering (E), Information Systems and Management (ISM), Operations Research & Management Science (ORMS), Management (M), Information Management Systems (IMS) or Computer Science & Engineering (CS & E). This analysis highlighted the interdisciplinary nature of the research in the field of manufacturing capabilities.

<i>Most cited Journals</i>	<i>Number</i>	<i>Classification</i>	
		<i>ABS</i>	<i>ISI</i>
International Journal of Operations & Production Management	12	OTM	M
International Journal of Production Research	10	OTM	ORMS & E
Journal of Operations Management	9	OTM	ORMS
Decision Sciences	8	ORMS	M
International Journal of Production Economics	8	OTM	ORMS & E
Institution of Mechanical Engineers Part B – Journal of Engineering Manufacture	3	N/A	E
Production and Operations Management	3	OTM	ORMS & E
Omega	2	ORMS	M
Strategic Management Journal	2	M	M
Industrial Management and Data Systems	2	IMS	CS & E
CIRP Annals – Manufacturing Technology	2	OTM	E
Journal of Manufacturing Technology Management	2	OTM	Not classified
Others	40		

Table 2.3: Most cited journals

Following these initial classification exercises to understand our data and which journals they are predominantly published in, a more thorough classification for the identified paper was undertaken, according to their methodological and epistemological perspectives

2.4 Article Classification Results

2.4.1 Research Paradigms

The paradigmatic approach to any research endeavour should occupy centre stage in the research process and should be given adequate consideration before commencing on the activities. According to Guba and Lincoln (1994), a paradigm is defined as “the basic belief system or world view that guides the investigator, not only in choices of method, but in ontologically and epistemologically fundamental ways”. Without this, (Mackenzie and Knipe,

2006) suggest that there is no basis for subsequent selections regarding methodology, methods, literature or research designs.

While several paradigms have been identified in the literature (Table 2.4), there are two major opposing philosophical perspectives: positivism and interpretivism. The positive paradigm generally adopts an objectivist approach, with ontological assumptions that believe an objective world exists, “with reality as a concrete structure” (Morgan and Smircich, 1980). Procedures and methods used in natural sciences are therefore the preferred research approaches with strategies such as experiments and surveys leading to analytical methods such as statistical techniques and mathematical modelling. These methods generate ‘objective’ knowledge and are devoid of any subjective or ‘human’ input.

Classification	Categories	Examples of previous references using similar classifications
Research Paradigm	Positivist / Interpretivist / Critical Realist / Positive Realist	Burrell and Morgan (1979); Morgan and Smircich (1980); Denzin and Lincoln (2005)
Research Designs	Survey / Conceptual / Longitudinal / Case study / Experimental / Literature Review / other	Orlikowski and Baroudi (1991); Bryman and Bell (2007)
Research Methods	Surveys / Interviews / Observations / Simulation / Mathematical Modelling	Sachan and Datta (2005)
Data Analysis Techniques	Statistical / Modelling / Process Mapping / Content Analysis / Conceptual / Descriptive	

Table 2.4: Research paradigm classification framework

Interpretivism, on the other hand, adopts a subjectivist approach, with core ontological assumptions that see “reality as a projection of human imagination” (Morgan and Smircich, 1980) i.e. that access to reality is only achieved through social expressions such as language, culture and shared meanings. Preferred research strategies include case studies, action research and ethnography, with data collection methods such as unstructured interviews and observations, which allow the researcher to focus on meanings, try to understand what is happening and then interpret the results

Beyond these two contrasting perspectives exists a third stream known as realism which has elements of both positivism and interpretivism, where both qualitative and quantitative methodologies are seen as suitable tools (Healy and Perry, 2000) for researching the underlying structural mechanisms that constitute social systems, ideas, causes and effects. Two different realist perspectives can be found in the literature: the *critical realist* and the *positive realist*, which lean more towards qualitative (interpretivist) or quantitative (positivist) research, respectively (Wass and Wells, 1994)

Following the above discussion, four paradigms (Positivist, Positive Realist, Critical Realist and Interpretivist) were used to categorize the 104 articles identified. If the paradigmatic approach was not made explicit by the authors of the article, the selection criteria summarised in Table 2.5 were then used to make an assessment in terms of the article belonging to one of the 4 paradigms.

Research Paradigm	Selection Criteria	Examples of Methods Used
Positivist	<ul style="list-style-type: none"> Utilize natural science methods in social world Objective approach devoid of 'human input'. Researcher detachment Search for correlations between different social facts using statistical, mathematical or numerical evidence Human behaviour described in terms of cause and effect 	Surveys Questionnaires Statistical methods Math. Modelling Deductive
Positive Realist	<ul style="list-style-type: none"> Utilize natural science methods in social world Adopt more positivist approaches rather than critical realist. More likely to look for generalisations Recognize the possibilities of human perceptions about the real world impacting upon their actions 	Case studies Interviewing May have surveys May be contextual Participant observation
Critical Realist	<ul style="list-style-type: none"> Reject the view that the world is created solely by the minds of human observers (Interpretivists). A mind-independent reality, which has its own order, exists See things as being the case whether people recognise them or not (i.e. objectivity) Causal explanation aiming to identify objects, structures and mechanisms that connect them that cause events to occur Retroductive analysis of data i.e. take an outcome and try to explain it 	Case studies Contextual Interviewing Participant observation Action Research Grounded Theory
Interpretivist	<ul style="list-style-type: none"> There are no situations other than those which individuals create through their activities Interested in people and trying to understand how their actions and their view of the world is structured Researchers want to interpret these structures 	Interviewing Observation Ethnography Discourse analysis Action Research Grounded Theory

Table 2.5: Research perspectives

Following the completion of the classification process of the 104 articles (Table 2.6), it is evident that over the last 30 years the positivist paradigm has taken the dominant position in manufacturing capabilities research by a great majority. Table 2.6 indicates that 66.3% of all research contributing to this field did so by using positivist approaches. 10.6% were based on the interpretivist paradigm, which is “dependent on the ability to understand the way in which human beings shape the world from inside them” (Morgan and Smircich, 1980). This in itself presents a clear indication about what makes up acceptable and / or what might be ‘easily publishable’ manufacturing capability research.

<i>Paradigm</i>	<i>Frequency</i>	<i>Percent (%)</i>
Positivist (P)	69	66.3
Critical Realist (CR)	13	12.5
Positive Realist (PR)	11	10.6
Interpretivist (I)	11	10.6
Total	104	100

Table 2.6: Dominant Research Paradigms in Manufacturing Capabilities Research

This positivist philosophical stance, however, is not peculiar to manufacturing capabilities research alone. Other management disciplines such as the management of information systems (Orlowski and Baroudi, 1991; Chen and Hirschheim, 2004), logistics (Mangan et al., 2004), supply chain management (Burgess et al., 2006) and general operations management (Craighead and Meredith, 2008) all indicated the dominance of the positivist paradigm. This suggested that knowledge was being conceptualized as a rational function and investigated as a “science” (Burgess et al., 2006). However, Orlikowski and Baroudi (1991) previously warned on the dangers of an overwhelming dominance of a single research perspective in a field as being unnecessarily restrictive. Positivist studies are premised on the existence of a-priori fixed relationships within phenomena which are typically investigated with structured instrumentation. Such studies serve primarily to test theory, in an attempt to increase predictive understanding of phenomena. Little emphasis is placed on the historical context of the firms, the wide environment in which they operate or, for example, the role of the employee participation in the decision making, knowledge

management and/or innovation processes. Rowan (1973) argues that such a posture is not conducive to the discovery and understanding of non-deterministic and reciprocal relationships and notes that “research can only discover one-sided things if it insists on setting-up one-sided relationships”.

2.4.2 Dominant Research Design

By research design we refer to the set of tools, including methods and procedures, used to integrate the different components of the study in a coherent and ordered way towards ensuring that the research problem is addressed. Operations management authors, for example, Voss et al. (2002), have stated that “research design in operations management should pay attention to what processes and systems are to be studied, the methods for studying them, and the operating data to be collected from them”. This of course, ensures the quality and validity of the research especially due to its abilities to inform practice.

<i>Research Design</i>	<i>Frequency</i>	<i>Total Frequency</i>	<i>Percent (%)</i>
Survey	P(53), PR(2)	55	53
Conceptual	P(16), I(4), CR(6), PR(2)	28	27
Case Study	I(4), CR(8), PR(4)	16	15
Longitudinal studies	P(1), I(3), PR(1)	5	5
Total		104	100

Key: P (Positivist); PR (Positive Realist); CR (Critical Realist); I (Interpretivist)

Table 2.7: Research design in manufacturing capability research (based on Guba and Lincoln, 1984)

The 104 selected articles illustrate a strong dominance of empirical studies (76 articles, which adopted research designs such as surveys and case studies, with the remaining 28 papers being conceptual in nature (see Table 2.7). MacCarthy et al. (2013) previously argued that in operations management research, where the main scholarly contribution is to identify, model, explain or otherwise categorize an empirical phenomenon (Slack et al., 2004), the corresponding concerns of the academic operations management field have primarily been about whether it was sufficiently focused on “real” managerial preoccupations (Wilson, 1995), hence calling for empirical studies. However, MacCarthy et al. (2013) debate that operations management researchers need to do more to identify

robust theories emanating from a sound empirical base that have the potential to provide useful generalizable knowledge. This requires more “meta studies”, such as that reported by our article, in order to evaluate and synthesise research for generating usable knowledge.

Findings from the classification exercise in relation to the research design employed in manufacturing capabilities research also indicate, however, that in the empirical papers reviewed survey designs dominate (55 papers, representing 72% of all empirical articles). This is not surprising, considering the dominance of positivist related research in the field of operations management, as identified in the previous section. However, as previously argued by Meredith (1993), although the proportion of empirical research in the area is increasing, empirical research with a strong conceptual and methodological base appears less common. The dominance of survey design highlights that researchers have been preoccupied with building quantitative models, which scholars in most fields would classify as theory-testing rather than theory-building research. It is argued that such research has little or no relation to reality and offers little or no help to managers responsible for managing real world systems (Meredith, 1993)

A notable find, though is the increased presence of conceptual research designs. These involve the use of conceptual research methods based on descriptive, empirical investigations and can significantly increase the external validity of research conclusions and, as a result, can increase their corresponding relevance to managers. Conceptual methods, building primarily on description and explanation, lead to a better balance between theory-building and theory-testing research. However, out of the 28 conceptual articles, 16 (representing 57%) belonged to the positivist paradigm, following a theory-testing approach (based on quantitative modelling, simulation, and laboratory experimentation).

The findings also highlight noticeable absences from the research design choices such as action research, grounded theory and ethnography. Though grounded theory and ethnographic based studies may be unfamiliar territory for operations management researchers, operations management scholars have previously called for the use of action research, for example see Coughlan and Coughlan (2002). Their argument for the use of this methodology is centred on action research being an approach that aims at taking action, engaging in research that is interactive, conducted in real time, and creating, rather than testing, knowledge. Similar arguments for the use of grounded theory in operations management, though scanty, are available. Binder and Edward (2010) argue that

operations management will benefit from more qualitatively led studies which will develop theories that help to explain current phenomena and the relationships between their relevant building blocks.

2.4.3 Research Methods

Various options exist whereby researchers not only collect their data for their research, but also working towards answering research questions or satisfying research objectives, while also utilising some data analysis tools. Those options utilised in manufacturing capabilities research are given in Table 2.8.

<i>Research Methods</i>	<i>Frequency</i>	<i>Percent</i>
Questionnaires (Surveys)	56	53.8
Interviews	18	17.3
Mathematical modelling	14	13.5
Conceptual (Thought pieces)	13	12.5
Literature review	3	2.9
Total	104	100

Table 2.8: Research Methods in Manufacturing Capability Research

Unsurprisingly, in light of the previous findings, a strong bias can be observed towards quantitative research methods, such as surveys and modelling (67.3%), as opposed to only 32.7% of the papers reporting the use of conceptual, qualitative methods. Another issue of concern is the relative lack of mixed methods being used. To achieve triangulation of findings and increase generalizability, it is generally recommended that a number of methods be used to address research questions (Wacker, 1998). The lack of mixed-methods can have an adverse impact on the development of a field that already appears to focus on theory testing approaches.

2.4.4 Content Analysis of Research into the Management of Manufacturing Capabilities

The next step in the study was to identify 'what' has been the focus of research in the field of manufacturing capabilities over the past 30 years. The results of content analysis with regards to emerging research themes can be found in Figure 2.3, where an initial high-level analysis shows that the majority of studies into manufacturing capabilities are concerned with aspects related to *Processes / Organisation* (86 papers), compared to only four papers addressing aspects related to specific *Technology* adoption and 14 papers focusing on *People / Attitudes*.

It needs to be highlighted here that no pre-defined frameworks, themes or codes were used at the outset of this activity, towards avoid any bias of trying to fit the data into a pre-determined model. As such, with regards to the content analysis and coding of each paper's contribution to knowledge, various steps were taken to achieve this task, using a modified version of Mayring's (2004) framework for content analysis (see Figure 2.2). Phrases such as "*the paper proposes a model of the relationships among sources and outcomes of competitive advantage*" or "*in this paper, we provide a summary of the recent management theories by comparing their salient features*", were given adequate consideration as indicators to the content and argument of that paper.

2.4.4.1 Technology Focus

Four papers clustered into this category, as they particularly focused on the management of advanced technologies as a core manufacturing capability. Within these 4 papers, Chung and Swink (2009) investigate the relationship between patterns of Advanced Manufacturing Technology utilisation and manufacturing capability attainment; Terjesen et al. (2011) investigate manufacturing capabilities contributing to low operating costs and high product quality in the context of high technology new ventures; Zhang et al. (2006) and Spanos and Voudouris (2009) address the use of advanced manufacturing technologies as an antecedent to flexible manufacturing competence.

2.4.4.2 People / Attitudes Focus

The limited number of papers in the *People / Attitudes* category (14) is particularly concerning, especially as only a single paper (Camuffo and Gerli, 2007) was identified

which relate manufacturing capabilities to personal, more tacit, knowledge and skills management within the organisation and emphasises the importance of human resource management (*HRM*) in this context. Within the *People / Attitudes* category, a further sub-category of 13 papers were identified, which focused on the importance of *Knowledge Management* (*i.e.* knowledge of the organisation) in developing manufacturing capabilities, though the human factor was not made as specific as in the *HRM* category. Within this sub-category, three papers emphasise the aspect of *Transfer* of manufacturing capabilities (either within the same organisation, over time – e.g. Zander and Kogut, 1995; or from an external entity – e.g. Liao et al., 2011), seven papers propose *Models* for knowledge management in the context of manufacturing capabilities (e.g. Paiva et al., 2002 address manufacturing capabilities from a knowledge based view of the firm) and three papers highlight the importance of the *Learning* organisation in this context. For example, Huang et al. (2008) investigate the role of learning in the development of mass customization capabilities.

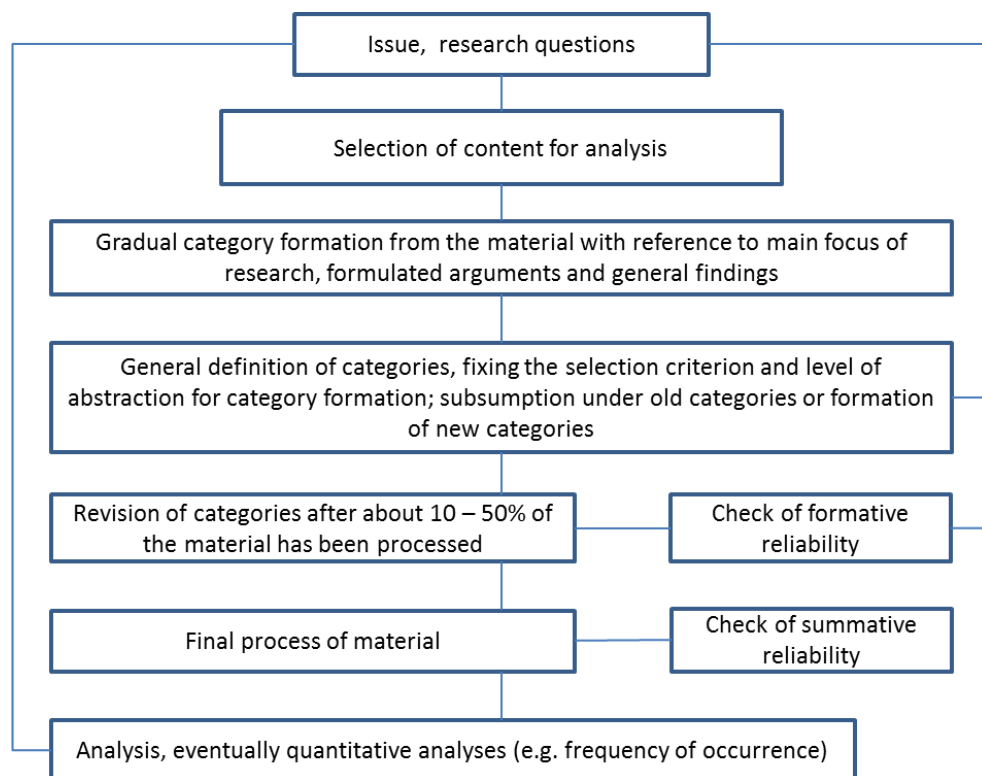


Figure 2.2: Flow-chart of procedures for qualitative content analysis

2.4.4.3 Process / Organisation focus

Within the *Process / Organisation* category, by far the largest (86 papers), a series of four sub-themes emerged: *Strategy* (60), *Evolution* (13), *Outsourcing* (2) and *Measures* (11). The large number of papers in the *Strategy* sub-category (60) is perhaps unsurprising, considering the fact that manufacturing capabilities have long been perceived as having a strategic role in the firm, contributing to competitive advantage and performance improvement in terms of both operational efficiency and efficient product development. The majority of these papers follow the sandcone or cumulative theories found in manufacturing capabilities research. Within the papers in the *Strategy* sub-category, five main themes emerged: *Performance* (23), *Competition* (8), *Configuration* (22), *Networks* (3) and *Innovation* (4). The *Performance* theme is the largest Level 3 cluster identified across the content analysis, with 23 papers focusing on ascertaining the impact that the adoption of certain manufacturing capabilities may have on key performance indicators (flexibility – e.g. Fawcett et al., 1996; customer satisfaction – e.g. Rosenzweig et al., 2003; financial performance – Vickery et al., 1991), with some also highlighting certain contextual variables that might mitigate the effect. Within this sub-category, a strong emphasis on positivistic research was apparent (96% of papers), as expected by the strong focus of these studies on measuring the impact that the adoption of certain capabilities might have on performance.

The *Configuration* theme (22 papers) includes papers that focus on understanding the way manufacturing capabilities should be configured within an organisation. For example, Ward et al. (1996) develop strategic configurations which describe commonly used paths by manufacturers to achieve competitive advantage, while other papers refer to the strategic arrangement of capabilities, in particular forms or combinations, giving rise to either the Trade-Off, Sandcone or Cumulative theories (Avella and Vasquez-Bustello, 2010; Sarmiento and Shukla, 2011). The *Competition* cluster (8 papers) particularly discuss manufacturing capabilities in the context of ensuring competitive advantage (e.g. Linden et al. (1998) examine capabilities that Asian 'second movers' such as Korean and Taiwanese firms adopted in order to build globally competitive advantage, in competition with Japanese firms, which were thought of as the leaders in the then regional production hierarchy). The *Innovation* cluster (4 papers) emphasises the role of manufacturing capabilities in supporting product and process innovation, especially with reference to external market forces. For example, Bozarth and Berry (1997) present a methodology for evaluating the congruence between market needs and manufacturing plant capabilities while Corbett and Campbell-Hunt (2002) examined how the operations of six manufacturers responded to the

turbulence in their business environments. The *Networks* cluster (3 papers) captures the importance of competitive priorities being grounded not only in the development of internal manufacturing capabilities but also in the design and management of the supply chain. The relatively small number of papers in the *Networks* category is even more surprising considering the fact that, particularly in the developed world, there is an increasing trend towards management of manufacturing being no longer confined to an individual firm but outsourced to global locations. As such, the role of the supply network in managing outsourced manufacturing capabilities appears as a notably under-researched area. That is, of course, not to say that there are only three papers in the body of operations and supply chain management literature currently addressing the role of supply chain management in managing suppliers which manufacture a variety of goods or services. It is the particular focus on the management of manufacturing capabilities, through appropriate integration mechanisms, that is missing in this context.

Evolution of manufacturing capabilities (13 papers) was the second sub-category in the *Process / Organisation* category. 4 of the papers focus on *Co-evolution Modelling* of various capabilities within the firm (for example, AlGeddawy and ElMaraghy, 2011) hypothesize that the evolution and co-evolution of products and the machines used to manufacture them is akin to that observed in the adaptation of biological species and they proceed to study the symbiosis between products and manufacturing capabilities using real examples). 8 papers concentrate on aspects related to *Development* of manufacturing capabilities (e.g. Gavronski et al. (2011) propose a model for factory resources leading to the development of green manufacturing capabilities and global sustainable manufacturing competencies). 1 paper discusses aspects related to manufacturing capabilities in the context of *Firm Growth* (Zhai et al., 2007). Overall, papers in the *Evolution* sub-category specifically highlight the fact that, as products and markets change over time, the role of manufacturing capabilities should change too. As such, when making strategic decisions regarding manufacturing capabilities, it is important for firms to consider their dynamic nature. This concept is referred to in some of the strategic management literature as “*dynamic capabilities*”, defined as a learned and stable pattern of accumulating experiences through which organizations systematically generate and modify their operating routines in pursuit of improved effectiveness (Macher and Mowery, 2009), but without making specific consideration to manufacturing capabilities, which was the focus of our review.

The *Measures / Dimensions* sub-category (11 papers) within the *Process / Organisation* category focuses on quantitatively assessing certain manufacturing capabilities. Wu and Pearn (2006), for example, propose a Bayesian approach to provide numerical measures

on whether a process is capable of reproducing products which meet the manufacturing specifications, while Wu (2006) developed a capability testing procedure to enable practitioners to make reliable decisions in order to determine whether their processes meet the pre-set capability requirement for production control planning. Similarly, other researchers, such as Hsu and Shu (2008) present a fuzzy inference to assess whether a process conforms to the defined manufacturing capability prerequisite. Again, perhaps unsurprising, as the focus of these papers is the measurement of certain variables, there is a strong bias towards the adoption of a positivistic stance in this category (8 out of 11 papers, representing 73%).

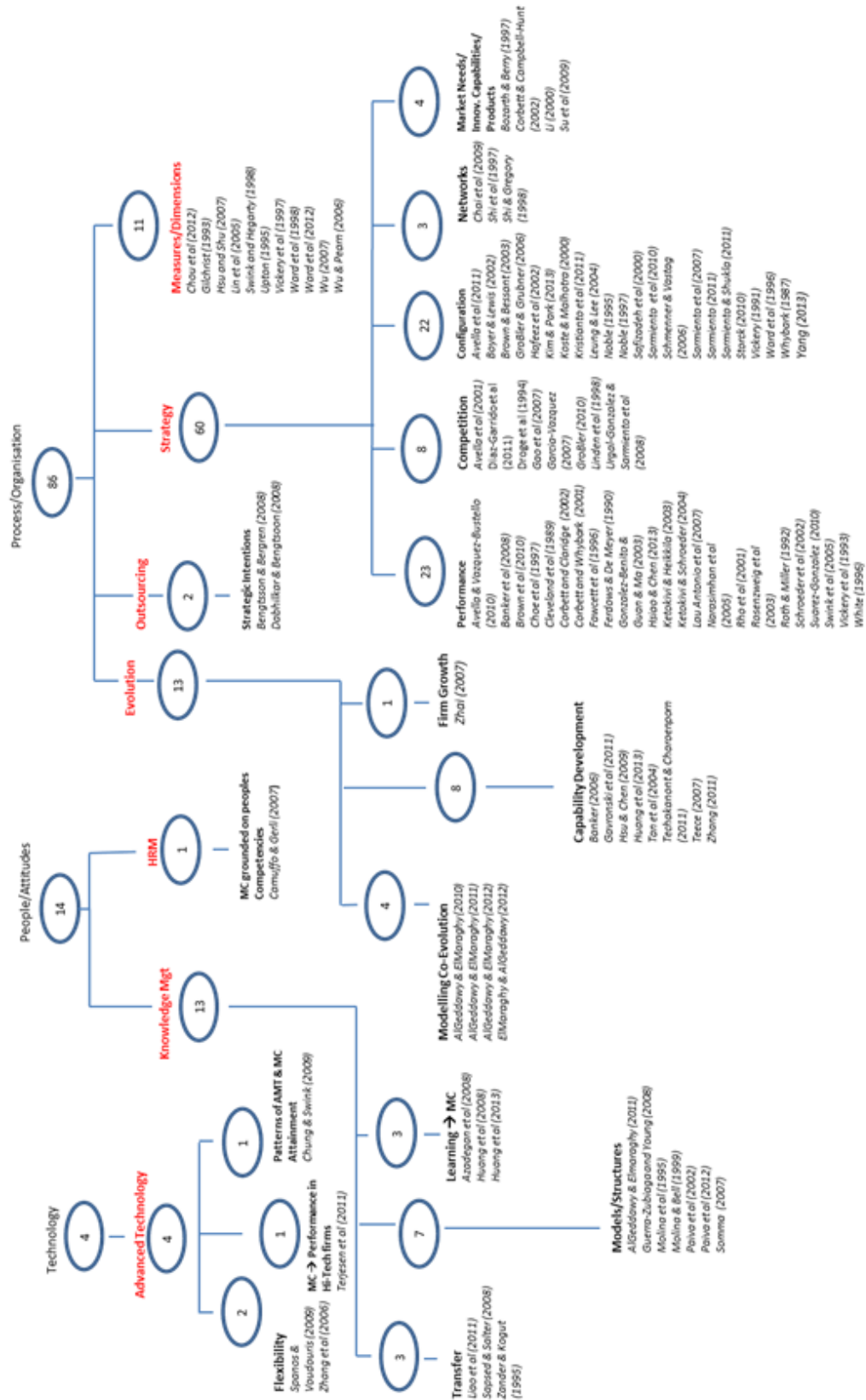


Figure 2.3: Content analysis results and emerging themes from manufacturing capabilities research

The *Outsourcing* Level sub-category (2 papers) specifically explores the dynamics associated with outsourcing manufacturing capabilities. As was the case of the *Networks Level 3* theme (3 papers) under the *Strategy* sub-category, the lack of focus of research on managing manufacturing capabilities beyond the boundaries of the focal firm is of particular concern, particularly in the context of globalisation and fragmentation of today's supply chains.

2.5 Discussion

The study investigated how operations management research into manufacturing capabilities has been conducted from different methodological perspectives, including detailed insights into the research paradigms, research designs, research methods and the different analysis techniques used during these endeavours. The study also addressed 'what' the foci of the different research activities in the field of manufacturing capabilities over the last 30 years have been, by highlighting the emerging themes with regards to the key contributions to knowledge made.

The research revealed that the manufacturing capabilities field is dominated by a positivist 'hard core', in which quantitative research methods such as surveys and modelling take precedence. This is, perhaps, unsurprising considering the fact that the field is grounded in the operations management discipline, which has strong influences from operations research, management science and engineering. Indeed, this has implications for the development of theory as well as for the practice as it is believed that more of a focus on the interpretive, qualitative methods will nurture a more conducive atmosphere to continually develop current and relevant theories which solve problems within the field. According to the findings, data collection methods such as qualitative case studies and interviews, where the researcher is actively engaged with the participants, are not widely used, although authors, such as Craighead and Meredith (2008), have argued for the field of operations management to evolve toward more interpretive research and analysis based on natural observations of reality, thus increasing its relevance to practice.

In order to advance the field further, considering the findings above, the paper calls for more 'applied' research towards finding new channels through which to obtain organizational insights (Daft and Lewin, 1990). Some of the methods and methodologies within operations management research may include those least used, such as ethnography, grounded

theory, action research and other observational based data collection approaches. Currently, these appear not to be used at all in the area of manufacturing capabilities.

A second aim of this study was to explore the specific focus of research into manufacturing capabilities. The main findings highlighted an 'uneven' distribution across the discipline. Definitions of manufacturing capabilities as "the strength or proficiency of a bundle of interrelated routines for performing specific tasks" (Peng et al., 2008) implying that these competencies are a combination of both soft and hard resources, which should include people, skills, processes, machines, technology.

More notably, the impact and importance of the behavioural / human factor aspect, as well as the technology contributions, seem to have been particularly under-researched in the manufacturing capabilities studies reviewed. Moreover, with the people and technology aspects of manufacturing capabilities research not being adequately represented, with 3.8% and 13.5% respectively of the total research conducted in the field of manufacturing capabilities, as opposed to an 82.7% majority in the process/organisation aspect, these should also be approached scientifically by using more interpretive methods of inquiry. Some exceptions do exist.

The findings also indicate opportunities for the advancement of manufacturing capabilities research. These may be achieved through the investigation of manufacturing capabilities in relation to human resources management, outsourcing and technology, particularly in terms of the emerging advanced manufacturing capabilities. The amount of operations management research in the field of manufacturing capabilities is steadily increasing and there is a high risk that, if the same patterns are followed in terms of both paradigm choice and research focus, more of the same knowledge will keep being produced, thereby missing out on the opportunity to make a real difference in terms of practice.

2.6 Chapter Reflections

Having engaged extensively with practitioners in the course of my job, I saw the extent to which they needed solutions to problems they faced on a daily basis. Having also read through a lot of academic publications, some of which were done in collaboration with industry, the applicability of a lot of them towards developing practical solutions to industry challenges was in doubt. For many of these organisations, developing practical step-by-

step processes to support the acquisition of certain skills and capabilities was enough to solve their problems – for example, LEAN transformational processes such as TIM WOODS⁸ or DOWNTIME⁹, which supported the development of certain types of manufacturing capabilities using visual and socially oriented processes to solve immediate problems.

On the contrary, during my engagement with practitioners, they spoke of instances where they had approached academics concerning practical problems only to be coerced into participating on some ‘funded change project’ which invariably involving complicated scientific or engineering studies or numerical analytical processes which at best, partially solved their problems. Apparently, they (the practitioners) arrived at the conclusions that the academic had probably spent so much time immersed in his/her tools and software (objectivism) conducting fundamental research, that they had lost the ability to interact for extended periods of time (interpretivism) towards developing solutions fundamental to ongoing problems. This therefore informed the decision to carry out this PhD thesis solely, on the basis of grounding the data in practice, hence, the choice for the use of grounded theory methodology. While the challenges were many, the interest garnered from practitioners has been worth it.

Finally, the major gaps identified in the literature included the following:

- Majority of the studies appeared to address process/organisational aspects of manufacturing capabilities, at the expense of people/attitudes and technology adoption (see Figure 2.3). This therefore represents some opportunities for the advancement of manufacturing capabilities research by conducting research into areas such as the relationships between manufacturing capabilities and HRM
- There seemed to be a paucity of inductive, theory building research, especially those using methodologies such as grounded theory and action research. Most publications accessed were deductive in nature, seeking to test and confirm different hypotheses

⁸ TIM WOODS is an acronym that provides organisations with a framework for identifying wasteful steps in organisational processes and operations so that they can be removed. T represents Transportation, I represents Inventory, M represents Motion, W represents Waiting, O represents Over-production, O represents Over-processing, D represents Defects, S represents Skills (Kumar and Sanchez-Rodriguez, 2018)

⁹ Graban (2018) identify eight main types of wastes in healthcare summarised with the acronym DOWNTIME, where D represents Defects, O represents Overproduction, W represents Waiting, N represents ‘No use of stafF’, T represents Transportation, I represents Inventory, M represents Motion, E represents Extra processing.

Chapter 3: Research Design and Methodological Considerations

3.1 INTRODUCTION

Yin (1994) in his seminal work described a research design as an action plan for getting from here to there, where 'here' was defined as the initial set of questions to be answered and 'there' signified the logical end of the endeavour where some set of conclusions, which provided systematic interpretations in response to these initial questions asked were provided. He stated further that, "between here and there may be found a number of major steps, including the collection and analysis of relevant data". This proposition for the effective accomplishment of research suggests the need for a series of careful, orchestrated and interrogatory steps to be undertaken. These 'interrogatory steps' are the subject of frameworks and orchestrated processes proposed by Brady and Collier (2004), Frankfort-Nachmias and Nachmias (2007), Denzin and Lincoln (1994), Mason (2002) and Walliman (2016). Of all these frameworks, a combination of Denzin and Lincoln's (1994) as well as Mason's (2002) theories was adopted by the researcher due to their initial explicit statements suggesting that issues such as the researcher's self-beliefs and ethics as well as the theory and philosophical paradigms and perspectives be taken into consideration before the actual research design and methodological choices are made. This modified and combined research process framework is shown in Figure 3.1

This chapter therefore, and first of all, takes into consideration the researcher as a partaker in the research process and analyses how the choices made during the activities are influenced by the totality of the individual. Following this, the chapter also provides an overview of the philosophical and methodological considerations that constitute the overall research design of this study. The foundation of research paradigms will be discussed following which three major research paradigms will be explained and rationalised. Herewith, the researcher's philosophical and methodological positions will be acknowledged and critically discussed thereby considering the current debates and factions surrounding these and other related issues within [operations] management theory and research. These debates include the criticisms and challenges that surround each of the paths taken as well as the likely results that may be derived from the research, had alternative paradigms been considered and/or adopted.

Thirdly, an overview of the Grounded Theory (GT) methodology will be presented and justified as an appropriate choice for the present research endeavour. Starting with the seminal work by Glaser and Strauss (1967), the origins and growth trajectories of this construct will be discussed and the factions within assessed, especially as this study adopts the Glaserian version of the grounded theory methodology. A brief overview of GT led studies – or paucity of, in management research, especially with respect to operations management will be highlighted also giving reason for the researcher’s choice of methodology.

Lastly but equally importantly, ethical considerations will be discussed relating to the overall conduct of this study. Issues such as informed consent, confidentiality and anonymity will be discussed and reasons for these considerations will be stated.

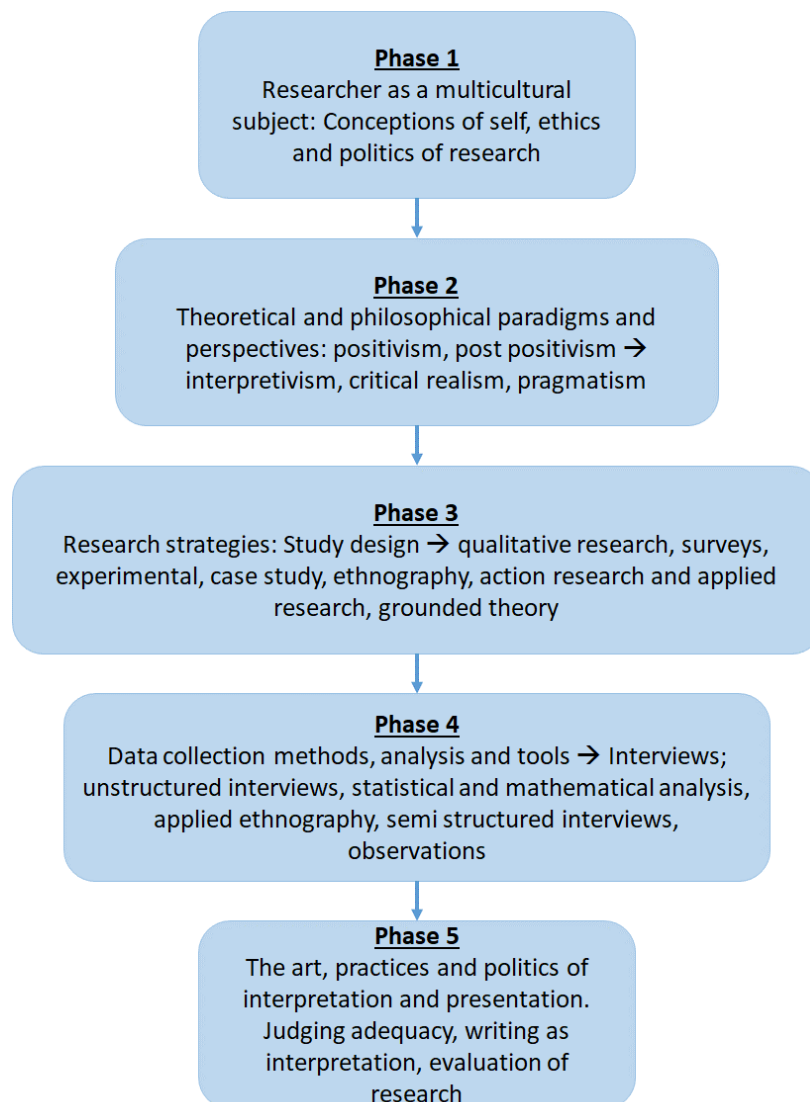


Figure 3.1: Research framework

3.2 The Researcher as a multicultural subject

Various scholars have brought about a greater understanding concerning the subject of the researcher as an individual, a multicultural subject as well as a stakeholder in the activities surrounding the research journey he or she is engaged in. While it is often emphasized that researchers should strive to maintain 'value free' research activities, which include adopting approaches that are not influenced by political, moral and racial considerations which eventually influence the outputs, it is often proposed that only a conscious and well thought of strategy can facilitate the achievement of this task. Denzin and Lincoln (1994) for example, describe the researcher as a 'bricoleur', who understands that research engagement is an interactive and dynamic process which is continually shaped by his or her personal history, biography, gender, social class, race and ethnicity. Gummesson (2000) on the other hand, uses the word 'paradigm' as described by Kuhn (1962), to explain further, that people's value judgements, frames of reference perspectives, ideologies and standards govern their thinking and action, and thereby influence not only their research choices, but also their interpretation of events arising from the engagement with their research subjects.

Denzin and Lincoln (1994) further emphasize that these characteristics are often in subtle and constant conflict with those of the people in the research setting, due to their own inherent characteristics and personal agendas. It is therefore considered an important part of the research undertaking to reflect upon, as much, transparent and honest as possible, these conditions and how they will influence the engagement with the research subjects as well as the possible outcomes from the research process. According to Gummesson (2000), "it is desirable that academic researchers account for their personal values, at least to themselves". These arguments have indeed, given the researcher enough impetus to question his motives, ideologies and research choices in relation to this project. Once again, as highlighted in the introductory chapter, the reasons for embarking on this project were to understand the factors behind the continued and competitive successes of a select group of 'high growth, high value' manufacturing small and medium enterprises and to develop models of best practice for onward use in helping other organisations needing business interventions to enhance their competitiveness.

Using more scientific methods, this issue has been delineated by other researchers and educational psychologists. For example, James and Vinnicombe (2002) and Biggs (1978) have examined in some detail the psychology behind how personal characteristics affect

academic studies, research interests and their respective outcomes. James and Vinnicombe (2002) for example, have examined the individual behind the role of researcher and concluded that it matters in a variety of ways and accounting for individual preferences in management research is of particular importance. They have proposed three ways of highlighting the individual thereby identifying psychological preferences which influence a researcher's choice and approach. These include:

- personal interests and perspectives – personal aims are never far from the choice of, and directions taken in research activities. This therefore introduces the concept of 'value laden' research. Because of this, it is argued that researchers need to be aware of their own values, biases and experiences and how these inadvertently impact on their study results (James and Vinnicombe, 2002).
- personal relationship to data – once again, it is highlighted that the quality of data collected depends on the individuals understanding and their involvement with the topic. This is especially applicable with interpretive approaches, *where the researchers' personal interpretation of events and how they combine to create knowledge is an integral part of the new knowledge creation. It is pertinent to state that no two people, given the same evidence across multiple sites, will arrive at the same conclusions.*
- personal characteristics – as it is with individuals, some researchers may favour more visual methods of data collection, analysis and representation, while others may be more conversant with numerical structures. In the same vein, some may prefer to spend time immersed in ethnographic pursuits to facilitate their data collection while others favour the anonymity of IT enabled web survey tools. According to James and Vinnicombe (2002) these may be explained from the dimensions of human characteristics such as extroversion and introversion, sensing and intuition, thinking and feeling as well as judging and feeling

Biggs (1978) on the other hand proposed a model in which the study process mediates between presage factors and the final product. In this case, the presage factors were identified as personal (cognitive style, IQ, personality and home background) and institutional characteristics (i.e. subject area, teaching and research methods and course structures), providing further indication that these factors, individually or combined, affect the research outcomes, which in this case is represented by the product (see Figure 3.2)

This discourse concerning the researcher and how he or she understands the research subject(s) in relation to self-identification and interests offers further enlightenment through the application of reflective and reflexive practices. Once again, James and Vinnicombe (2002) emphasize that some self-awareness is appropriate and high levels of reflexive behaviours need to be articulated in the reporting of the research results. According to Dalos and Stedmon (2009), “reflective and reflexive processes potentially allow us to be self-critical and ethical in our clinical practice, nurturing our development as therapists and sustaining our practice-based learning”. Although their submissions on the issues of interest were directed towards medical and healthcare interventions, the applicability of the reflective and reflexive behaviours to management research is equally significant and has been explored by both management researchers and practitioners. Once again, this has emphasized the need for the researcher’s consideration of such matters, which will be explored in the next section.

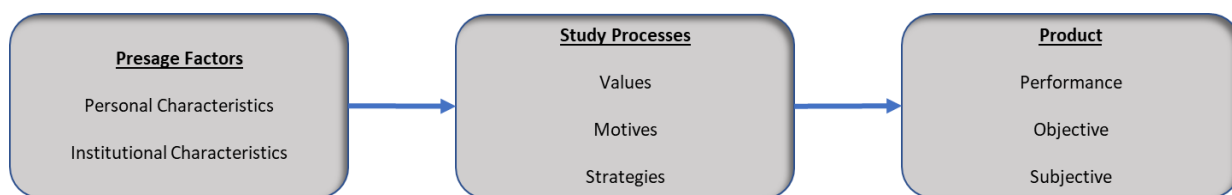


Figure 3.2: Model of Study Process – Factors affecting outcomes

3.3 Reflexivity in Management Research: Personal Considerations

In order to understand ourselves as management researchers, the process of engaging with ourselves through thinking about our own thinking is necessary (Weick, 1999). This process however is difficult to engage with as Nadin and Cassel (2006) argue that there is little information available to the qualitative researcher about how to ‘do’ reflexivity in practice. According to Johnson and Duberley (2003) however this entails noticing, evaluating and being suspicious of the relationship between the researcher and the ‘objects’ of research.

Some of the issues surrounding the management and development of reflexive practices for business, management research and management education have been somewhat

explored by scholars across multiple disciplines within the management continuum. HRM and Organizational Studies have developed arguments such as those put forward by Janssens and Steyaert (2009) for example, who argue that reflexivity is needed for theorizing HRM and taking the field further. Others such as Cunliffe (2002, 2003, 2004, 2009), Alvesson (2003), Alvesson et al. (2008) Chia (1996) and Hibbert (2013) all make arguments for reflexive considerations in Organisational Studies and management learning. Other disciplines including Accounting (Schneider, 2015), Leadership (Cunliffe, 2009) and Strategic management (Booth, 1998) have developed arguments for the embedding of reflexivity practices in their activities. Operations Management is not left out, as scholars such as Leonard and McAdam (2001) and Johnson et al (2001) develop arguments referring to practitioner reflexivity in TQM research and the need for reflexivity in negotiating field roles in manufacturing management research respectively.

As a prelude to the discourse surrounding the importance of reflexivity in research activities however, the researcher builds his argument upon Watson's (1987) statement that "being reflexive is structuring communicative products so that the audience assumes the producer, process and product are a coherent whole". Easy as that statement may seem, the process leading to its achievement is far from straightforward and perhaps the definitions and arguments management researchers have engaged in will provide the information needed to furnish the researcher with the knowledge needed to consider the construct in his endeavour.

Management researchers, for example Booth (1998) define reflexivity as "a general scepticism towards one's own and others' knowledge or truth claims". In a sense, Booth (1998) simply cautions us towards thinking deeply about the knowledge we [think we] possess, a sort of self-awareness, as well as that which others claim as truth, especially if we attempt to use this knowledge for a purpose. Alvesson and Skoldberg (2000) also define reflexivity as, "the way different kinds of linguistic, social, political and theoretical elements are woven together in the process of knowledge development, during which empirical material is constructed, interpreted and written". During this process of constructing and interpreting the empirical materials, the process of regulating one's thoughts through recognising one's own prejudices and assumptions and situating these with the research being undertaken, as though an 'out-of-body' experience where the researcher is watching himself while undertaking his research, is necessary. This is aligned to Hibbert's (2012) argument that reflexivity is intrinsic to the emancipation of thinking and the overcoming of our deeply hidden influences and constraints, hidden within our own assumptions. In a more explicit manner, reflexivity recognizes the inevitably dynamic relationship between

researchers and their subjects and rejects the notion that the researcher is able to discover facts about his/her subject without influencing, or being influenced by the subject (Orr and Bennett, 2009). In the search for value-free research therefore, the need to adopt processes and/or procedures to eliminate these incidences of personal bias tainting the research processes, whether during the data collection, analysis or dissemination stages, established methodologies need to be employed. According to Johnson and Duberly (2003), there is a need for the researcher to rigorously deploy well established scientific methodologies to enable the accumulation of facts...so as to objectively develop and ground theory.

Alvesson et al (2008 on Reflexivity)	Further Descriptions	Actions taken by Researcher
Reflexivity as multi-perspective practices	...some theorists argued that a multi-paradigmatic view of a particular phenomenon or study could be used to provide a more comprehensive understanding (Gioia and Pitre, 1990) Morgan (1983) acknowledged 'the fallacy of trying to evaluate the different perspectives from a single perspective within the system and argued in favour of a dialectic between a number of such points of view	Early in the research, multiple considerations were debated concerning the philosophical options available. Although the choice to go down the positivist route was never considered, due to the 'hardness' of its methods, the choice between adopting a purely Constructivist approach to that of the Critical Realist was debated
Reflexivity as multi-voicing practices	The second set of practices focuses on the identity of the field worker and their relation to the 'other', defined as the research subject ...furthermore, it has been suggested that the researcher and the research subjects collectively negotiate the meaning of language, undermining the privileged position of researchers over research subjects and weakening the claims of the former to report reliably on the experiences of the latter (Denzin and Lincoln, 1994)	Following the transcription of some of the recorded interviews, the transcripts were given to the interviewees who sometimes responded with further interpretations to particular aspects of the transcripts. This process of course, reduced the power I had, to a certain extent to form my personal interpretations of the materials and interviews.
Reflexivity as positioning practices	...emphasizes the fact that 'knowledge is not something that people possess in their heads, but rather, it is something that people do together' (Gergen, 1991)	The researcher chose this research endeavour, the sole purpose of which was to 'create' new knowledge in collaboration with industry practitioners.
Reflexivity as Destabilizing Practices	Influenced by the writings of Derrida and Foucault, this literature is different from the above in that researchers do not reflect on their own theorizing but target the unreflexive research of others	Although it was difficult for the researcher to determine which research cited was 'unreflexive', a lot of knowledge was used, and built from the findings of other researchers.

Table 3.1: Reflexivity Considerations

A few other studies corroborate the importance of these subjects and provide adequate reference points from which the researchers' endeavours are framed. When making a case for reflexivity considerations, Easterby-Smith et al (2015) for example, argue that researchers need to consider their roles and the way the research process is affected, especially during data collection.

In support of reflexivity, Alvesson et al (2008) identifies four sets of textual practices that organization and management theory scholars have used in their attempts to be reflexive. These include reflexivity as multi-perspective practices, multi-voicing perspectives, positioning practices and destabilising practices.

Following the researchers' identification and alignment with some of Alvesson et al's (2008) textual practices, the researcher further identified and assessed recommendations proposed by other researchers. Nadin and Cassell (2006) for example, advocate the use of a research diary as a tool for reflexive practice. Citing examples of their previous research activities, the use of the diary provided them the opportunities to capture both the practical issues as well as the experience of the interview as a social encounter including all momentary emotional situations. The use of a research diary was one adopted early in this researcher's journey due to the methodological choice. Grounded Theory (discussed in a following section), being a methodology used to generate theory has always advocated the use of a diary and/or memos to capture situational occurrences or ideas and thoughts that come to mind

3.4 Research Philosophy

In order to be emancipated from identities associated with 'laypersons' and be removed from the pedestrian realm into the domains of enlightenment and erudition, the analyses of the different philosophical underpinnings in our areas of specialisation, the reading about the great thinkers' theories and their ideas concerning evolution of both physical and social sciences research, enable us contemplate how we view the world, thus realizing our own construction of knowledge and social reality (Mack, 2010). The confidence provided by understanding these different philosophical positions empowers researchers to engage in intellectual debates concerning the merits of each logical step taken with regards to the

approach to enquiry. Indeed, as expounded in the previous paragraphs, this supports the calls for reflexivity in our research as the consideration of philosophical paradigms causes the researchers to consider their individual biases and outcomes from the different considerations thereof.

This indeed, lays the foundation for intellectual development and independent thought, where a great emphasis is placed on the move from instructional surface learning to a deep structure which includes reflexive, learning and independent critical analysis (Bates and Jenkins, 2007). These concepts, deep and surface learning, are well established in higher education literature (Beattie et al, 1997) where surface learning, as described by Garrison and Cleveland-Innes, (2005) “employs the least amount of effort towards realizing the minimum required outcomes”, which in other words involves the memorization and regurgitation of facts without giving enough thoughts to their origins and the intentions (Entwistle, 1997). Surface learners therefore, are motivated to complete a task rather than absorb and internalize the required learning objectives. Deep learning (not to be confused with the branch of machine learning) on the other hand, involves the critical interaction with the contents of the particular area of study as well as the examination of the logic of arguments and related evidence which leads to the final conclusions (Beattie et al, 1997)

The foundation for deep learning is therefore dependent on the teaching and understanding of the foundations of research paradigms, which according to Guba and Lincoln (1994) are a set of basic beliefs that deal with ultimate or first principles...they represent a worldview that defines, for its holder, the nature of the world, the individuals place in it, and the range of possible relationships to that world and its parts. For a clearer definition of paradigms however, the researcher first of all turns to Thomas Kuhn’s 1962 book, *The Structure of Scientific Revolutions*, which according to Morgan (2007) is directly responsible for the popularity of paradigms as a way to summarize researchers’ beliefs about their efforts to create knowledge. Kuhn (1962) also defined paradigms as, “universally recognized scientific achievements that, for a time, provide model problems and solutions for a community of researchers”. He went on further, in a much simpler manner, to state that, “a paradigm is an accepted model or pattern...shown to be particularly revealing of the nature of things...and by employing them in solving problems, the paradigm has made them worth determining both with more precision and in a larger variety of situations”. A paradigm could also be regarded as an organising structure, a deeper philosophical position relating to the nature of social phenomena and social structures (Morgan 2007)

In a different slant, Paul and Marfo (2001) argue that paradigms differ in their assumptions about what is real, the nature of the relationship between the one who knows and what is known, and how the knower goes about discovering or constructing knowledge. In other words, paradigms shape, constrain and enable all aspects of educational enquiry

With respect to the paradigmatic discussions however, Guba and Lincoln (1994) emphasize that these paradigms can be explained in three elements; ontology, epistemology and methodology. The learning of, and purposeful interaction with these metaphysical concepts fosters reflexive thinking by encouraging learners to confront and justify their own beliefs, ideas and positions (Denzin and Lincoln, 1994; Saunders et al, 2007). This process therefore discourages the regurgitation and plagiarism of 'old' knowledge and encourages the critical analysis of multiple perspectives through questioning, challenging and even considering their uses, towards the development of new theories and knowledge

Firstly therefore, "ontology is the starting point of all research, after which one's epistemological and methodological positions logically follow" (Grix, 2002). Social ontology is concerned with the question about the nature of reality; whether social entities can and should be considered social constructions, built up from the perceptions and actions of social actors or whether they can be considered as objective entities (Bryman and Bell, 2007), which interact according to fixed laws (Morgan and Smircich, 1980). This resolution consequently splits the ontological positions into two perspectives, subjectivism and objectivism respectively. Broadly speaking, subjectivism is generally understood in social sciences, to be a position that emphasizes that social phenomena and their meanings are continually being established by social actors. This, according to Bryman (2001) indicates phenomena which are in a constant state of revision, undoubtedly through ever changing perceptions of the actors and events. Objectivism on the other hand is an alternative ontological position that 'asserts that social phenomena and their meanings have an existence that is independent of social actors' (Grix, 2002). In such cases, reality is likened to a concrete structure where according to Morgan and Smircich (1980), "the social world is a hard, concrete, real thing 'out there'....it can be thought of as a structure composed of a network of determinate relationships between constituent parts". It is indeed clear from these descriptions how a researchers' ontological position will influence the manner in which his research activities are conducted. This is indeed, evident in management research areas like OM, where it has been argued that the favoured ontological position is objectivist. This shall be further touched upon later in this chapter, where arguments for and against the adopted critical realist position are enumerated.

	Subjectivist approaches to social science					Objectivist approach to social science
Core ontological assumptions	Reality as a projection of human imagination	Reality as a social construction	Reality as a realm o' symbolic discourse	reality as a contextual field of information	Reality as a concrete process	Reality as a concrete structure
Assumptions about human nature	Man as a pure spirit, consciousness, being	Man as a social constructor; the symbol creator	Man as an actor, the symbol user	Man as an information processor	Man as an adaptor	Man as a responder
Basic epistemological stance	To obtain phenomenological insight, revelation	To understand how social reality is created	To understand patterns of symbolic discourse	To map contexts	To study systems, process, change	To construct a positivist science
Some favoured metaphors	Transcendental	Language game, accomplishment, text	Theatre culture	Cybernetic	Organism	Machine
Research methods	Exploration of pure subjectivity	Hermeneutics	Symbolic analysis	Contextual analysis of Gestalten	Historical analysis	Lab experiments, surveys

Figure 3.3: Subjective - Objective debate within Social Science (Morgan and Smircich, 1980)

As a complete *volte-face* to the ontological position, epistemology according to Thomas (2004) asks questions such as “how can we know anything with certainty...how is knowledge to be distinguished from belief or opinion...what methods can yield reliable knowledge?” Once again, Grix (2002) argues that epistemology is concerned with the theory of knowledge, especially in regard to its methods, validation and ‘the possible ways of gaining knowledge of social reality, whatever it is understood to be’. These epistemological claims are very often established on certain metaphysical assumptions and on the use of particular methods of reasoning. Thomas (2004) states for example, that empiricists argue that we can only be certain about knowledge that is based on our sensory observations while rationalists argue in favour of philosophical reasoning due to the unreliability of our senses. This therefore necessitates constant defensive arguments against criticisms from others who do not share the same assumptions and find fault with the research methods employed (Chia, 2002). This paradigm therefore focuses on how knowledge is gathered and the best ways in which this can be achieved towards “developing new models or theories that are better than competing ones” (Grix, 2002), or offering novel and practical extensions which take into consideration newly established phenomena.

To further understand epistemological concerns as well as provide in-roads into the researchers' philosophical stance, with reference to the general OM extent in the philosophical space, a brief look at the subsets of epistemology is explored. Two contrasting orientations dominate the debate in the social sciences: positivism and interpretivism. Although these two orientations are the most prominent, other lesser known orientations such as realism and post structuralism are also explored.

Positivism is generally known as an epistemological position that encourages the use and applications of the methods of the natural sciences to the study of social reality while constructivism is a position that "is predicated upon the view that a strategy is required that respects the differences between people and the objects of the natural sciences and therefore requires the social scientist to grasp the subjective meaning of social action (Bryman, 2001, cited in Grix, 2002). On the other hand, one of the lesser known epistemological positions, realism, argues that there exists a reality totally independent of our representations of it. It is therefore clear that the decision to adopt one epistemological choice over the other, will influence not only the methodology and methods used for the research undertaking, but the results as well.

3.4.1 Fundamentals of the Positivist Approach

Much of the modern philosophy of science elaborates upon various empiricist positions especially the radical empiricist stance known as positivism - the basis of which was that only analytic and synthetic statements have cognitive significance and the nonanalytic are only meaningful if they can be subject to empirical tests (Caldwell, 1980). This argument by Caldwell (1980), in his historical trajectory of the concept, argued further that assertions that only meaningful statements, i.e. those backed up by tangible evidence, were to be given scientific consideration and accorded the status of knowledge claims. This inadvertently set the scene for the bias towards positivist research, which remains until this day.

The positivist approach to research maintains that the methods of natural science constitute the only legitimate methods for use in social science. The ontological assumption in positivism identifies with an external world independent of the researcher while the epistemological assumptions are that this external world can be observed objectively (See Figure 3.3 for description of objectivity characteristics). Coined by Auguste Comte in the

19th century, 'positivism' was used to describe the doctrine laying the foundation for the development of the 'scientific method' (Sarantakos, 1993), which was especially important during that period when developments in the natural sciences were reflected in social and political life leading to Europe's position as the center of civilization.

Positivism therefore inclines towards the use of quantitative data because according to Bryman (1984), the paraphernalia of positivism are characterised typically in the methodological literature as exhibiting a preoccupation with operational definitions, objectivity, replicability, causality and the like. This 'preoccupation with operational definitions, objectivity, replicability and causality' are associated with research methods such as mathematical modelling, structured questionnaires, simulation and laboratory experiments. These methods characterised by the 'binarification' of the social world, events and phenomena has the advantages of providing a structured 'distance' between the researcher and the subjects of study, thereby incurring a reduction in research costs. The disadvantages and weaknesses include accepting the knowledge that these methods only seek to explain phenomena rather than understand them. Another disadvantage includes having to relate with the subjects of study from a distance.

3.4.2 Fundamentals of the Interpretivist Approach

According to Crotty (1998), Interpretivism is a major anti-positivist stance which advocates 'culturally derived and historically situated interpretations of the social life-world'. In other words, the interpretivist paradigm holds that the world is socially constructed and consists of people's interpretations of institutions and events because according to Thomas (2004) humans are self-aware and endow the world they live in with meanings. In these situations, therefore, the researcher and the researched are interactive and inseparable, thereby wielding degrees of influence on each other – *which may or may not infuse value into the research*. In this situation, research tends to be intrusive, looking at how people live their lives or interact with society. Unlike positivists, interpretivists do not generally begin research with a theory or hypothesis and therefore reject the logic of scientific experimentation as a tool in conducting social research. According to Creswell (2007), "the inquirer works from the 'bottom' up, using the participants' views to build broader themes and generate a theory interconnecting the themes". This paradigm is therefore favoured by researchers who need to develop and build new theories, models and frameworks, probably in response to certain challenges or problems faced by society or a group of people. The advantages of employing the interpretivist approach to research include; increased validity

due to a true representation of the subject of study as well as personalised, in-depth results which cannot be generalised. The disadvantages include the possibilities of value laden research possibly tainted by personal interests, cost of the research and the difficulties in generalising the results.

3.4.3 Fundamentals of the Pragmatist Approach

To be pragmatic, according to the Cambridge Dictionary involves, “solving problems in a sensible way that suits the conditions that really exist now, rather than obeying fixed theories, ideas or rules”. Ideally, and as expected, this approach might be suitable to real world researchers, who for the purpose of financial caution, seek immediate solutions to challenges faced within their professional sectors, as opposed to academic researchers whose aims are not necessarily to save money or find solutions to critical issues. In recognition of this, James (1907) has argued that a pragmatist turns his back on habits dear to those who consider philosophical and methodological issues before taking action, and rather turn towards concreteness, facts, action and practical solutions. With this submission however, Robson (2002) suggests that the real-world researchers and pragmatists are more likely to do a better job when they appreciate and include something of the theoretical bases to social research.

Other than this general explanation, the philosophical definition refers to Pragmatism is an alternative paradigm which allows the researcher to address research problems using multiple paradigms thereby freeing themselves from the constraints imposed by the forced dichotomy between postpositivism and constructivism (Cresswell and Plano Clark, 2007). This approach allows the research to use ‘whatever fits’ with his/her research, thereby focusing more on solving practical problems in the ‘real world’. Teddlie (2005) for example, argues that,

“...pragmatists decide what they want to research guided by their personal value systems; that is, they study what they think is important...they then study the topic in a way that is congruent with their value system, including variables and units of analysis that they feel are the most appropriate for finding answers to their research questions. They also conduct their studies in anticipation of results that are congruent within their value system”.

In translating epistemological concerns into research methodology and finally the decision of research methods, Feilzer (2009) argues that the pragmatic paradigm poses some methodological questions such as, “if phenomena have different layers how can these layers be measured or observed?” In practical research terms therefore, pragmatism does not limit researchers to particular research methods or techniques, but allows them the full range of options especially the options to ‘mix and match’. Robson (2002) therefore proposes some features of the pragmatic approach:

- rejects traditional dualisms, such as rationalism vs empiricism or facts vs values, and prefers more moderate and common-sense versions of philosophies based on how well they work in solving problems
- knowledge is viewed as being both constructed and based on the reality of the world we experience and live in.

3.4.4 Fundamentals of the Realist Approach

Bryman and Bell (2003) suggest that there are two major forms of realism; empirical and critical. According to them, empirical maintains that “through the use of appropriate methods, reality can be understood” while critical is a form of realism that recognizes the reality of the natural order and the events and discourses of the social world. In other words, for critical realism, “we will only be able to understand, and so change, the social world if we identify the structures at work that generate those events and discourses... (Bryman and Bell, 2003). Critical Realism is largely based on the writings of Bhaskar (1975, 1978), who argued specifically against empiricism and positivism and proposed the existence of “the real, the actual and the empirical”:

“...real structures exist independently of and are often out of phase with the actual patterns of events. Indeed, it is only because of the latter that we need to perform experiments and only because of the former that we can make sense of our performances of them. Similarly, it can be shown to be a condition of the intelligibility of perception that events occur independently of experiences. And experiences are often (epistemically speaking) ‘out of phase’ with events – e.g., when they are misidentified. It is partly because of this possibility that the scientist needs a scientific education or training. Thus, I will argue that what I will call the domains of the real, the actual and the empirical are distinct” (Bhaskar, 1978)

Bhaskar in other words argued that there is a world that exists independent of our knowledge of it, thereby providing opportunities to researchers to develop explanations based on underlying structural mechanisms. Critical realists emphasize that social research has an emancipatory dimension as its research is not just about describing or explaining: it also provides a platform for a critique of contemporary society (Baert, 2005)

3.4.4.1 Choice of the Critical Realist research approach and its justification

Having provided the background to various philosophical leanings, the preferred choice for my research is the Critical Realist persuasion.

According to Easton (2010),

“A critical realist approach to case research involves developing a research question that identifies a research phenomenon of interest, in terms of discernible events, and asks what causes them to happen. The key entities involved, their powers liabilities, necessary and contingent relationships are then provisionally identified. Research then proceeds by capturing data with respect to ongoing or past events asking all the times, why they happened or were happening and taking into account the problems and issues associated with interpreting the empirical data back to the real entities and their actions. The research process is one of continuous cycles of research and reflection. The final result is the identification of one or more mechanisms that can be regarded as having caused the events”.

This choice for the critical realist position is due to the need to explore the underlying structures of competitive manufacturing capabilities and at the same time, understand the beliefs and attitudes of both the HVM SMEs as well as their employees.

3.4.5 Behind the veil: The ‘concreteness’ of the OM field and its philosophical perspectives

Having gained considerable impetus in the 80’s and 90’s, the debates over the comparative virtues of qualitative and quantitative methodologies as well as the validity of their findings,

have raged on in OM research. Although the underlying philosophical and paradigmic bases of these contestations were, and so far, have still not been explicitly posited in OM arguments, it is easily deciphered that the ontological positions are objectively biased and the epistemological choices lean more towards the positivist domain. Perhaps the fact that OM is heavily oriented towards the application of tools and mechanisms to bring about favourable solutions in the business world, “practical or methodological issues, rather than the ontological and philosophical reasoning behind a particular research approach” (Dobson, 2001) have been the order of the day.

Diversity, it has been suggested, plays an essential role in Operations Management research and practice since problems encountered in this discipline are inter - disciplinary in nature and span social, behavioural and technical disciplines (Linderman and Chandrasekaran, 2010). Defining the boundaries of OM is therefore thought to be difficult due to the fact that much of its impetus is derived from other disciplines (Binder and Edwards, 2010), blending ideas from subjects such as strategic management, organizational theory and management, economics and international business (Narasimhan, 2014). This is bound to continue as the maturity of the OM field is said to be dependent on aligning itself with the current trends evident from the growing use of, and dependence on, multidisciplinary solutions across most endeavours and industries. This position should ideally bring about a healthy division and broad range of ontological and epistemological persuasions across the board, thereby enhancing the maturity of the field and its ability to develop beforehand, solutions to yet undiscovered problems within OM. This however is not so, as researchers have often commented on the continued proliferation of quantitative methods, which are effectively objectivist and positivist in nature. Choi et al (2016) for example, identify analytical modelling and quantitative empirical research as major methodologies deployed for OM research while Singhal and Singhal (2012) argue that “academic research in O&SCM is currently dominated by mathematical models and by hypothesis testing based on mail surveys...”. More recently, Egbunike et al. (2018) in their review of manufacturing capabilities research also identified the dominance of positivist paradigms.

Interestingly, these arguments have long been the concerns of OM scholars dating back to the 1980s and 90s, when they argued that the OM field was weak on theory development, especially with regards to new knowledge and solutions to real life situations in business. This, according to Chase (1980), Flynn et al. (1990), Wood and Britney (1989) was as a result of the over-reliance on the analytical research paradigm, which although not specifically mentioned, is known to be of the positivist persuasion. Similarly, Meredith (1998)

in support of this findings, pointed out the relative paucity of theory development in OM. He argued that OM researchers still favoured the rationalist approach which included “modelling by equations, laboratory experiments and statistical surveys”, which once again favour the objectivist ontological sentiments.

Perhaps the reason for this focus on quantitative methods can best be attributed to Boyer and Swink’s (2008) argument that, “Though we seek objectivity, each of us is prone to form an attachment to a given perspective, influenced by our training and by the perspectives of our mentors and peers”. This statement invokes questions concerning the history of OM and how it has evolved over the years. Has more attention been paid to the quantitative aspect due to the historical circumstances of the qualitative foundations of OM. Production and operations management is one of the oldest disciplines in the general study of management (Buffa, 1980). History has it that between the 17th and 19th centuries OM focused its scientific lens on the agrarian-manufacturing industry due to their roles in the society then, as the primary wealth producing sectors (Soltani et al., 2014). This focus therefore influenced OM’s representation and future development, due to this early focus on production and shop floor management (Narasimhan, 2014; Heineke and Davis, 2007). The work done by Adam Smith and Charles Babbage in these areas include some of the earliest known research in managerial systems which dealt with production and opened up the doors to what is now recognised as the production system (Buffa, 1980). This orientation towards production and manufacturing, therefore resulted in an over reliance on the analytical research paradigm (Buffa, 1980; Flynn et al, 1990; Meredith et al., 1989; Pilkington and Meredith, 2009)

Having provided this brief summary of the prevalence of the positivist paradigm in OM research and practice, this research seeks to sojourn in the opposite direction by utilizing philosophical paradigms, other than the positivist approach.

3.5 Deductive and Inductive Approaches to Research

In the discussions concerning epistemology, Walliman (2016) suggested that the choice of two options exist in the study of social, as well as any other sciences; Empiricism, for which knowledge is said to be gained by sensory experiences using inductive reasoning, and Rationalism, in which knowledge is gained by reasoning using deductive reasoning. These ways of reasoning, the inductive as well as the deductive, are two contrasting views of the nature of the relationships between theory and research (Bryman and Bell, 2003).

According to Walliman (2016) the practicality in applying either extreme in a pure fashion is impossible, even though there are distinct differences which are easily outlined.

Inductive reasoning or research, according to Gummesson (2000) “starts with real-world data, and categories, concepts, patterns, models, and eventually, theories emerge from this input”. This definition emphasizes therefore, that inductive research primarily generates theory from all kinds of data that have been made accessible to the individual(s). Walliman (2016) suggests that this is the commonest form of scientific activity as our daily experiences as humans, lead us to make conclusions from which we tend to generalize. To make these conclusions general however, they suggest three things:

- there must be a large number of observation statements
- observations must be repeated under a large range of circumstances and conditions
- no observation statement must contradict the derived generalisation

Deductive reasoning on the other hand, is concerned with commencing the research with theories and concepts for which hypotheses are formulated and subsequently tested (Gummesson (2000). Bryman and Bell (2003) makes similar suggestions thus, “the researcher, on the basis of what is known about in a particular domain and of theoretical considerations in relation to that domain, deduces a hypothesis (or hypotheses) that must then be subjected to empirical scrutiny.

Some philosophers have however raised concerns about the wide spectrum between both ways of reasoning, fearing that a strict choice may exist for researchers, forcing them to choose between one or the other. They have therefore come up with a compromise – the hypothetico-deductive method, which Walliman (2016) suggests is a combination of both inductive and deductive reasoning, resulting in “the to-and-fro process of developing hypotheses (testable theories) inductively from observations, charting their implications by deduction and testing them to refine or reject them in the light of the results”. In addition, Gummesson (2000) also argue that after the initial stages, all types of research (referring to both inductive and deductive persuasions), become an iteration between the deductive and inductive, which is referred to as abductive research.

For the purpose of this research, the inductive approach is adopted due to its focus on the emergence of theory. Gummesson’s (2000) acknowledgement that this process commences

with real world data, leading to categories, patterns and eventually some emergent theory aligns with the tenets of the grounded theory process.

3.6 Research Strategy

To the discerning scholars, the preceding section has laid the foundation, albeit softly, for the necessary discussions surrounding the chosen research strategy, which according to Bryman and Bell (2003) refers to a general orientation for the way business research is conducted. As noted by Saunders et al. (2009) also, a researcher's philosophical choice and assumptions will underpin his/her research strategies as well as the methods chosen for the execution of those strategies. This section therefore sets the scene for the arguments surrounding the choice and adoption of a qualitative approach towards answering the research questions in a systematic manner. Methodological options such as Case Study, Action Research, Grounded Theory research and so on will also be discussed and the reasons behind the final choice given. The methods chosen, such as interviews, observations and document analyses will also be explained and justified.

3.6.1 Adoption of a Qualitative approach

There is no shortage of texts which support the researcher's argument for the adoption of qualitative research in management and social science disciplines, a few of which have been cited already (Gummesson, 2000; Guba and Lincoln, 1994; Denzin and Lincoln, 2008; Silverman, 2004). A few papers within the scholarly databases however, also provide end to end arguments for qualitative research which align with the researcher's choice for the approach. Morgan and Smircich (1980) in 'The case for qualitative research' for example, provided ontological and epistemological arguments concerning rival methods in social sciences and conclude that qualitative research is an approach whose appropriateness derives from the nature of the social phenomena being explored. Bryman et al. (1998) also argue for the introduction of qualitative research methods into management studies to improve this area of research by facilitating a wider range of contextual variables into different management styles. This conclusion from Bryman et al. (1998) aligns with this researchers' objective, as this research seeks to not only understand, but improve the area of competitive manufacturing capabilities in OM research and practice.

That said, qualitative research is understood to be an approach that involves discovery, especially in its bid to understand social reality in its own domain and natural settings. From

this activity, we develop the knowledge about human experiences from the descriptions given by the humans themselves. According to Parse (2001) qualitative research is ‘the systematic study of phenomena with rigorous adherence to a design, the data of which comprises oral, written, or artistic descriptions of human experiences, and for which there are no digital findings’. Savenye and Robinson (1996) on the other hand, introduce and define qualitative research as research that is devoted to developing an understanding of human systems through the use of descriptive studies, analytic descriptions or reconstructions of intact cultural scenes and groups.

For better understanding, and in addition to the definitions, Gubrium and Holstein (1997) suggest four traditions of qualitative research;

- Naturalism – seeks to understand social reality in its own terms and as it really is, devoid of any embellishments
- Ethnomethodology – seeks to understand how order is created through talk and actions in the social space
- Emotionalism – exhibits concerns with subjectivity through accessing ‘inside’ experiences especially the understanding of the inner reality of humans
- Postmodernism – exhibits sensitivity to the different ways in which social reality can be constructed by the actors.

Qualitative research therefore, through the understanding gathered from these definitions, was well suited for the purpose of this research undertaking. As discussed in chapter 1, the emphasis of this research was on building a theory around the experiences of how HVM SMEs identify and develop thereof, manufacturing capabilities that ensure their competitiveness in the markets they operate in. This research sought to identify and conceptualise, as much as possible, the phenomena which were distinct from the participant group but nonetheless, responsible for their operational successes. In support of this, Parse (2001) corroborated the researcher’s choice for the adoption of a qualitative research approach when they argued that all qualitative research endeavours possess phenomena to be studied that are distinct and separate from the participant group(s) where the choice of phenomenon reflect the ontological frame of reference to the researcher. The research questions arise from this frame of reference.

In addition to the above, the researcher also took solace in Gummesson's (2000) rationale, which struck a chord with the researcher's research aims and choice of a qualitative approach. According to Gummesson (2000), "we do not find truth and meaning in social life by watching the world from a distance and detaching ourselves from its turmoil, isolating ourselves in ivory towers, just reading what the well-known philosophers and authorities have said...". Indeed, this is the sole preserve of quantitative research which, according to Morgan and Smircich (1980), seeks to 'objectify' social sciences, thereby seeing reality as a concrete structure. In such a situation, man is a responder as opposed to our chosen qualitative study in which man is a social constructor and creator of his reality.

3.6.2 Action Research

The term is commonly attributed to Lewin (1946), who after having made "contact with a great variety of organisations, institutions and individuals who came for help in the field of group relations" coined the term 'action research'. In this research method, "collaboration between the researchers and those who are the focus of the research, and their participation in the process, are typically seen as central to action research" (Robson, 2011). Bryman and Bell (2003) suggest further that this collaborative process is often geared towards the diagnosis of a problem following which a solution is developed and subsequently implemented, still in collaboration with the initial project participants. In other words, action research is targeted towards resolving ongoing challenges within organizations following which knowledge contributions are made to both academic theory as well as practitioner action. This acquisition of knowledge is supported by Lewin (1946) who considers "action, research and training as a triangle that should be kept together for the sake of any of its corners". This suggestion that action research should end in training for the sake of both the researchers and practitioners suggests that some opportunities to acquire new knowledge is one of the outcomes from action research

Other scholars suggest that action research plays a role in bridging the gap between researchers and practitioners. Gummesson (2000) refers to this as applied research, where studies in management are concerned with understanding and improving the performance of businesses through the provision of practical solutions to specific problems. Bryman and Bell (2003) refer to this as organisational consultancy, which is conducted by business school and other academics as a way of maintaining their relevant, and up to date, practitioner knowledge for the benefit of their teaching as well as generating some additional income. In recognition of the advantages of this method, Operations Management

researchers have called for its use. Westbrook (1995) suggests that action research has been relatively neglected in OM practice, unlike what obtains in organisational behaviour and management information systems. He suggests that operations management researchers learn from their colleagues who have used action research to create a new theory. Similarly, Coughlan and Coughlan (2002) suggest that action research is relevant and valid for the discipline of Operations Management and emphasize further, its ability to address the operational realities experienced by practicing managers. Other than these advocates for action research, some OM scholars have used this method in their research (see for example Smith, 1996; Phaal et al., 2001; Nair et al., 2011), thereby demonstrating its viability for operations management research.

As there are with other methodologies, some criticisms exist within the literature regarding action research. First of all, action research has been criticised by some, for lacking scientific rigour and repeatability, which has been attributed to (1) its ability to be actioned in only a single organisation at a time due to the uniqueness of the problem(s) needing solutions, and (2) its many different definitions and methodological details of how it is conducted (Kemmis and McTaggart, 2005). It has also been criticised for concentrating too much on organisational action at the expense of research findings (Bryman and Bell, 2003),

Although action research has been used to develop theories (Westbrook, 1995; Eden and Huxham, 1996; Dick et al., 2009) and was in serious consideration for the execution of this project, a final decision was made based on the primary aims of an action research approach. Given, therefore, that this research method is more suited for applied research (providing a viable solution to a practitioner problem within an organisation) it was deemed not suitable for this researchers' PhD work which fundamentally, was to develop a theory that is grounded in data. It was therefore dropped as a serious choice.

3.6.3 Ethnography

This method originates from the field of anthropology where the purpose is to describe and explain the social world in which the research subjects inhabit in the way that *they* would describe and explain it (Saunders et al, 2009). In so doing, a substantial amount of time is spent in detailed observations and interviews where the researcher participates in the social events to gain a first-hand knowledge of whatever multiple occurrences occur over a given period of time. With regards to a definition however, Silverman (2016) states that "the stretching of the term...has emptied it of its original meaning" and implies that extreme

ambiguity has been built into it due to the fact that the meaning has been expanded to such an extent that it encompasses forms of research that are extremely diverse from a methodological point of view. He however returns to the basics emphasizing that ethnography was born as a technique based on direct observation, citing other data collection methods as ancillary sources of information.

To further understand the process of ethnographic engagement, Easterby-Smith et al. (2015) identify its key principle as the immersion of the researcher into the setting, becoming part of the group under study in order to understand the meanings the people give to their behaviour and that of others. Furthermore, Atkinson and Hammersley (1998) suggest the following features exist in ethnographic studies:

- a strong emphasis on exploring the nature of social phenomena, rather than testing any hypothesis about them
- a tendency to work primarily with unstructured data
- investigation of a small number of cases, often just one case, in much detail
- outputs consisting of mainly verbal descriptions and explanations with quantification and statistical analysis playing a subordinate role, if at all.

Having therefore assessed ethnography in much detail and provided a brief overview of its characteristics, it was not considered a suitable methodology for the aims of the researcher's exploratory study. For one, the result of ethnographic inquiry is cultural description (Van Maanen, 1982), which only follows extended periods of time, overtly or covertly, spent watching people's daily lives, listening to what they say and collecting whatever data are available (Hammersley and Atkinson, 2007). As the researcher did not have 'a lot of time' to engage in just 'watching' the research subjects, this was not considered a viable option. Secondly, ethnography was not particularly known to be a method that was used to develop theory grounded in data. As this was the main aim of this PhD endeavour, ethnography as a choice for this study was also rejected.

3.6.4 Case Studies

Although case studies are defined in various ways, the underlying concepts remain the same in all of them. Yin (2014) for example, define case studies as an investigation into, "a contemporary phenomenon (the 'case') in its real-world context, especially when the boundaries between phenomenon and context may not be clearly evident". In another

definition by Osuszek et al. (2016) they define it as the, “analysis of one or more individual units (be they organisations, programmes, events, persons etc) which are internally complex and strongly connected with external factors”. What is evident from both definitions is the emphasis on a conscious, purposeful and deeper investigation into one or more phenomena or units in their natural settings. What is also evident is that a certain level of complexity exists in these phenomena to elicit the need to want to study, or understand them. Case studies are therefore an ideal methodology when an in-depth investigation is needed (Feagin et al., 1991), for example to develop theory in operations management research (Voss, 2010; Meredith, 1998; Barratt et al. 2011)

Yin (2014) also suggest that case studies are the preferred method in situations where ‘how’ or ‘why’ questions are posed, when the researcher has little or no control over events and when the focus of the study is a current development. Due to the fact that the research question for this study is a ‘how’ question, and at the same time the focus of current developments (exploration of capability development for innovation and entrepreneurial regions) the case study approach was suitable for the endeavour.

The case study methodology was therefore adopted for this research in tandem with the grounded theory towards achieving the aims of the research.

3.6.5 Grounded Theory

The GTM was selected for this study. As stated earlier, the reasons for this were to generate new theory as well as introduce a novel methodological contribution. The point of departure was that historically, OM practice and research have been predominantly dominated by quantitative methods (Barrat et al, 2011) which philosophically, align with the positivist school of thought. To further explore this field with the aim of developing useful theory, the researcher decided to inquire into the construct using instruments favoured by the anti-positivist movement. These anti-positivist stances included either interpretivist or realist schools of thought, which often engage in organic processes of social interpretation leading to the emergence of theory.

The Grounded Theory Methodology (GTM) was therefore selected for this study due to its potential to generate theory and its relative ‘newness’ and possible application in Operations Management (OM) research. Discovered and subsequently developed by Barney Glasier and Anselm Strauss (1967), the purpose of this methodology was to enable the ‘discovery

of theory from data systematically obtained from social research” and “a way of arriving at theory suited to its supposed uses” (Glaser and Strauss, 1967).

The Grounded Theory Methodology (GTM) has become a popular choice of methodology among social and management researchers in recent times. Regarded by many as one of the most recognised and widely used methodologies in social science research (Bryman and Bell, 2003; Bryant and Charmaz, 2007), GTM is one of a number of potent qualitative research traditions that includes case studies, ethnography, narrative inquiry and phenomenology (Creswell and Plano Clark 2007).

GTM was first proposed by Barney Glaser and Anselm Strauss in their 1967 text, *The Discovery of Grounded Theory*, and was defined as, “the discovery of theory from data systematically obtained from social research” (Glaser and Strauss, 1967). Following this initial definition and an evolutionary trajectory brought about by the experiences of its users, which includes the initial originators, other more encompassing definitions emerged over the years. Strauss (1987) for example defines GTM as “a style of doing qualitative analysis that includes a number of distinct features, such as theoretical sampling and certain methodological guidelines, such as the making of constant comparisons and the use of a coding paradigm, to ensure conceptual development and intensity”, while Martin and Turner (1986) define it as “an inductive, theory discovery methodology that allows the researcher to develop a theoretical account of the general features of a topic while simultaneously grounding the account in empirical observations or data”. Charmaz (2008) on the other hand, explained GT as a method of explication and emergence, which takes a systematic inductive, comparative and interactive approach to inquiry offering several open-ended strategies for conducting emergent inquiry.

While so many definitions were put forward by the different scholars, other than the originators, certain main features still remained mostly in place. In general, therefore, the main features of grounded theory, as identified by Denscombe (2003) include:

- **Theories should be ‘grounded’ in empirical research:** insisting that theories should be grounded brings with it the idea that fieldwork must be a fundamental part of the work that researchers do
- **Theories should be generated by a systematic analysis of the data:** this emphasizes that theories are developed out of the data through a persistent process of comparing the ideas with existing data and improving the emergence

of concepts and theories by checking them against new data collected specifically for the purpose

- **The selection of instances to be included in the research reflects the developing nature of the theory and cannot be predicted at the start:** a trail of discovery is followed, where each new phase of the investigation reflects what has been discovered thus far
- **The researcher commences with an open mind:** there is a need to approach the topic of interest without a rigid set of ideas that will inadvertently 'contaminate' the areas of research interest. An open mind does not encourage a blank mind on the subject. The argument, which will be discussed further in a later chapter, is that the 'hindrances' of previous theories should not be allowed to taint the possibilities of new and relevant theories.
- **Theories should be useful at a practical level and meaningful to those on ground:** one guiding philosophy of grounded theory is pragmatism, as acknowledged by Glaser and Strauss (1967). This emphasizes the practical applications rather than the abstract when the issues of knowledge and truth are at stake.

The main aim of grounded theory is therefore the generation – not the verification – of theory used in describing and explaining basic common patterns experienced in social life (Glaser, 1998, 2001; Glaser & Strauss, 1967).

3.6.5.1 History and Origins of GTM

The origins of Grounded theory can be found within the interpretive research traditions of sociology, which sought to discover and understand the meanings and concepts used by people in social settings. Specifically, the development of grounded theory was Barney Glaser and Anselm Strauss' reaction to the dominance of the positivist grand theoretical work that was gaining favour within their field of sociology. This grand theory, according to Suddaby (2006), was predicated on the belief that "the purpose of social research is to uncover pre-existing and universal explanations of social behaviour". This provided the opportunities for researchers to avoid the field and instead, "build upon axiomatic truths through logic to extrapolate these truths in new contexts" (O'Reilly et al. 2012). In other

words, grounded theory was conceptualised and developed at point in history when the prevalent opinion was that only quantitative or deductive studies could provide systematic scientific research (Alvesson and Skoldberg, 2000).

Glaser and Strauss, being qualitative researchers, challenged these narratives with arguments systematically laid out in a number of publications based on their years of research (Glaser, 1965; Glaser and Strauss, 1966a; Glaser and Strauss, 1966b; Glaser and Strauss, 1964; Glaser and Strauss, 1965). In all these works, Glaser and Strauss continually criticized the focus on the verification of theories only, as opposed to actually generating theory (Moore, 2009), and then verifying it – a two stage process they felt could replace the one-sided focus on verification only. This situation of inquiry occurred while undertaking their research, *Awareness of Dying* in which, they stressed a need to generate theory arising from their social research which they believed could be “more successful than theories logically deduced from a priori assumptions” (Glaser and Strauss, 1967). Following these arguments, Grounded theory was presented in *The Discovery of Grounded Theory* (1967) with three avowed purposes, which according to Strauss and Corbin (1994) were; (1) to offer the rationale for theory that was grounded and developed through data collected during research projects. It was suggested that this type of theory would contribute to closing the gap between theory and empirical research, (2) to suggest the logic for, and specifics of grounded theories, and (3) to legitimate careful qualitative research due to the fact that in the 1960s qualitative research occupied a low status among an increasing number of sociologists who believed it was not capable of adequate verification.

Following the 1967 publication, Glaser and Strauss continued to publish articles and books together until the 1970's and 80's when they each wrote further expositions of GT and published these separately (Kenny and Fourie, 2014). Glaser and Strauss therefore discontinued their professional collaboration due to disagreements concerning the precise nature of the methodology. At this point, according to Stern (1994) the differences between the two researchers which had always been apparent began to show, especially with Strauss' new publications (Strauss, 1987; Strauss and Corbin, 1990). Although, Glaser is generally recognised as having retained both the spirit and the substance of the original work (Locke, 2001). Glaser therefore, is often credited as owning the 'original' grounded theory version, aptly named the Glaserian or 'classic' method.

3.6.5.2 Choice of GTM Approach

While it is not the intention of this study to join the ongoing debates that have raged between Glaser and Strauss's versions of GTM, it is necessary to position this research on one of the two versions. With well documented studies highlighting the differences between both versions, it was the researcher's choice to adopt the Glaserian or classic method. This is because firstly, the classic method of GTM stressed the need to commence the study with an empty mind while Strauss favoured a general idea, which may already be under study (Jones and Alony, 2011). This again, was another point of contention with GTM as arguments surrounding what 'empty mind' meant raged on. Some argued that no one can claim to enter a field completely free from the influence of past experience and knowledge (Heath and Cowley, 2004). Holton (2007) however argued that, "as a generative and emergent methodology, grounded theory requires the researcher to enter the research field with no preconceived problem statement, interview protocols, or extensive review of the literature". This 'emptiness' therefore provides the eagerness for the researcher to explore a substantive area by allowing the concerns of the research participants drive the research towards the emergent issues.

Secondly, the classic method allowed for the emergence of the theory grounded strictly in the data collected and analysed through the flexibility of the constant comparison and theoretical sampling features. The Straussian version of GT however was more rigid, through the use of structured questions, which more often served as a 'guide' to the respondents. This made the Straussian version feel a bit rigid which Glaser (1992) termed as "forced, full, conceptual description". It also removes some of the power, on the part of the participants, to drive the research, due to the fact that the researcher approaches the engagement with preconceptions

Glaserian	Straussian
Beginning with general wonderment (an empty mind)	Having a general idea of where to begin
Emerging theory, with neutral questions	Forcing the theory, with structured questions
The theory is grounded in the data	The theory is interpreted by an observer
A basic social process should be identified	A basic social process need not be identified
Coding is less rigorous, a constant comparison of incident to incident, with neutral questions and categories and properties evolving. Take care not to 'over-conceptualise', identify key points	Coding is more rigorous and defined by technique. The nature of making comparisons varies with the coding technique. Labels are carefully crafted at the time. Codes are derived from 'micro-analysis which consists of analysis data word-by-word'
Regarded by some as the only 'true' GTM	Regarded by some as a form of qualitative data analysis (QDA)

Table 3.2: Comparison of the two schools of Grounded Theory

3.6.5.3 GTM Process

Although many different frameworks explaining the process of the GTM exist, the researcher favoured the GTM framework developed by Hoda et al. (2011) for use in this study (see Figure 3.4). The figure, which provided a good representation of Glaser and Strauss's (1967) process was divided into 3 major phases for easy application. Phase 1 represented the stage from which the core categories were developed. The tools used in this phase included unstructured interviews as well as periods of observation. Following the generation of the core categories, Phase 2 was entered into and driven by semi-structured interviews until theoretical saturation was reached. The last Phase dealt with the sorting of data and information, leading to the emergence and presentation of the substantive theory. In both Phases 1 and 2, periods of observation were used as a secondary means of data collection and provided some further information in each of the cases where they were used. Each of these concepts will be presented in the following stage

It is worth mentioning that certain key principles are essential for the successful application of GTM in research endeavours. These key principles which differentiate it from other

qualitative research methodologies include 'constant comparison', where data collection and analysis are an iterative process, as well as 'theoretical sampling' where data collection decisions are progressive and subject to the theory being constructed (Fendt and Sachs, 2008). Although these two principles have been explored extensively in literature, a brief outline is provided in the following discussions as they are key features of the GTM process and were keenly put to use by the researcher in the actualisation of the substantive theory in this thesis.

- **Constant Comparison** - The constant comparison method was described by Glaser and Strauss (1967) in four distinct stages (1) comparing incidents applicable to each theme that emerges from the data; (2) integrating themes and their properties; (3) delimiting the theory; and (4) writing the theory. This process was solely dependent on the simultaneous and dynamic interplay of data collection and analysis, which again is another unique feature of GT. During these situations, reflexive and analytical thinking was applied to support the generation of themes and categories, as the researcher was required to reflect on how the knowledge gathered from the research participants could be integrated into densified categories and subsequently moulded into an emerging theory.
- **Minor Literature Review** - Issues surrounding whether or not to engage in a literature review before embarking on the GTM journey have been the subject of arguments and numerous academic papers. This is explained in the introductory section of Chapter 2. A literature review was therefore carried out for this research (see Chapter 2) towards providing some understanding concerning the general subject of manufacturing capabilities and their contributions to the competitiveness of firms. This provided enough understanding to the researcher to enable him contextualise emerging issues as well as provide limitations on their reach.
- **Data Collection** - Glaser (2004) recommends that the researcher start with collecting data, taking memo's, observing, coding and going through this process iteratively while constantly comparing data from the participants. During this stage, ***unstructured interviews*** were used. They had no predetermined questions but were favoured for GT methods because they have the potential to generate rich and detailed accounts of the individual's experience (Goulding, 2002). This method of interview was applied in the first phase of the GT process to enable the generation of more focused areas of research, especially when these areas are the concerns

put forward by the research participants. The disadvantages to using unstructured interviews include not being able to discern quality data from the amount of data generated as well as the possibilities of the discussions digressing from the topic of interest. This is however, one of the challenges of GT, as large amounts of data will be generated, most of which may not be relevant to the emerging theory. For our study, large amounts of data were collected following which the analysis was carried out. In our case, as advised by GT, each interview was recorded and transcribed following which the analysis was carried out. This process helped in the management of the data as the concept of theoretical sampling guided any further interview questions as well as choices of respondent selection. It was however, the responsibility of the researcher to ensure that the interviews were kept within acceptable boundaries as well as ensure that coding was carried out reflexively to generate quality data.

- **Open Coding** - This was the first step of the data analysis towards the discovery of categories and their properties, as a constant comparison after each subsequent interview was carried out eliciting highly relevant data categories. For example, after interviewing *Respondent1*, the transcript was analysed and important points were highlighted and given codes. After interviewing *Respondent2*, the transcript was also analysed and coded following which the findings were compared to *Respondent1* for any similarities and/or differences. At this point, depending on the individual interviews, the codes from each transcript did or did not begin to show similarities. The same process was also repeated with *Respondent 3's* transcript as it was compared to the combined findings from that of *Respondents 1* and *2* following which similarities between them were also be highlighted. This iterative **Constant Comparison** process continued until a **Core Category** was generated. As advised by literature (Ng and Hase, 2008), it was important for the theory generation activities that the open coding happened concurrently with **Memoing** as it was the memo writings that recorded our progress towards the emerging categories. Glaser (1998) writes that “memos are the theorizing write up ideas about substantive codes and their theoretically coded relationships as they emerge during coding, collecting and analysing data...” This memo writing therefore required active reflexivity on the part of the researcher due to the need to not only think deeply about the newly created categories and the relationships that made up these categories, or think about ensuring consistency in the assigned codes, but to also question his thinking about ‘why’ he thought those categories were important enough for advance considerations.

- **Data Collection (Theoretical Sampling)** - With the emergence of a core category the theoretical sampling begins. In this phase, data collection is driven by the core category and companies who are able to support the generation of relevant data to the fullest should be sought (Glaser and Strauss, 1967). For example, if during the open coding phase [phase 1], a core category such as “collaborative partnerships” emerges, only companies that are involved in such “collaborative partnerships” will be approached to provide more relevant information to progress the research. In other words, purposeful sampling will continually drive the research process. Once again, as demonstrated from the previous coding phase, **memoing** should take place as well as the **constant comparison** and the iterative process continue as the data is being collected.

During this Phase 2 part of the project, **semi-structured interviews** were administered as the data collection tools with questions generated from the core categories forming parts of the ‘interview guide’ during these more focused but flexible sessions. With these types of interviews, the sequence of questions were altered to take into consideration the participants lines of discussion as well as the directions in which the research was progressing. In retrospect, some of the disadvantages encountered included situations in which the participants provided information they thought was ‘best’, rather than what was pertinent for the project at that point. Multiple methods of data collection however, including the observations, often validated or disproved their responses when analysis was carried out.

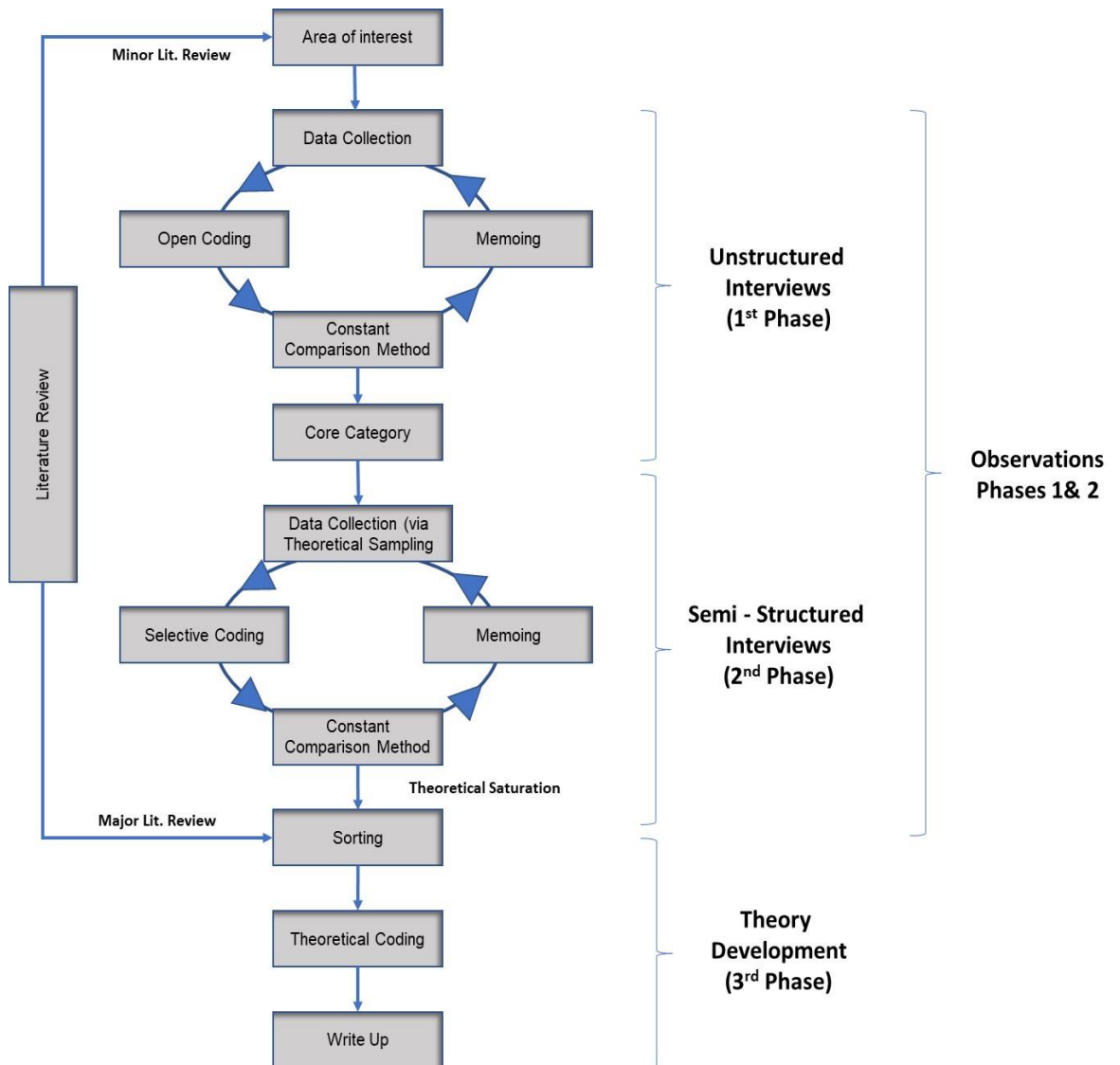


Figure 3.4: Overview of the adopted Grounded Theory process (Hoda et al, 2012)

- Selective Coding** - This is the coding that takes place as data emerges and understanding of the core category has deepened. During this stage, coding is delimited “to only those variables that relate to the core category in sufficient ways to be used in a parsimonious theory” (Glaser, 1978). In other words, selective coding is the process where the researcher generates codes only for the data that significantly relate to the core category. During this stage however, any other categories relating to the data analysis are not discarded but become secondary to the core category under focus (Glaser, 1978). The task however, of continuously saturating the core category continues until theoretical saturation is reached, where

the researcher is ready to assume the task of theoretical coding, which begins the process of outlining the substantive theory. Once again, during the process of coding, not only for this selective coding but others as well, periods of reflexivity were observed to ensure uniformity in the codes and an alignment with the directions in which the data was leading towards an emergent theory

- **Theoretical Saturation** - This process occurs when in constantly comparing the coding from the memoing and analysis, no new properties of the data emerge as the whole process is repeated through the full extent of the data (Glaser, 1978). This is the event that occurs during the GT process to signify progress, as well as a pointer to the fact that the next stages are imminent. It is at this stage that the **Sorting**, which is the key to the theory formulation (Glaser, 1992), begins. Sorting is the process where all previous memos are grouped based on conceptual ideas and the relationships between them established (Hoda et al, 2011). This is an essential step and cannot be overlooked (Glaser, 1978). At this stage, Glaser (2004) also advises that a **Major Literature Review** be undertaken to ensure that the literature in the substantive area be “woven into the theory as more data for constant comparison”. This process will also ensure that the theory generated by the process is built up within the general body of knowledge

- **Theoretical Coding** - Although this is a fundamental step in the classic grounded theory, Cutcliffe (2000) argues that it is one of the least understood procedures. This theoretical coding, according to Glaser (1992) is where “the property of coding and constant comparative analysis yields the conceptual relationship between categories and their properties as they emerge”. Simply put, theoretical coding is the point at which the examination of all the categories that have been created towards identifying the relationships between them, if any, commences. This is according to Holton (2007), who argues that ‘theoretical codes conceptualize how the substantive codes may relate to each other as hypotheses to be integrated into the theory’. This in itself presents some challenges, as experienced by the researcher, due to the attempt to resolve and understand the ‘many to many’ relationships between the categories as well as identify the particular relationships among the many possible options, which indicate the particular social processes that are core to the objectives of the research activity. During this process however, the integration of the theory commences and the conceptualization of how the

categories generated earlier relate to each other, thus setting a background for the generation of a substantive theory becomes clearer.

Following the description of the GT process, a further diagrammatic representation is highlighted in Figure 3.5, where the research position and coding process is represented and divided into chapters for easier assessment. A modified version of the diagram is highlighted before each relevant chapter to show the progressive stage of the substantive theory generation activities.

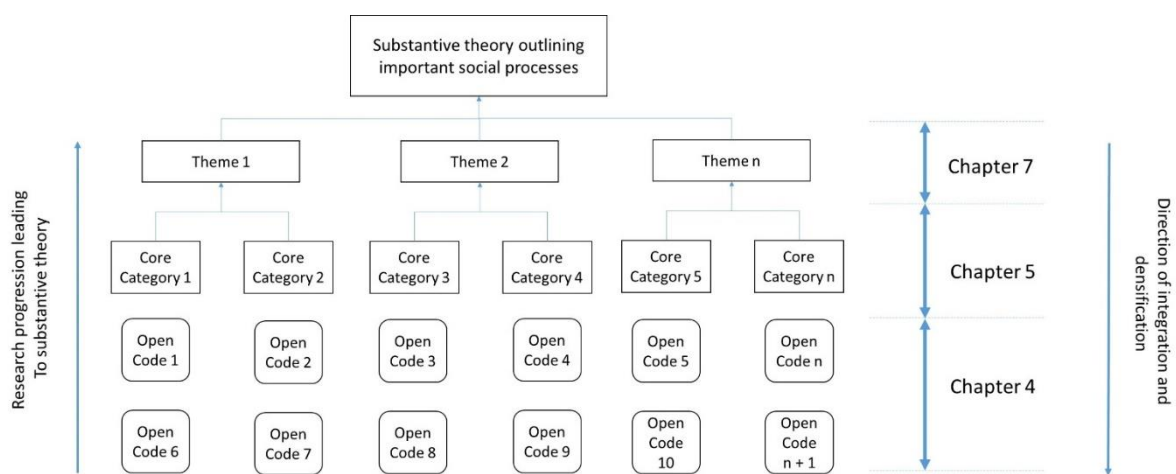


Figure 3.5: Research positioning and coding progression (adopted from Stiel et al. 2010)

3.7 Data Collection Tools - Qualitative Interviews

Having discussed the different qualitative methodologies considered as well as those chosen for this research purpose, the tools used to collect the data will be discussed in this section. According to Gauri and Gronhaug (2005), the choice of tools to be deployed for data collection are influenced by the researcher’s skills, research problem, research design and the nature of the participants in the study. Regarding GTM, the qualitative data collection tools that can be used for this study are in-depth interviews, both unstructured and semi-structured, and observations (Denzin and Lincoln, 1994)

Interviews are a daily occurrence in life and they take many forms for different purposes. A lot therefore has been researched and written about interviews, as they are among the most

common tools used in the collection of research data across a multitude of disciplines, especially medical, social sciences and business/management sectors. Within these different disciplines, different kinds of interviews abound as they are used for different purposes. As some research is designed to test certain hypothesis, a very structured interviewing format is used, “in which the stimulus (questions) and analysis are standardised, while other research seeks to explore meaning and perceptions to gain a better understanding and/or generate hypothesis” (DiCicco-Bloom and Crabtree, 2006). The latter which describe more, the characteristics of unstructured and semi-structured interviews, are applicable to my research as my research seeks to explore ‘meaning and perceptions’ about how competitive manufacturing capabilities are developed. This type of interview is the qualitative interview, the purpose of which is, to derive interpretations and not facts or laws, from participants, who are more likely to be viewed as meaning makers, and not passive conduits for retrieving information (Warren, 2002). Other scholars such as Törrönen (2002); Charmaz (2003); Fielding and Thomas (2008); Mason (2002), have also written about qualitative interviews.

In summary, interviews should allow us to investigate, critically, our participants understanding of their experiences and beliefs, as well as our own, in relation to a particular topic or subject under study (Dilley, 2004). Based on the above, as well as the ontology and epistemology of my research, three kinds of interviews relevant to my research endeavour are; unstructured, semi-structured and focus groups. The focus of this research is however on unstructured and semi-structured interviews.

3.7.1 Unstructured Interviews

This type of interview typically has only a list of topics or issues, often called an interview guide, to be discussed freely in informal settings. Although Mason (2002) considers the term ‘unstructured’ to be a misnomer, because no interview can be completely lacking in some form of structure, other researchers such as Saunders et al (2009) consider the ‘unstructured’ aspect of this form of interviewing gives the interviewee the opportunity to ‘shape’ the discussion to take it in any direction they see fit. In this sense, there is no structure to this. According to Saunders et al. (2009), “there is no pre-determined list of questions to work through in this situation, although the researcher needs to have a clear idea about the aspect or aspects they need to explore”

In this regard, my discussions with the respondents will revolve around the answers prompted by these questions:

- What is your business? (*What do you produce and/or manufacture?*)
- Who are your competitors? (*What products do they produce that are similar to yours and what are your order winners and qualifiers?*)
- What do you do differently from your competitors? (*What are your order winners?*)

After I have given a proper introduction to my project and what it is all about, my first question to the respondent would be, “*What is your business*”. This question serves as the interview opener and proposes to put the respondent at ease. This is because if there is anything the respondent will be able to talk about freely, it is his/her line of business. This strategy follows what Rubin and Rubin (1995) emphasize, when they mention the three kinds of questions, “*main* questions that begin and guide the conversation, *probes* to clarify answers or request further examples, and *follow up* questions that pursue the implications of answers to main questions”. The first question “*what is your business*”, is a *main* question as it begins the conversation. Again, the purpose of this main question, which is very broad and open ended, is to douse any initial apprehension which may have developed, especially between the interviewer and the interviewee, who are new to each other (DiCocco-Bloom and Crabtree, 2006). The purpose of the question is also to allow the subjects to tell their own stories of their world (Warren, 2002), which indeed, is part of the aims of this research endeavour.

The second question, “*Who are your competitors*”, is a logical flow from the first question, as it seeks to find out from the respondent, if he/she is aware of any other firm that occupies the same business segment as them. In certain cases, this question may be answered by the respondent, when the first question is asked because it is logical for people to talk about their competitors while talking about their own businesses.

It is worth noting that taking the overall research aims into consideration, this question begins to prime the respondents’ mind into thinking about ‘competition’ and how his/her products are differentiated from that of the competitors. Competition is one of the drivers for two important aspects of the overall research project which are: the identification, development and evolution of competitive manufacturing capabilities, moderated by advanced manufacturing technologies adoption.

This second question once again leads into the third question which may be casually injected into an ongoing discussion (without giving away the fact that it is a question) thus, "...so if those companies are your competitors, what are the things that you do differently from them", in other words, this question asks the respondent what their order winners are or what makes their product different from that of their competitors. This of course, encourages the respondent to speak in more detail, about the things his/her company does and the kind of skills (or capabilities?) they have developed to perform those tasks. This question begins to lay a foundation for the next phase of interviews, which is the semi-structured phase.

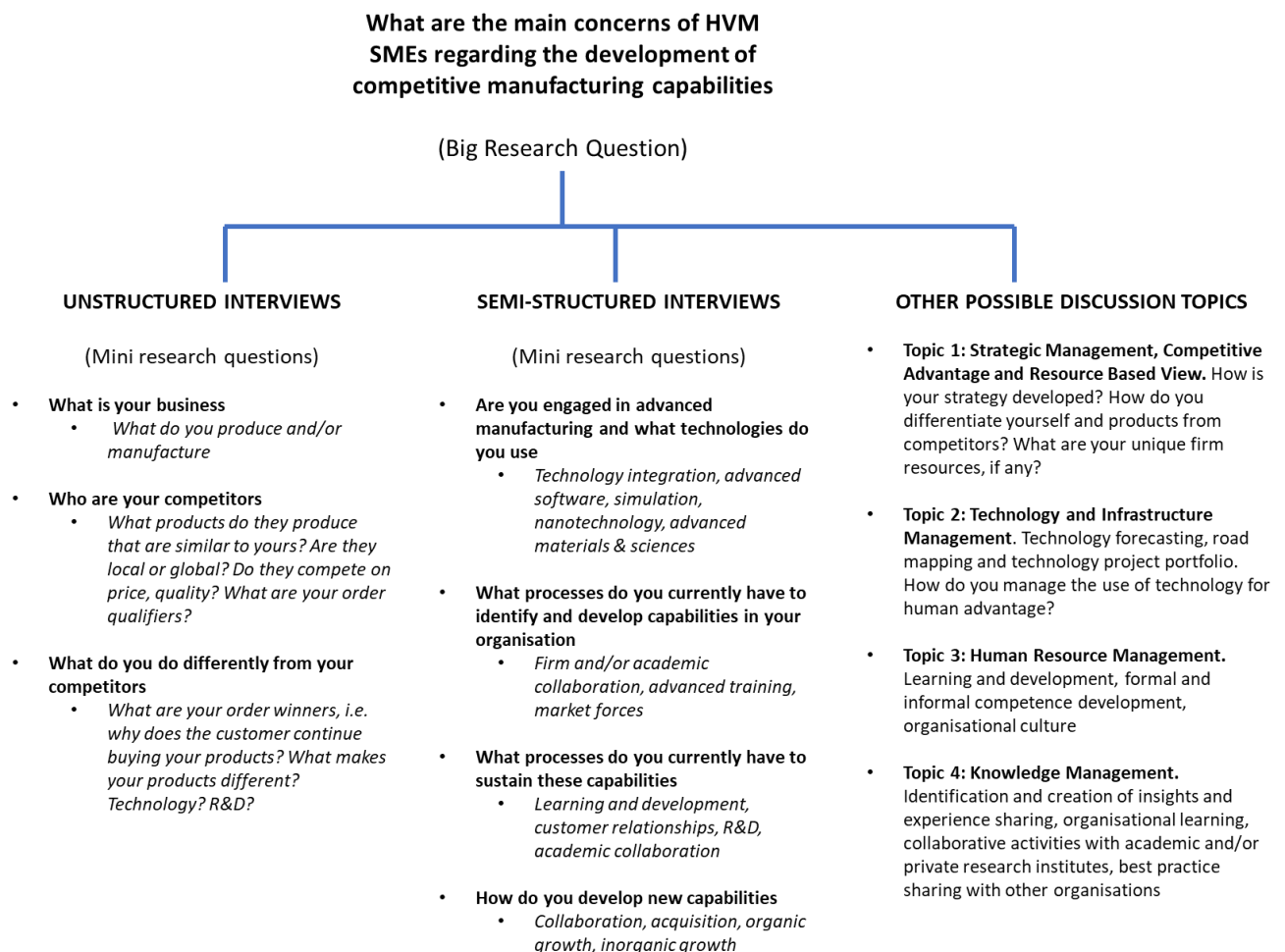


Figure 3.6: Interview strategies - breakdown of interview approach

It is worth mentioning again, that in these unstructured interviews, it is not necessary for the researcher to ask these questions mechanically, especially after the first 'ice-breaking' questions. Since the second and third question flow logically from the first question, they can be injected into the ongoing conversation perfunctorily, while maintaining a lengthy and vibrant discussion.

3.7.2 Semi-Structured Interviews

These types of interviews are widely used in multi-strategy design such as mixed methods research projects, where interviews are combined with qualitative surveys. In this type of research, interviewers have their shopping list of topics and want to get responses to them (Robson, 2011). This 'shopping list' may be what Bryman and Bell (2003) refer to as 'interview guide' when they mention that, "the researcher has a list of questions on fairly specific topics to be covered, often referred to as an *interview guide*...". According to DiCicco-Bloom and Crabtree (2006) semi structured interviews can also be, and are often, the sole data source for a qualitative research project and have been widely applied thereof.

With this introduction, some of the questions asked and discussed during this Phase were:

- What processes do you currently have to identify capabilities? (*What do you currently have and what do you aim to develop – to enable your company do better than the competition? How did you identify these capabilities?*)
- What processes do you currently have to develop your capabilities? (*Do you integrate advanced technologies into your firms and how?*)
- What processes do you currently have to sustain your capabilities? (*Staff training, customer relationships, R&D*)
- How do you develop 'new capabilities'? (*Through collaboration, acquisition, organic growth?*)

As these questions follow from the unstructured interviews phase, the next question, "*What processes do you currently have to identify capabilities*" follows from the last 'prompt' in the

unstructured phase that asked what the company did differently from their competitors. This question has been developed to elicit from the respondent, the steps they take or have taken to identify their current skills or capabilities base and how and why they have identified which capabilities they would like to acquire. The word 'processes' evokes a series of steps or actions taken to make this identification.

Identifying and developing capabilities does not ensure superior competitive advantage in the global marketplace. 'Sustainable competitive advantage' a term used by scholars (Reed and DeFillippi, 1990; Hall, 1993; Barney, 2012) remains the single most important acquisition for companies. The question therefore, "*what processes do you currently have to sustain your capabilities*" is the next logical question after asking for information on how they identify and develop these capabilities. With this question, the topic of advanced technologies and their continuous upgrades (*capability development*) once again may be an important factor in the company being able to sustain their competitive advantage.

The third question, "*how do you develop new capabilities*" elicits from the respondents, the methods used in bridging gaps that they have identified and hope to reach. This question seeks to explore whether these SMEs, due to their financial, resources or infrastructure constraints, engage in collaborative networks, collaborative partnerships with educational and research institutions or just grow organically and acquire talent as and when needed. This also is where the AMT once again, may be a factor in the development of new capabilities.

It should also be noted that some questions in this phase may be omitted or the order of questions may be varied, depending on the flow of the conversation (Saunders et al. 2009). For example, the third question, "*how do you develop new capabilities*" may be answered alongside the first question, depending on how the participant answers the question. On the other hand, additional questions or further prompts may be required to explore in some more detail issues that have been brought up during the conversation. These new issues may be relevant to the aims of the research, but were not thought of during the formulation of the questions and can be incorporated into the discussion. This is one of the advantages of semi structured interviews, its flexibility (Saunders et al. 2009)

It should be duly noted that the questions in both the unstructured and semi-structured phases are focused on the singular research problem identified earlier in this chapter. With close inspection and reflection, answers to all these questions will provide the substance,

which when combined, will provide a robust and insightful understanding of how capabilities combine with advanced technologies towards the renewal of the former.

3.8 Ethical Issues and Considerations

This chapter ends with the discussions surrounding the important ethical considerations involved with this study. These considerations, it is said, are necessary to regulate any research being carried out so that the participants on the project are protected from overzealous research practitioners who are willing to overstep the limits imposed on them in order to deliver 'cutting edge' results. Considering the earlier discussions in this chapter, regarding access to sites as well as the intricate discussions entered into with the human research participants, the need for ethical considerations was paramount to consider the effects such as the potential for harm, stress, anxiety and other consequences for the research participants.

Within the research ecosystem of The Business School at Cardiff University (CARBS) was the Ethics Committee which was responsible for the ethical reviews of projects taking place across the school by all research active students and staff. Ethical approval for the present study was therefore obtained from the Ethics Committee at the Cardiff University Business School in April 2012 (see Appendix F). The study adhered to the Academy of Management Code of Ethics (Academy of Management, 2005)¹⁰ which highlighted issues such as responsibility, integrity and respect for people's rights and dignity. In addition, privacy, confidentiality and anonymity will also be adhered to

3.8.1 Informed Consent

Informed consent is thought to be the major ethical issue in conducting research as it is the gateway through which participants are onboarded onto the project. Informed consent refers to the process whereby the research participant is provided with as much information as they need about the proposed project to enable them make informed decisions about agreeing or refusing to participate thereof. This is often achieved through (1) a document given to the participant stating the aims, objectives, processes of the research project(s), as well as the rights of the participant to withdraw at any stage, and (2) a dialogue between

¹⁰ Academy of Management. 2005. Code of Ethics. Available at: <http://www.aomonline.org/governanceandethics/aomrevisedcodeofethics.pdf> [Accessed 25 August 2019]

the researcher and the participant where the participant is led to comprehend the nature, alternatives and risks involved in their participation.

As required by the CARBS Ethical Committee therefore, all participants in this study were provided with both the CARBS Research Ethics Consent Form as well as an Access Letter (see Appendices A & B), before the interview meeting via emails. By reading these documents which highlighted the aims of the research as well as a summary of what was expected of them during the project, the participants inevitably had an idea of the research and sometimes raised more questions about the process. More importantly, the contact details of the research supervisors were also provided to enable the participants access those within a supervisory capacity of the project. Ethical considerations such as confidentiality, anonymity and the rights to withdraw at any point during the research process were also highlighted.

To ensure the complete understanding and consent given, on the part of the research participants, a brief discussion was held with the participant, once again, to verbally gain consent towards commencing the research activities. It will be noted that it was also reported in some interview sites that the request to make voice recordings, or take pictures of laboratory equipment was denied by the participants.

3.8.2 Anonymity and Confidentiality

Before the General Data Protection Regulation (GDPR) for the EU was adopted in May 2016 and implemented and enforced in May 2018, issues concerning the handling of data; how it was acquired and accessed, what it was used for and how it was stored was of utmost importance in the research field. This information had to be made known to the research participants to provide assurances of ethical considerations, including confidentiality, anonymity and sometimes, security.

Following the successful progress from the informed consent stage, having gained approval from the research participants, their anonymity and confidentiality are central to ethical research practice. The principle of confidentiality provides assurances to the research participants, that information disclosed during the research engagement will not be shared with any unauthorised parties without their permission. Some have cited the well-known, formally enforced non-disclosure agreements (NDA), which are legal contracts between two parties outlining the confidentiality of any materials, knowledge and information shared, as

examples of this confidentiality agreements between a researcher and his research subjects. Anonymity on the other hand, refers to the responsibility on the part of the researcher, to ensure that the data collected from the participants lacks all unique identifiers pointing back to the research participants to ensure they are hidden away from public scrutiny.

Both anonymity and confidentiality assurances in the research process offer high levels of respect for the privacy of the research participants and that of their companies, thereby ensuring that the data and information provided during the research activities cannot be traced back to them in any, and all forms of dissemination. This is necessary, especially in research where in-depth interviews are conducted with the possibilities that sensitive information may be revealed to the researcher – the assurances that the data acquired will not be used for anything other than the research are necessary.

In this research endeavour, all company information and identifiers were anonymised through the allocation of codes (for example, Company A, Company B...., or Respondent A, Respondent B...) to both the companies and respondents. This was done such that it may be possible for each individual respondent as well as the researcher who collected the data through the interviews and observation sessions. to identify parts of the report where their organisations appear

3.8.3 Other ethical considerations

Other important ethical considerations were considered and executed in the actualisation of this research project. The participants were shown respect and accorded all the dignity that the researcher could give. Issues pertaining to deception and untruths were avoided by all means to ensure that trust was built between the researcher and the participants. All questions were attended to; before, during and after the engagement, while all necessary information was shared with them to enable them make informed decisions. In addition to the respect and dignity shown, all participants were given space to reflect on the interviews once the sessions ended. They were also encouraged to contact the researcher if any issues arose during any further reflexive periods on their part. Following the completion of the research project, some of the respondents were once again contacted in order to share some of the findings with them. Due to the volatility of the HVM sector and organisations, the researcher was unable to reach all of them, as he was informed that some of the respondents had changed jobs or their companies had been acquired by others.

3.9 Chapter Summary

In this chapter, a detailed account of the researcher as a part of the research, as well as how his influence has the power to alter it is discussed. Reflexivity concerns are then tabled following which the philosophical concerns are presented. In this section, both the ontological and epistemological paradigms and how they influenced real world research, especially concerning their implications for research methodologies and methods are examined and the rational for selecting the critical realist philosophy is also explicated. Further, the chapter presents the qualitative research inquiry and why the grounded theory method was selected for the research.

Chapter 4: Data Collection and Analysis – Phase 1

4.1 Introduction

This chapter describes the first stage (Phase 1) of the Grounded Theory enquiry process where twelve (12) organisations were queried in a cyclical manner until data saturation was reached. Before the organisations and respondents are introduced however, the strategies relating to the choice of respondents is explored. This includes the site selection and access given to the different respondents, which is covered in the GTM concept known as Theoretical Sampling. Following this, the analytical procedures used for the abstraction of data and its interpretation are explained. For this first phase therefore, Open Coding, which is the very basic stage of coding is discussed. Unstructured interviews were used in this phase, as a basis for all the organisations sampled. For some of these organisations however, additional methods were used to get a first-hand feel of the organisation as well as capture data, especially when the involvement with these organisations was based on official business interventions, i.e. relating to the ASTUTE project.

A summary of each organisation is provided therefore, highlighting the business of each one, and the responsibilities of the executives and members of staff who were interviewed. In some instances, the interviewees were nominated by the company executives, who were the first point of contact in all cases. More importantly, both ongoing and future projects which are in alignment with aims and objectives of this research are briefly described. It is thought that the activities and dynamics behind these projects will provide the essence this PhD endeavour seeks to capture and delineate. In addition, the approach to data collection, initial data extraction as well as analyses is also described in some minor detail, reminiscent of the methodology chapter. This methodological recall is essential to continually bring to mind the complexities and rigour of the chosen Grounded Theory methodology. This process of course, feeds into the second stage, for which a brief outline is provided.

More importantly, it should be noted that this chapter is based on Egbunike et al. (2015), a conference paper that was presented at the EurOMA 2015 conference, Switzerland. This paper therefore incorporates the insightful feedback that was provided by a few of the delegates during the Q&A sessions.

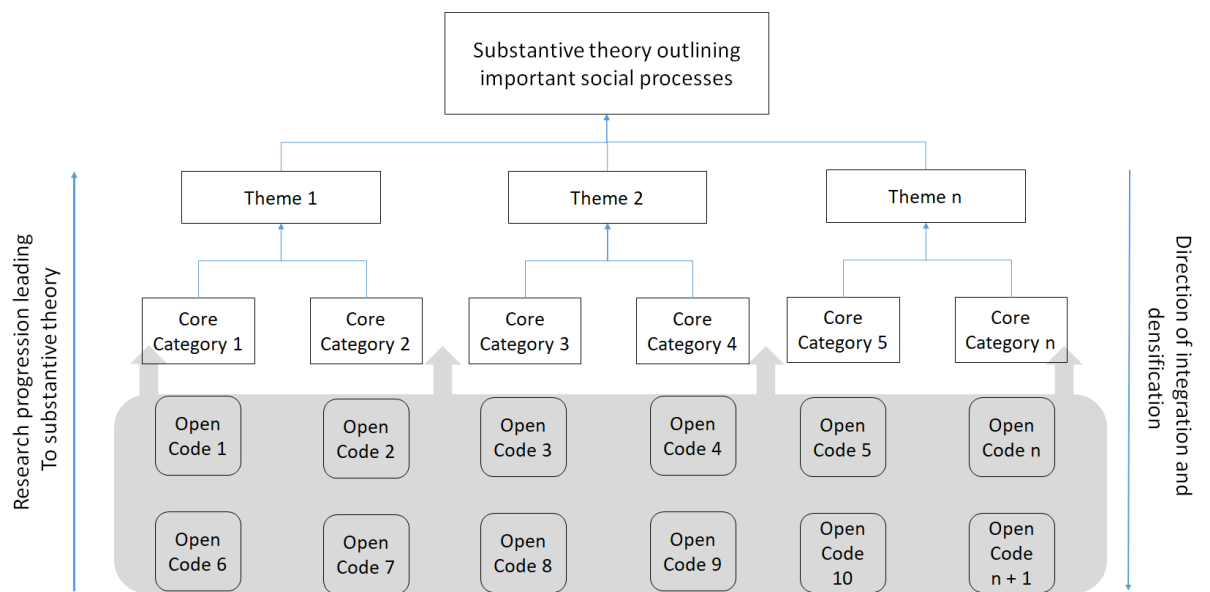


Figure 4.1: Research position & coding process of the Grounded Theory Method

4.2 Theoretical Sampling: Site Selection and Access

As it is with all purposeful research endeavours, the overall aim of any research activity is to achieve measurable increases in knowledge through the development and execution of systematic work and inquiry. Research, according to OECD (2015), “comprise creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society...”. Inferences from the definition indicate therefore, that the selection of participants, phenomena and case study sites, all enmeshed in the context of which the study is defined, constitutes an important part of the process as it affects the quality of the research outputs generated towards increasing the stock of knowledge. With respect to this research, especially with regards to its chosen methodology, prescribed sampling and data collection methods are necessary for effective study completion.

To facilitate the quick selection of case study sites, theoretical sampling was used for this process. Theoretical Sampling, as explained earlier in the methodology chapter, is a process of data collection controlled by the emerging theory which is made up of data that has been collected, coded, analysed and then used as the basis for the next round of data collection in order to continue developing any emergent theory (Glaser and Strauss, 1967)

Although the concept of theoretical sampling originated from the earliest concepts of grounded theory (Glaser and Strauss, 1967), it has become a commonly used research tool as researchers continually make reference to it concerning its use in the selection processes of case studies in general qualitative methods outside grounded theory. Johnson (1998) for example, uses Theoretical Sampling to select information rich cases to highlight the commonalities and differences among their selected sites while Eisenbeiß and Brodbeck (2014) draft a theoretical sampling grid to map the diversity they sought in terms of interviewee's society and cultural background. With regards to Operations Management studies, Sting and Loch (2016) use this method to sample six German manufacturing units that are selected based on stringent criteria, Kim et al. (2014) used it for the same purpose, while Wilhelm et al (2016) used a theoretical sampling approach to for their case selection in their study on implementing sustainability in multi-tier supply chains. What is evident from these studies is the care and precision surrounding the selection criteria with which the case studies and respondents were recruited for the study

Using a theoretical sampling approach therefore, our case studies selection began by identifying HVM SMEs that were characterised by an increasing and vital need to not only launch critically needed products into the market, but also to create and develop new manufacturing and market related capabilities to enhance their market competitiveness. Due to the ongoing support activities that had hitherto been developed between all the universities in Wales and numerous Welsh based enterprises towards the delivery of the ASTUTE project, initial access to a pool of HVM SMEs to enable a detailed assessment of these different organisations was made possible. Due to the focus of this research which was targeted at healthcare, medical and biotechnology organisations, of particular importance and benefit to the researcher was the relationship between the ASTUTE project and MediWales¹¹. This relationship provided further opportunities to the researcher to gain easier access into the HVM organisations than would have been possible without the professional relationship with ASTUTE.

The sampling process for these organisations involved a three – step selection procedure; the first being organisations currently classified as HVM firms and/or those using and/or investing substantial resources in advanced manufacturing technologies to enhance their

¹¹ Founded in 1992, MediWales is the life science network and representative body for wales. They provide advice, support and business opportunities for their members, whilst promoting collaboration within the life science and health technology community in Wales. The network has 180 members largely made up of life science organisations, pharmaceutical services and medical technology companies.

competitiveness. Regarding the second step of the sampling process, we sought to access organisations currently involved in, or proposing to engage in high levels of collaborative and multidisciplinary R&D with university or private sector institutes. It is believed that these collaborative relationships informed the knowledge intensive nature of the organisations value creation processes. Following this, the last step included organisations that, for their continued survival and increasing competitiveness, recognised the importance of resource renewal and organisational flexibility and were engaged in one form or the other of some internal resource reconfiguration to respond to the increasingly demanding nature of society's needs. This of course, highlighted the organisations attitude to learning, continuous improvement and organisational agility.

To support this very specific selection of companies therefore, I adopted a combination of definitions which provided some clarity as to the type of companies that were relevant for this study. I took into consideration, Innovate UK's (2012) definition of High Value Manufacturing which indicated that this is, "the application of leading-edge technical knowledge and expertise to the creation of products, production processes, and associated services which have a strong potential to bring sustainable growth and high economic value...". I also considered another definition from Martinez et al. (2008), who emphasized that high value manufacturers do not compete primarily on cost but rather, deliver value for their stakeholder groups by "contracting for capability, delivering product/service innovation, establishing process excellence, achieving high brand recognition and/or contributing to a sustainable society'.

In addition to the direct data collection activities from the selected SMEs, a second set of organisations were considered, assessed and selected for the purpose of eliciting a much richer data set concerning the importance and development of new and competitive capabilities for the organisations. These organisations, which I considered to be business support organisations, often offered professional, nonfinancial support to HVM SMEs in the form of information and advice to enhance the capability of these firms to drive and manage their own development (Mole and Bramley, 2006). Similarly, and according to Bruneel et al. (2012), business support services accelerate the successful development of start-ups and fledgling companies by providing an array of targeted resources and services. Indeed, Cardiff University's role in this stead, under the banner of the ASTUTE project, provided similar support program to Welsh based enterprises (Egbunike and Biggs, 2014). The rationale behind this choice of eliciting more information, not just first-hand from the selected HVM SMEs but also from other organisations that provided certain services to the HVM

SMEs is hinged on another Grounded Theory tenet which stipulates that, “all is data” (Glaser, 2001)

4.3 The Case Study Units of Analysis

The units of analysis for this case study are the entities that are being analysed and studied in this research. Having defined them earlier as HVM SMEs operating in the medical, biotechnology and healthcare sector(s), they are described in much detail below:

4.3.1 Company A

Company A is a multinational wound care SME with state-of-the-art pharmaceutical production units in the United Kingdom, Germany and the United States of America. They specialise in the manufacture and distribution of larval debridement therapy products used for the treatment of chronic and hard to heal wounds. Established in 2004 as a spin-out of a National Health Service Trust, one of the first of such spin-outs of an NHS trust in the UK, the company is one of the leading Welsh home-grown businesses known as an international leader in its niche field. In two funding rounds since June 2014, they have raised over £7 million pounds

Two interviewees provided the information used in this project. The first was **Respondent A1**, the General Manager for Group Quality and Regulatory Affairs, who had spent over 20 years in the industry in various roles ranging from the shop-floor laboratory scientist to more senior level management and administrative support. A key part of her role as GM for Company A was being able to look at, and understand the ‘bigger picture’ to enable her work collaboratively with colleagues, both internal and external towards delivering innovative products. Other responsibilities covered the understanding and development of Quality Management Systems as well as the development of customised processes for Regulatory Approvals of the company’s innovative medical products. Part of her duties also required detailed understanding of the full life cycle of product development and release due to her involvement in the product from development to manufacturing to approval to launch.

The second person interviewed was **Respondent A2**, the Laboratory Scientist who provided a detailed tour of the laboratory as well as the brief but insightful opportunity for a four-hour observation period. A key part of his role included reviewing, revising and authoring control documents, SOPs, work instruction and technical documentation. Other responsibilities included carrying out all aspects of product related microbiological testing, isolating and identifying contaminants as well as continually developing and delivering on all ongoing microbial monitoring plans towards meeting the production quotas and/or improving them through the design and development of new and improved bespoke, or other, processes

Current projects being executed in the company included the pursuit of medicinal licenses for their products to enable them freely market and advertise the products to prospective clinicians and patients. As part of their development, this pursuit included the development of direct and indirect capabilities which would inform the knowledge needed to continually achieve this pursuit. According to **Respondent A1**:

“...all medicines need a license of some kind and individual countries within Europe can make their own arrangements for special use for medicines that have not been through this licensing process. As this is different in every country in Europe, the UK has something called ‘specials’. If your product is designated as an unlicensed medicine, it can be used on patients under very specific circumstances, while you are going through the route of getting it licensed. So obviously, we’ve started the process. It started with our German organisation and we are eventually bringing it to the UK. At the moment, we need to have a facility that is fit for purpose with the right skills and capabilities needed to manufacture and maintain the products and services. This will be inspected by the MHRA who will inspect for good manufacturing practice every 2 years...”

Further discussions in this area highlighted the urgent need for the identification and development of critical scientific and manufacturing capabilities to enable the company remain on the cutting edge of technology and innovative developments. As a first example, the respondents spoke about the need to for the organisation synthesize the naturally occurring chemicals secreted by the living organisms due to the fact that they could not acquire as much of the chemicals from the organisms as they wanted, when they wanted it. Although this need had previously been recognized (by earlier research conducted by

this company), that there was a critical need for these naturally occurring chemicals, no previous efforts had been made to produce them in laboratories for increased and wider adoption. This was therefore made a mid – long term priority for the company going forward.

Other priorities regarding their upcoming internal projects included monitoring and managing the effects of a changing business model. These activities involved the design, development and implementation of various internal processes to facilitate these changes. Having recently acquired a competitor based in Germany, some of these major projects included integrating this company and selecting appropriate systems and processes going forward. In addition, the company was moving towards an R&D focused operation, with the development of collaborative partnerships with university research institutes as priority. As an indication of this, investments had been pumped into a new R&D laboratory and furnished with advanced equipment. Agreements had also been concluded with academic research institutes to recruit and part-sponsor two PhD students. It was expected that these two students will bridge the gap between the universities and the organisation as well as offer Company A adequate knowledge to take their operations forward to the next level.

4.3.2 Company B

Founded in 2003 as a spin-out from the Cardiff School of Engineering, Company B is an international bio-pharmaceutical SME that specialises in advanced scientific enterprise in areas such as micro fluidics, polymer science and drug delivery science. With a multidisciplinary research team cutting across scientific disciplines such as chemistry, nanomedicine, biology, engineering and medical science functions, Company B develops innovative sustained release drug formulations for diseases and medical needs that have remained unmet. According to **Respondent B**;

“...one of our most high research concerns is taking drugs that are known and have been approved and reformulating and repackaging them so that they can have a much longer duration of action in the body. So for example, you may receive one injection that will continually release the drug we are interested in for maybe a month or up to three months. So that is really what our technology does and what we are doing is honing that technology and making it as suitable for manufacturing as possible at this point”.

At the time of this exploratory interview in 2013, Company B had raised a total of approximately £8.5 million through various funding mechanisms and opportunities such as through angel investors and venture capitalists. This was an indication of the investors beliefs (many of who were experts and globally known authorities in the areas of biosciences, engineering and finance) in the efficacy and novelty of this new technology for which they expected global impact and future returns – financial and otherwise.

With over 10 years in the biotechnology sector, **Respondent B** - the interviewee - was the Chief Scientific Officer whose responsibilities included managing the in-house R&D team towards focusing on the development and use of novel micro & Nano medicine platforms for drug development and delivery, the planning and execution of revenue-generating R&D programmes as well as investor relations and stakeholder management. Having previously been responsible for Company B's collaborative research partnerships, Respondent B also built and managed collaborations and strategic partnerships with universities in the UK and US and was equally responsible for sourcing funds from both public and private sector organisations to sustain these collaborative partnerships.

Having just completed a £3.6 million Series C financing round to expand its portfolio of drug formulations, establish a manufacturing facility on mainland Europe as well as establish its manufacturing capability, a major project to be undertaken in the coming years included the establishment of a sterile pharmaceutical production facility to house one of the company's proprietary technologies to enable them meet current Good Manufacturing Practice standards for the production of their innovative products. As a priority, the identification of the requisite capabilities and their subsequent embedding within the organisation were considered critical.

4.3.3 Company C

As a service provider to HVM SMEs, the vision of this organisation is to facilitate the advancement of medical science through innovation and enterprise brought about by multi and interdisciplinary research for the benefit of human health and mankind in general. In addition, the vision extends to link the aforementioned to the economy by encouraging Open Innovation through open interactions with other organisations.

Established in 2007 as a collaborative partnership between an academic institution, a regional government, a world leading multinational technology company as well as industry practitioners and numerous business partners a first phase investment of £52 million delivered a state-of-the-art building to house over 200 professional specialists in multidisciplinary specialities around medical research, engineering and technology and technology transfer professionals. Following the wider economic successes and disruptive innovations generated from the Phase 1 project, a second organisation, the Phase 2 project, was opened in 2012 to advance translational medical science initiatives. £29 million was invested in this phase to enhance the development of capacity and expertise through the acquisition of a range of fully operational incubation units and the development of a Nano Health centre to concentrate on creating products that are a combination of Nano Engineering and Biological sciences.

Two interviewees were questioned by means of three face-to-face unstructured but sequential interviews following which an extended period of observations was undertaken and conducted alongside one of the earlier interviewees. The first interviewee - **Respondent C1** – was the Head of External Relations and the second interviewee – **Respondent C2** – was the Senior Laboratory Facilities Manager. Two other employees who were spoken to during the two-hour observations and site-survey period provided some extra insight into the enquiry. These were not recorded as ‘major’ data generating activities hence, their discussions were not recorded or transcribed but captured in my notes and memo’s as **Respondents C3 and C4**

The Head of External Relations was responsible for developing an integrated strategic communications plan to establish and raise the company’s reputation with all stakeholders as well as help the business to deliver on its mission to advance discovery through effective communications and networking. In addition, the role was also expanded to include the creation of strategic alliances, networks and joint working arrangements across boundaries to create and develop collaborative partnerships across the different organisational boundaries. According to **Respondent C1**:

“.... having been thrown into this role, I realised that the responsibilities went beyond that of the traditional communications manager to incorporate those of boundary spanner. My duties have therefore morphed into a kind of hybrid role, where I am not only responsible for the traditional communications activities but also for the linking the organization and its tenants with external sources of

information and business opportunities. This has been a great opportunity for me to learn first-hand, the need for, and advantages of information harnessing for innovation and enterprise”.

Respondent C2, the Senior Laboratory Facilities Manager was the second interviewee. He had only just recently taken up this role after over 10 years as a Senior Research Scientist with a successful start-up located a few kilometres away. He was responsible for the general facilities management which included designing, planning and organizing the operations of the institute’s laboratory. This included the establishment of standard protocols and practices for the effective and safe operations of the laboratory as well as researching the practices, capabilities and design effectiveness of similar laboratories. The aim was to design effective knowledge transfer mechanisms to enable the transfer of best practices into his own space to increase and improve process innovation capabilities of the incubator tenants. According to him;

“...the importance of laboratory space and skilled workers to our high-value manufacturing start-ups is almost as important as breathing is to human beings...it is almost a life or death situation for these organisations...because not all of them have the financial capacity to afford these facilities, we have to provide as much of the basic, and relevant ones as possible. We have also found out that the opportunity to share these equipment fosters a lot of knowledge sharing opportunities that are very valuable...”

4.3.4 Company D

Company D was founded in 2005 by a group of engineers in close collaboration with medical doctors and clinical scientists. Their motivation for the development of devices that could reduce morbidity and mortality from acute lung damage was based on the fact that immediate family members, as well as millions of other people were suffering, or had died, from acute respiratory infections, while others continue to suffer life-long debilitating chronic ailments such as Emphysema. The idea behind this innovative product was to develop the next generation Extra-Corporeal Membrane Oxygenation (ECMO) device, in other words, a medical device to deliver oxygen directly to the blood, thereby augmenting any reduced capacity of the lungs in patients with acute or chronic diseases. The initial focus of the

device was for post-operative support following any cardio pulmonary surgery towards improving recovery rates and drastically reducing hospital stays – thereby improving outcomes and saving money. This medical device, ideally, was considered to be a prosthetic or artificial lung and is the first ever invention or innovation of the sort necessitating the application for, and acquisition of, various intellectual property rights

As one of the founders of Company D, the Managing Director was interviewed for this research endeavour and the information he tendered provided extensive insights to the operational activities of the company with respect to the development of capabilities and the factors which both affected and accelerated the process therein. Having spent over 3 Decades in positions of authority across both private sector and academic organisations, **Respondent D1's** career included a senior position in a chemical manufacturing organisation as well as the academic position of Professor of Chemical Engineering in a British university

During the time of this interview, early in 2013, the strategic projects that had been ongoing in the last 5 years included as a first stage, the development of interdisciplinary as well as multidisciplinary protocols to enable the successful integration of collaborative working outputs. According to **Respondent D1** some recently concluded projects included:

“...so we recruited one of Professor X's PhD graduates, someone with a PhD in Rheology, Complex Flows...We needed to look at how we make the surfaces more biocompatible, which was not something that had previously been done in Swansea. Working together, we had ideas of how it would be done so we recruited another graduate who had a PhD in Chemistry...he had been looking at Nano-medicine, looking at deep wound healing...he was a very numerate Chemist as well so we got someone who knew about interactions between bodily fluids and things you stick into them...he had been developing a novel polymer which could seal a deep wound and it was structured such that natural flesh will grow through it and gradually dissipate the polymer...he was well grounded and started looking at surface coatings which we could have. One of the key things is that whatever he developed had to be compatible as well as stable...”

These collaborative working partnerships were further emphasized and explored, during later stages of the discussions when the ongoing and planned projects were discussed in detail. Once again, according to **Respondent D1**;

“...the next stage now is that...we have been sort of fortunate because a big American company that does cardio pulmonary bypass, basically heart lung machines...we contacted them and said can we get a pump for blood...they became interested in what we were doing, they liked the novel design we had and they asked if they could enter into a co-development agreement with us...so what we are trying to do at the moment...it is not exactly what we set out to do originally, but it is something which puts us into the market...if we meet their performance criteria by early next year, then they will give us firm purchase orders for 5 years and then we can set up a manufacturing facility somewhere in South Wales to make it...”

“...in order to go into production, the team we have in Swansea are all recruited from people who have done research and the skills to go into production are very different. So we have retained a company in Hungerford...who have some experience in design for manufacture...we are hoping to have our first prototypes in a couple of months and if they work, we will make 20 – 30 better ones which we can send over to the States for testing...”

By 2015, Company D had raised around £2m in private equity investment and had also benefited from grants awarded by the Welsh Government and NHS. Company D was also awarded a £1.2m TSB innovate grant to continue developing the novel device.

4.3.5 Company E

With a vision founded on three pillars; innovation, product development and commercialisation, Company E was founded in 2009 as a spin-out from the Welsh Institute for Minimal Access Therapy (WIMAT) – a part of Cardiff University that runs one of the most active multi-disciplinary training centres in the UK. Specifically, Company E was set up to develop and commercialise products that improve the safety, efficiency and outcomes of surgical procedures. Company E is now considered to be a leading innovator of minimally

invasive surgery technologies, which includes the world's first XXXX™ system, a device used to clear the vapour and particulate matter that is generated by surgical cutting instruments during laparoscopic surgery.

The data used in assessing Company E's general attributes, regarding their operations, growth strategies and organisational behaviours was provided by **Respondent E1**, who was the founding Managing Director, and still is the Managing Director. With a career spanning the last 13 years, starting with a first degree in Biochemistry followed by a DPhil in Biochemistry, his experience cut across both academic and private sector organisations locally and internationally. His responsibilities as the Managing Director of Company E included the development and management of overall company strategy, the execution of operational excellence within the company as well as the recruitment, development and general management of talent and teams.

Projects being undertaken by the company at the time of the interviews included the in-house development and embedding of the relevant knowledge and capabilities to optimise the current and future product ranges being offered by the company. According to **Respondent E**;

“...not minding some of our registered successes, we developed a lot of our work on shoestring budgets by collaborating extensively with academic institutions and outsourcing some other tasks such as prototyping. With some recent seed funding however, we would like to expand our operations and begin the process of enhancing our in-house capabilities through the recruitment of technical, scientific and other skilled people. We realise that we cannot do everything through collaboration because our collaborators have their own priorities which often may not fit with ours during times of critical need...”

At the time in the last interview in 2015, the company was still at the pre-revenue stage. In February 2017 however, Company E received around £6m venture capital funding from investors and by June 2017, had received another \$5.8m from other venture capital investors to support the commercialisation of its surgical device.

4.3.6 Company F

Founded in 2013 as an innovative diagnostic company, Company F is spin out from Swansea University that has developed an alternative, non-invasive novel approach to the monitoring and diagnosis of chronic and acute diseases, using infrared spectroscopy at the point-of-care. This infrared spectroscopy involved the measurement of tissue samples via light waves to understand the differences between healthy and non-healthy samples and the creation of a spectrum to quickly diagnose ailments. Diseases, especially those of the Chronic Obstructive Pulmonary Disease (COPD) type, are diagnosed from biomarkers in the patients' saliva and mucus. COPD continues to be an important cause of morbidity, mortality and healthcare cost internationally (Mannino & Buist, 2007). According to Soriano and Lamprecht (2012), it is a major public and global health issue that remains a challenge for clinicians in the 21st century. In the UK for example, an estimated 1.2 million people are diagnosed with COPD, making it the second most common lung disease in the UK, after asthma¹².

As a former executive in one of the world's largest pharmaceutical companies, **Respondent F** is a leading figure in the United Kingdom diagnostic industry with over 3 decades of professional experience. As a serial entrepreneur entrusted with current responsibilities for contributing to the board - level management of a few start-ups, having founded a few of them, **Respondent F** provided some of the data used for this study. His overall responsibilities, as the Founder and CEO of Company F, included setting the overall strategic direction of the company based on the initial vision behind the innovative product as well as managing the identification and acquisition of the relevant skills and capabilities needed by the organisation to match the strategic direction

According to Respondent F;

“...we are building a company that will have the potential to drastically increase the quality of life of patients who may be suffering from debilitating infections and diseases. We aim to achieve this through the development of multiple combinations and configurations of medical and technological knowledge that

¹² British Lung Foundation. 2018. Chronic Obstructive Pulmonary Disease (COPD) Statistics. <https://statistics.blf.org.uk/copd>

incorporate current, and even futuristic, technologies...to an ever-demanding and increasingly expanding market”.

Strategically important projects that were being undertaken in the company included their collaborative partnership projects with Swansea University towards the development of the miniaturised, portable device modelled after point of care devices, i.e. those devices that simplify medical tests such that they can be performed at the bedside within minutes at home or in a clinic using a patients' urine, blood sample or saliva.

Again, according to Respondent F;

“The infrared spectroscopy we are using has been around for a while and has been used in different industries such as the food and medical areas...what we are trying to achieve now, is to remove this technology from the laboratories and put into the hands of the patients to quicken diagnosis, save costs and improve patient outcomes... this will involve miniaturising the technology into a point of care device...this of course, involves multidisciplinary research on the micro and nano-scales which by themselves when working in silos (single disciplines) are quite a challenge...and then we now have to combine these...”

Future projects included the search for, and identification of, commercial partners to assist in the deployment of their devices into global markets. In addition, closer collaboration with Swansea University as well as other R&D partnerships were being nurtured to support the development of critical markers to aid in the utilisation of this device across other diseases such as diabetes and cancer.

Most importantly, speaking about the future elicited the following response from **Respondent F**;

“We need to get the people right, both internally and externally which includes collaborators, board level advisers, internal scientific, technology and laboratory level staff, external stakeholders... As a High Value SME, a single recruit, collaborator who turns out to be...to be a mistake or someone or something not needed at this point in time, will be dangerous for the company. We therefore have

to try and understand a future we do not know and cannot predict adequately...”

4.3.7 Company G

Company G is a specialist medical manufacturer and supplier of pressure area care and infection control products to the healthcare sectors in the UK and internationally. With approximately 25% of their sales coming from exports, they are also involved with the development and deployment of clinical waste and harm reduction products. Founded over five decades ago as an innovative enterprise in the forefront of pioneering simplicity, they have continually remained innovative and relevant through their pursuit of simplicity by providing cost effective and clinically efficient medical solutions that help prevent harm as well as improve patient outcomes – which of course, are amongst the most pressing needs of the NHS and other national and international healthcare organisations.

Two interviewees provided the data used in this initial phase of the research project. The first interviewee, **Respondent G1**, was the R&D Manager, who was responsible for R&D activities leading to new product and service development. As a board level member, a major part of these R&D responsibilities also included focusing on the analysis, design and implementation of new business processes and workflows to support the continuous improvement of the organisation in order to remain competitive. Other responsibilities included boundary spanning for any external sources of knowledge and information to support the creation and development of collaborative projects and partnerships as well as knowledge management.

The second interviewee, **Respondent G2**, was the Design Manager responsible for applying design and systems thinking methodologies to develop solutions to solve both company and consumer problems, when necessary. A major part of his responsibilities included supporting the R&D Manager to translate these into advanced development projects, which were often collaborative and/or multidisciplinary in nature to support the co-creation activities undertaken with the clients and/or cross functional collaborators. For example, **Respondent G2** stated that;

“...the way we solved a problem which a few of our clients had brought up with our suppliers was to engage with a few of them in a

workshop to understand the problems and offer them (the clients) the opportunity to engage in an ideation workshop towards solving the problem. Following this, we knew we did not have the in-house capabilities to even begin to rectify the problems...which was almost like re-creating a part of the product...just completely changing one part of the product. We then had to find another external organisation to collaborate with us – and the clients – to re-develop just that that little aspect of the product to satisfy our users...”

Respondent G2 also lead and/or supported cross-functional brainstorming sessions to encourage innovative and disruptive thinking, where the best ideas and solutions were taken forward for companywide consideration. According to **Respondent G2** again;

“A minute percentage of these ideas ended up in prototypes which were tendered for internal reviews, testing and end-user validation. A few ended up as product improvements...although we are yet to create a completely new product from this process, we have found out that it aids our incremental innovation capabilities due to the new knowledge and learning it inspires the teams to engage in...”

Current projects at the point of this research, that were relevant to this study included an on-going collaborative project with the ASTUTE project of Cardiff University. The purpose of this project was to facilitate the transfer of Lean manufacturing and production principles into Company G’s production operations towards embedding a Lean culture which supported continuous improvement activities throughout their manufacturing cycles. Methodologies adopted to enhance the embedding of new capabilities within Company G included Action Research principles as well as learning through the gamification and group simulation of continuous improvement concepts and principles.

Future projects that were planned to ensure long term competitiveness included initiating and conducting collaborative projects to support the development and embedment of scientific approaches to the monitoring and execution of injection moulding optimization processes. This project was planned to include the bi-directional transfer of knowledge (between Company G and the collaborators, who in this case was going to be the ASTUTE team once again), the development of new process improvement methods, the acquisition of new software such as those used for simulations and advanced statistical and data analysis. Indications showed that the intentions of this organisation were to embed the

capabilities needed to support and drive a knowledge-based organisation to enable them chart an informed path into the future which remained unpredictable.

4.3.8 Company H

Established in the early 2000s, Company H is a biotechnology-based company that develops and manufactures long term, market leading antimicrobial technology and solutions for clients operating across multiple industries, including the medical and healthcare sectors. The term ‘antimicrobial’ refers to a broad range of technologies that provide varying degrees of protection for products and buildings against microorganisms¹³ (White et al., 2003). Other researchers define them as chemicals that either kill or inhibit the growth of bacteria at defined concentrations, and function by targeting systems critical to bacterial physiology (Adu-Oppong et al, 2017). As such, their importance in events and activities that seek to limit, control or eradicate the proliferation of harmful bacteria, fungi, algae and all other microbes has been explored extensively and is still being explored by various academic and private sector organisations due to growing problems of antibiotic resistance and outbreaks of hospital acquired infections.

Company H operates within this domain and in addition to already developed market leading products, they are currently developing whole new range of products targeted at combatting new ‘superbugs. According to **Respondent H2**,

“...the economic and human health impact of disease, odours... the deterioration and decomposition of everyday materials such as those used in hospitals, food and drinks industries and buildings... these materials cost millions of pounds to maintain and/or replace each year as well as cause deaths which could have been avoidable. These are some of the motivating factors for us, in our pursuit of the development of new antimicrobial solutions...”

By infusing the different materials from their various clients with antimicrobial products therefore, Company H opens the doors to new marketplaces for their clients such as offering their clients’ products new features such as excellent protection against various illness causing bacteria and fungi such as E. coli and MRSA.

¹³ <https://www.microbedefence.com/support/pdf/FAIExpo2003Paper.pdf>

Two interviewees, **Respondents H1** and **H2** who were both Directors, provided the information used in identifying and assessing the development and evolution of the organisational capabilities needed to perform their company activities. Over a period of 18 months both directors were interviewed together, twice. Data was also collected via the observation of their in-house operations regarding the consultations around the development of an in-house laboratory, the acquisition of advanced machinery for plastics processing as well as the required organisational processes used in managing these new capabilities.

At the time of the interviews in 2013, **Respondent H1** had spent over 20 years in mid to senior level roles as a manufacturing and production engineer in the local manufacturing sector. Similarly, **Respondent H2** had spent just over 15 years as a professional, also in the local manufacturing sector. Before co-founding Company H, his last role was spent with a manufacturing company as an Engineering Director for 10 years.

Due to the start-up nature of the organisation, both directors did not have individually defined responsibilities but took on whatever tasks were needed to ensure the company's value proposition to the customers was met. Both of them were therefore responsible for the general management of the company regarding issues such as strategic planning, business development, human resources and project management. More importantly, they were also responsible for horizon scanning activities and the general management of operations for issues such as (new) product development, supply chain management and general boundary spanning for the acquisition of collaborative support.

Projects being undertaken by Company H at this time of the interview included the setting up of an in-house laboratory to develop the capabilities to support their in-house R&D, production and testing. Additional equipment included injection moulders and extruders to increase their in-house end-to-end manufacturing capabilities. With regards to the development and evolution of their capabilities, an excerpt from **Respondent H1's** discussion included:

“Our (business) model is based on a lot of collaborative relationships with many other organisations. As you have seen...from our site, facilities, we do not have the full resources and capabilities needed to provide all the solutions our customers need so we work with other companies to achieve this. Ideally, we need to develop our in-house

laboratory...a small to medium sized one that will be located in that room (points to a very large but empty room across the hall) ...we will also employ an R&D Manager to manage this laboratory space...he will locate and work with the relevant research institutes to learn from and develop some knowledge transfer activities....”

Following some further discussions, **Respondent H2** added;

“This opportunity you are talking about...ASTUTE...can you help us determine the resources we will need for the laboratory as well as any internal processes we will need to develop for this? Do you have any Project Officers who have bioscience backgrounds...maybe people from biochemistry, chemistry, lab technology who understand regulatory and Good Manufacturing Process issues? We have looked at Cardiff and Swansea Universities and see that there are some advanced research knowledge activities going on there that we can tap into...”

With regards to future projects, Company H mentioned their intention to remain on the cutting edge of technology through the adoption of dynamic business models to keep their collaborative partnerships as ongoing concerns. They mentioned their intention to take advantage of the UK national innovation agency’s programmes such as the Knowledge Transfer Partnerships and research funding opportunities.

According to **Respondents H1** and **H2**

“...even though we are currently dependent on the facilities and knowledge of others to support the delivery of our products and services, our growth and acquisition of these facilities will not deter us from any further programmes and projects. We will still seek to establish relationships that will support internships and post graduate engagements such as MSc or PhD projects...this will keep us clued up and ahead of our competitors, we hope...”

4.3.9 Company I

Company I is an international manufacturer and distributor of medical equipment including pressure care and positioning products, mobility aids as well as respiratory products. Although the company was not an initial choice for this study, a brief change management project¹⁴ displayed their suitability which warranted some further enquiries from them based on the aims and objectives of this research. The outcomes of the change management project highlighted the need for further capabilities identification and development for staff in the areas of advanced technology adoption for topics such as lean and agile manufacturing which included the adoption of Kaizen/continuous improvement processes, value stream mapping, business process reengineering and total productive maintenance.

Data was provided by two senior members of staff, **Respondents I1** and **I2**. **Respondent I1** was the Production Manager whose role was to lead the overall vision and direction for daily manufacturing operations which were designed to meet their periodic production schedules. In so doing, his responsibilities also included enabling the teams with the tools and training needed to continually deliver their high-quality products and services to their customers.

According to **Respondent I1**:

“My role in Company I, is simple – I do whatever it takes to maintain our production quotas or improve on them. To achieve this, a lot of effort goes into managing the company’s resources which includes our staff, infrastructure, equipment...To break the role down, I assess our resource requirements, I ensure that our staff are well equipped to carry out their roles, I keep an eye out on improvement projects to improve on our product quality, delivery times, reduce costs and so on...”

¹⁴ A collaborative project with the ASTUTE team was initiated to transfer and embed Lean Management principles into Company I. The commitment from the company assumed great importance as shop floor operations were noticeably disrupted to ensure that all critical staff were involved in the improvement project. Following the initial pilot study, a group of company champions were nominated to take the project forward into much more critical areas of the business to effect a complete change to the organisations operations.

Respondent I2, the Engineering Manager was responsible for initiating and managing the essential activities needed to keep the factory operations (and equipment) working. Part of this included developing continuous improvement projects and the facilitation of process enhancements with the objective of delivering high quality products in a cost-effective way and on time. With some overlap in role responsibilities with **Respondent I1**, **Respondent I2** was partly responsible for improving manufacturing efficiency by analysing and planning complex workflows, equipment layout and space requirements.

Respondent I2 developed a particular interest in this project as he wanted to develop a deeper understanding of manufacturing capabilities and the supporting ecosystem, if any, surrounding the concept. It was his wish that the final framework or theory be put to the test using his organisation as a test bed. The aim of this proposed trial was to further identify their positioning on a scale, if any, to enable them incorporate the suggested changes and/or recommendations.

One project, which was the basis for this company's involvement on this endeavour, was being developed to support the acquisition of new knowledge and new technologies to enable Company I develop and market new products such as beds, mattresses and cushions that are effective against pressure care and seating. To achieve these aims, Company I had approached academics in the Clinical Innovation team at Cardiff University to request for collaborative support.

According to **Respondent I2**;

“...at this stage of our development...especially with what is going on with the global economy...competition, recession, clients' needs...we believe that we desperately need some injection of new knowledge to stir up the innovative, creative and dynamic capabilities of our staff...and with all the good things we have heard, read and seen from university research groups such as Cardiff and Swansea, we believe that any collaborative work with them will stimulate our internal capabilities...”

Upon further discussions with the company's project team members it was identified that the company was embarking on a business model change to incorporate specialist and advanced knowledge derived from external sources as their central theme for organisational effectiveness and improvement

4.3.10 Company J

According to Cooper (2000), enzymes are characterized by two fundamental properties – they increase the rate of chemical reactions without themselves being consumed or permanently altered by the reaction and secondly, they increase reaction rates without altering the chemical equilibrium between reactants and products. For example, their importance in the human body help speed up chemical reactions by binding themselves to molecules to alter them in particular ways. They are necessary for multiple bodily functions such as respiration, the digestion of food and nerve functions amongst other things (Newman, 2018)

Founded in 1990, Company J is an international biotechnology company that manufactures specialist enzymes and catalysts for a variety of industries such as those in the food, pharmaceuticals and life science sectors. With a simple but multi-faceted strategy that focuses 100% on providing customers with customized and novel enzymes through active co-creation partnerships, their capabilities were under constant scrutiny and required frequent and timely renewals to meet both their clients' as well as policy and regulatory demands. This was particularly important due to the need for specific enzymes for specific reactions in specific industries because according to Cooper (2000), the appropriate enzyme is needed to accelerate reactions by well over a million-fold so that reactions which would take years in the absence of catalysts can occur in a fraction of seconds.

Their capabilities included the ownership and use a metagenomic library, fermentation and downstream processing capabilities as well as Good Manufacturing Practice capabilities amongst other things. More importantly, according to **Respondent J1**:

“...our strengths as an organisation are achieved through collaboration with any, and every organisation that has the capabilities that we need internally...to satisfy our internal curiosities, answer our difficult questions, support our disruptive innovations...all in the effort to satisfy our customers with the value they need...”

Company H maintained ongoing relationships with leading university research institutes around the UK and internationally and routinely engage in research studentships and knowledge transfer partnerships for the acquisition of new knowledge. Many of their projects, it was later identified, were co-funded by the UK's prime innovation agency, Innovate UK (Technology Strategy Board)

Some of the data from this company was provided by **Respondent J1**, who was a Product Development Scientist/Manager. **Respondent J1** joined the company after a PhD degree in Molecular Genetics and was responsible for the discovery, development and manufacture of novel enzymes which conformed to the exact needs of the clients. More detailed responsibilities included customer facing interactions to elicit customer requirements, the development and execution of collaborative R&D activities for NPD as well as detailed in-bound knowledge transfer.

In addition, some more data was provided by **Respondent J2**, who was approached during a period of laboratory and workspace site survey and observation. **Respondent J2** was a Product Development Coordinator responsible for the initial requirements capture towards developing a customized solution for clients that could not use previously manufactured and standard off-the-shelf products. Incidentally, Respondent J2 was enrolled in her second year, on a PhD program, at the time of this data collection activity, with a provisional research topic titled, "Embedding critical user requirements into the design and development of complex multi-use biomaterials for medical and pharmaceutical use"

Current projects being undertaken by the company at the time of this interview included the identification and development of newly discovered materials to facilitate the reduction of new product development process times. The aim of this project was to continually offer customers the opportunity to reduce the time to market for their products and services. This project was being undertaken in collaboration with a university using a recently acquired Innovate UK grant. A future project which was being explored, subject to adequate external funding, involved the conceptualisation and prototype design of an innovative production plant incorporating newly developed processes and production methods to expand their current technical capabilities and allow them produce commercially viable and bespoke enzymes within shortened timeframes at reduced costs.

4.3.11 Company K

With a team of immunology scientists on a mission to improve patient care through research, education and technology driven new product development, Company K is a biotechnology company that specialises in the research, development and manufacture of products and services for personalised immunotherapy R&D, diagnostics and treatment for people with cancer and other debilitating diseases

The data from this company was provided by **Respondent K**, the Operations Director, who had been in the position for 2 years. With a PhD in Biomolecular Sciences and over 5 years' experience, including 3 as a post-doctorate researcher, his responsibilities in his role included establishing collaborative R&D partnerships and activities with academic institutions due to the fact that Company K had recently entered into the UK market through Foreign Direct Investment from a parent company abroad who itself, was an SME. Other responsibilities included identifying and applying for funding from public sources, preparing technical presentations for international networking events as well as setting up an in-house state-of-the-art laboratory to gradually take up research that had hitherto been carried out by academic partners and contract manufacturers. In addition to these, his responsibilities included managing the recruitment of a technical team to manage these in-house activities.

According to **Respondent K**;

“...it is obvious that the parent organisation recognises that the UK is a huge market and a gateway into the EU market hence the investment and heightened interest in this market. They also recognise that there are very specialist and advanced science skills and capabilities present in this market...they want to develop new products and services which they can patent and then sell internationally. My job is to manage all these expectations by building a multidisciplinary team to achieve all these....”

Projects currently being carried out by the company, which was also in the longer-term plans for further future developments, included the development of suitable platforms towards generating and optimizing multi-specific antibodies to be used in the management of oncological emergencies.

4.3.12 Company L

With a history of evaluating medical devices for a succession of NHS organisations since the 1970's, the majority of Company L's work was, and still is funded by a national UK health organisation responsible for providing advice to improve health and social care. They provide information and recommendations on emerging health technologies, medical devices and diagnostic tests amongst other things to support quick decision making by policy makers, clinicians, healthcare managers and stakeholders on issues such as the medical innovations likely adoption benefits, cost of use and general value propositions including their strengths and weaknesses.

Among the activities achieved by this company at the time of the interview were:

- The critical assessment of the *Brand L1* device made up of contact lens sensors that continually measure changes in ocular dimensions over 24-hour periods
- The assessment of a Brand L2 diagnostic tool that uses electrical spectroscopy to detect pre-cancerous cells in the cervix of women.
- The point-of-care diagnostic test to identify anti-hepatitis C virus antibodies intended for use in the community.

It was believed that the experiences gained from these activities would provide usable evidence for this research endeavour hence, the detailed discussion with **Respondent L**, who provided some of the data used in this study. As a Director in the company, Respondent L was responsible for leading the team towards achieving the aims and objectives of the organisation which is to focus on healthcare technology R&D as well as the evaluation of medical and diagnostic devices. That said, their activities which span several clinical categories including point-of-care diagnostics and wound healing enable them enter into collaborative partnerships with academic institutions, start-ups and publicly funded organisations.

Respondent L holds a PhD in Medical Physics and has extensive experience in nuclear medicine, radiation protection and ultrasound, Respondent L has led the R&D arm of one of the Local Health Boards in Wales

4.3.13 Summary of findings

Having introduced all the companies, the respondents as well as their ongoing internal projects, most of which were in alignment with the aims of this thesis, the data collection stages are going to be described in the next section below. It is pertinent to mention that following these initial meetings, access to all the organisations was easier as the researcher was given the go ahead to reach out to them as, and when needed, to collect data as well as interview the different respondents.

It should also be noted that the information provided about all the companies are not similar. This was done on purpose for two reasons; (1) some of the organisations provided certain information but specifically requested for them not to be mentioned, and (2) some organisations refused to provide the data. Reasons given for withholding such information was based on the need for anonymity – some information being unique identifies would have given away the identity of the organisations.

4.4 Preliminary Interviews and Data Analysis: Phase 1

During this first phase of the research endeavour, at least one respondent from each of the 12 organisations was interviewed. Each interview followed Seidman's (1991) model which focused on life history, following which a detailed exploration of the experiences in this history were outlined. Lastly a reflexive process to identify the meanings of these experiences was embarked upon, especially when these experiences were in line with the interest that was being studied. The purpose of this method was to use the relevant aspects of the respondents' professional experience as the point of departure for our engagement. Being in positions of authority, most had at one time or the other, been responsible for aspects of capabilities and competitive development.

The first question therefore, dwelled on the life narrative method (Reissman, 2008), with regards to the company and its origins. Questions such as, "what does your company do", "what is history of the company and how have you become the company you are today" and "what are the social, economic and technological factors that have shaped the organisation up to date". This question elicited the broadest possible company history to emerge, providing the researcher with various company milestones and experiences from which to extract specific manufacturing capability related phenomena for deeper

interrogation. Some of the discussions naturally fed into the interview guide shown in **Appendix C**

Following the first and second interviews, data analysis and preliminary coding from the companies were conducted simultaneously following which the constant comparison method was used to analyse the data, cumulatively, once multiple interviews were undertaken. The purpose of this constant comparison method of joint coding and analysis according to Glaser and Strauss (1967), is to generate theory more systematically by using explicit coding and analytic procedures. Data was collected sequentially, with the comparison happening after each interview in a cumulative manner (see Figure 4.2). This constant comparison method is one of the core tenets of the Grounded Theory methodology (Strauss and Corbin, 1998)

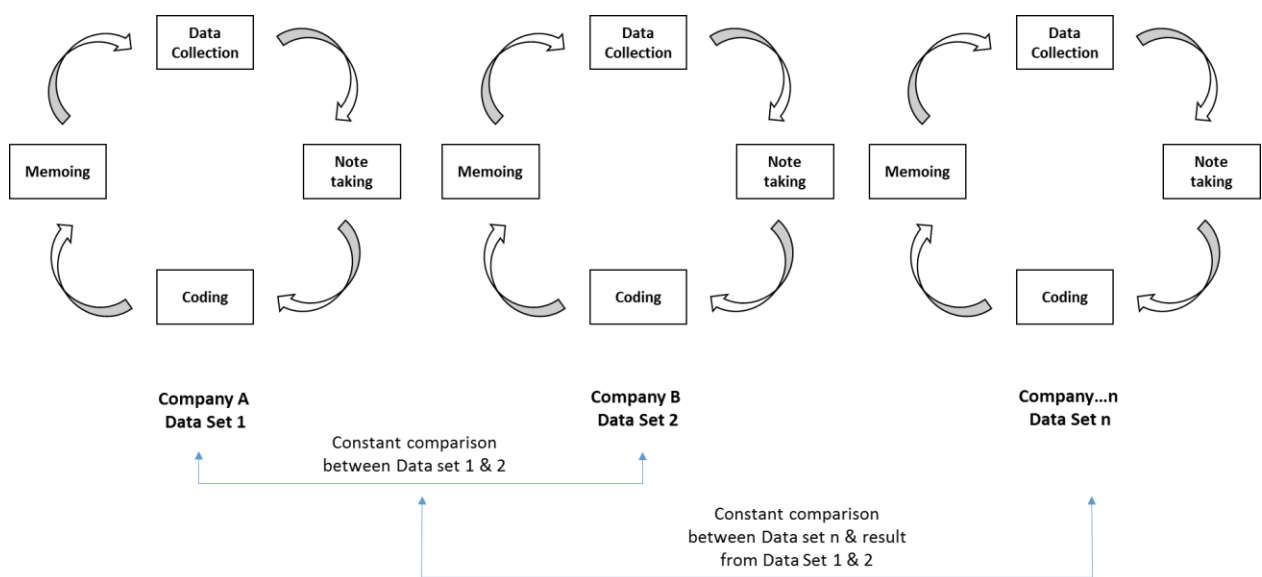


Figure 4.2: Constant Comparison method of data analysis (adopted from Jones and Alony, 2011)

This process served as a prelude to the multi-case study data collection and analysis (See Chapter 5) where it was expected that the beginnings of a substantive theory will emerge, using the preliminary codes which fed into the more detailed and in-depth case studies. The rationale behind this slight methodology modification was to sample a much wider pool of respondents to enable the collection of more relevant data representative of the wider

concerns of practitioners. In other words, this wider pool of respondents contributed to the core category, which eventually shaped the rest of the research/category developments. It must be stated however, that even with the slight methodological modification, the full Grounded Theory process was followed to ensure rigour as well as the quality of the results arising from the analysis of the data collected. In so doing, this slight adaptation of the conventional grounded theory approach was used, without compromising the aims of the research and data management process

In this stage, the data collected from the 12 organisations was done via different methods which included interviews; semi structured and unstructured, periods of observation as well as document analysis. The aim of this mixed data collection activities was to collect both primary as well as secondary data to ensure that all possible ways of 'validating' each of the data sets, i.e. both primary and secondary data, was observed. This was in alignment with Glaser's (2001) argument that 'all is data';

"...all is data is a well-known Glaser dictum. What does it mean? It means exactly what is going on in the research scene is the data, whatever the source, whether interview, observations, documents, in whatever combination. It is not only what is being told, how it is being told and the conditions of its being told, but also all the data surrounding what is being told. It means what is going on must be figured out exactly what it is to be use for, that is conceptualization, not for accurate description. Data is always as good as far as it goes..." (p.145)

In total, there were 13 first stage interviews, each ranging in duration from 1.5 to 3.5 hours, 7 periods of observation (in 7 organisations) as well as document analyses for 7 companies. The common denominator for all companies was the interview with some being unstructured while others were semi-structured. As the opportunities arose, whether during or after the initial interviews some observations were conducted to enable the researcher speak to, and observe some of the employees in their workspaces. This process helped to put some of the details discussed in the initial interviews into context to ensure that the journey towards the development of the substantive theory captured the necessary information in the right context. In addition, the researcher requested for official documentation from the companies to provide some additional information about the company's products, processes and developmental pathways. Documents such as product manuals, intellectual property applications, marketing materials and brochures were

provided where necessary. In addition to this, the researcher was sign posted to academic databases for more information, mostly concerning the technical and/or scientific details, due to the ongoing multidisciplinary collaborative relationships with research institutes. Lastly, but not surprisingly, a few companies directed the researcher to YouTube videos, which showcased various video clips regarding their operations, products, investment updates and various commercially relevant details. All these repositories provided a rich and varied source of information and data relevant to the aims of the first stage enquiry.

4.4.1 Coding

Following every interview, transcription took place and the researcher commenced the process of coding, which was mostly descriptive. This involved the categorization of data to reflect the various issues highlighted and emphasized during the interview discussions. According to Miles and Huberman (1994), "Data analysis involves classifying events and the properties that characterise them...". During this phase, descriptive labels were attached to distinct instances of events or instances, which could be identified and repeated over the course of the interview and therefore, easily identifiable and comparable.

It must be emphasized again, that due to the selection of the Glaserian or classic Grounded Theory methodology, as highlighted in the methodology chapter, three levels of coding were used in this study. These coding mechanisms were open, selective and theoretical coding. While we focus on open coding later in this chapter, the following paragraph, Block Groupings, also involved some coding activity, which was only used as a means to familiarise myself with the data through some quick, initial consideration

4.4.2 Block Groupings

According to Miles and Huberman (1994), codes are assigned to 'chunks' of data, usually phrases, sentences or paragraphs that are connected to a specific context. This provides the researchers with opportunities to engage in data reduction and simplification, as well as expansion, transformation and reconceptualization (Coffey and Atkinson, 1996). At this stage, it should be emphasized that the coding activities referred to by Miles and Huberman (1994) for this stage, differ from the Open Coding activity that is usually carried out for the first stage of the grounded theory process. Other than the provision of a high level, early understanding opportunity of the datasets, this initial block-coding analysis provided some indication and patterns of the possible underpinnings of a final substantive theory.

To commence the block coding phase, a preliminary interview analysis was embarked upon. This preliminary analysis involved reading through each of the transcripts and selecting blocks of data that were considered to be the key comments made by the respondents related to the questions that were asked i.e. locating whole paragraphs that had some relationship to the research problem that was being explored. During these initial stages of the analysis, each of the blocks of information provided a rich description of a point or event being discussed and therefore provided a summary understanding. Two methods of data capture and analysis were used for this process. During the first attempt to capture blocks of valuable information, the first method used was the highlighting and designation of a series of colours on the transcribed data sheet. This was used to block out paragraphs of data towards assigning preliminary codes. Following a collection of these highlighted paragraphs, the second step was to record the designated codes on the post-it notes towards the creation of a 'header level' collection of codes. These header level collections of codes made up the categories to which the future assigned codes from following interviews were assigned. In so doing, interviews with an average of 15 to 20 pages of transcribed data, were broken down into mostly 6 to 10 blocks of initial codes relating to the inquiry at hand. It should be noted once again, that only blocks of information which were relevant to the research focus were captured. It should also be noted that the entire transcripts were not allocated codes, as our focus was only on the data that seemed relevant to the study. In such a situation for example, a respondent who deviated from the topic at hand did not have this portion of the interview given a code on the transcribed interview sheet.

Owing to the higher-level analysis that this activity presented, it was slightly easier to engage with the Open Coding activity in the following stages, due to some of the pre-analysed data that was gathered at the end of this stage. Following the first interview, as an example of the block coding activities therefore, the initial data analysis embarked on proved to be straightforward and relatively enjoyable. For example, the following passage was blocked off and classified as '**information and communication management**', which understandably was, and still is, a key component of developing and maintaining competitive manufacturing capabilities in advanced or HVM enterprises. According to Respondent A1;

“What we do is, this is quite an unusual technology. Even if people have not used it themselves or had it used on them as patients they are aware that maggots can be used to clean wounds. So we

produce a range of supporting docs. We've got a lot of case studies, really to educate clinicians about what larval therapy can do because a lot of doctors still associate maggots with flies and infection that is not wanted. But they can be used in a way that is a positive benefit to patients. So we have a lot of information we give out and obviously, as a small company it's a big commitment for us to be able to produce things like this (pointing to colourful brochures and flyers) but it definitely gives the company a more professional edge, if you like. So we quite often give these out [when we] attend a lot of conferences. We have a team of nurses who are available to assist people and explain how to use.... On saying that it is still a very small company, under 30 people at the moment...I think there are 8 or 9 people actually in the field force who routinely give out, and collect lots of information on our behalf... When you look at the number of people on site, it's quite a small group on site. So there are six people in manufacturing...3 people in QC and then the admin team, the warehouse team. So, this is a very small group of individuals...some of whom have been with the company since its spin out in 2006...all of who have been instrumental in educating potential users as well as collecting and providing information to the corporate body..."

This block was initially coded as 'outward education', due to the fact that parts of the paragraph openly alluded to this fact. In this context, 'outward education' was defined as the need to impart knowledge as well as provide adequate instruction to the users of the company's disruptive technology. On closer scrutiny however, 'information and communication management' was chosen as the final code on the basis of information and communication management being the foundation for education. In addition, outward education was thought to be a subset of information management. Both codes were not lost however as they were both captured as important and desirable capabilities, to be further explored in subsequent data analyses.

A second excerpt from the same interview narrative with Respondent A1 from Company A:

"We are going through the process for the German authorities, we are speaking to the French authorities, we are speaking to the Danish authorities, we speak to people in Finland, Austria, a lot of

different countries. Some countries say if it hasn't got a license, you can't sell it here. So, each country, we have to deal with individually and then if we look wider than Europe, for example, the US, Canada, they are obviously very big markets, but the product is regarded not as a medicine, but as a medical device. But then, you have to go through the FDA to get it registered as a medical device. So those we, we have a monthly...senior management team meeting, and then the feedback or the output from that meeting are then taken to the board meeting to advise them and then their feedback comes back to the senior management team meeting. So, there is a lot of meetings and then I will take anything I need to take from the senior meetings to the operational group meetings with my managers and talk to them about what they need to do. So, in terms of internal communication processes, there are some very robust processes, so the monthly meetings have an agenda. The key people need to attend. We erm, will 9 times out of 10 we will hold them at the German manufacturing facility because a number of directors are based over there or heads of group. So, we will get together, all of us in a room. Occasionally, someone will use skype, but it's better to be in a room"

This block was coded as '**bespoke communications**' due to the need for customized communication activities with the different regulatory authorities in the different countries as well as in-house to the organisation, between the operational group and the senior management team. The excerpt also provided an insight into the internal communications process of the organisation, highlighted below in a picture (see Figure 4.3) from my notes and memo during and after the discussion:

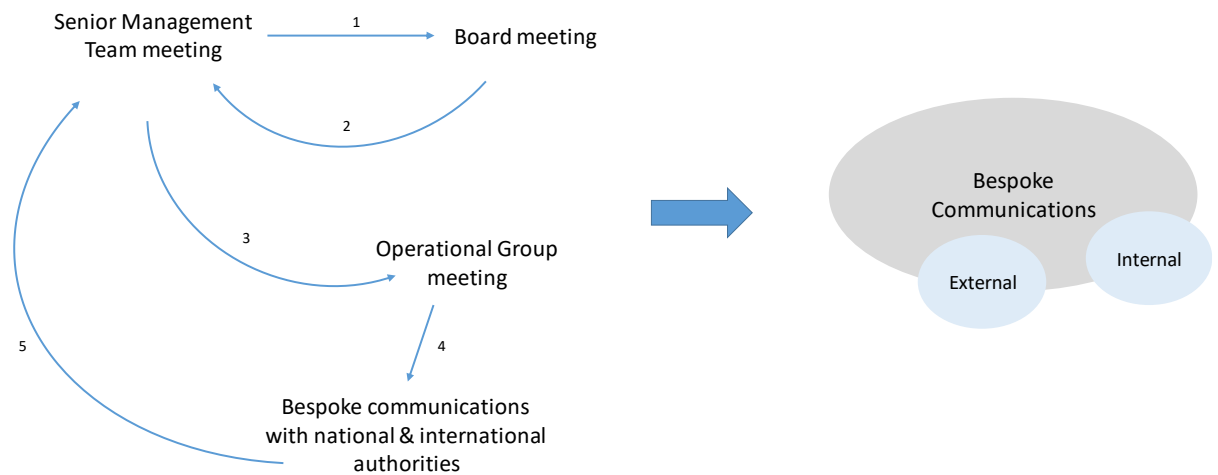


Figure 4.3: Example of conceptualised model of communications (Memo document)

Again, 'bespoke communications' was identified as a critical capability for Company A. Whether this was also a critical high-level capability for the other organisations remained to be seen, following the ongoing interviews, all underpinned by the theoretical sampling and constant comparison tenets

Using this process, other preliminary block codes identified from Company A's data analyses included the following in their very basic expressions;

- Proprietary research methodology/technology development
- R&D intensity
- Multi-disciplinary collaboration
- Learning capacity
- Skills absorption
- Technology valuation
- Information & communications management
- Knowledge conversion & reconfiguration

These codes were eventually compared with others during the constant comparison stage and during the process of clustering, some of them disappeared and were merged into others to form and generate condensed and more replete codes.

Lastly, another example from our preliminary block grouping exercise is taken from Company C, where respondent C1 said in her discussion:

“...I wish we could in some way, quantify the amount of ideas or things that have been progressed through here, not through formal meetings, but through chance meetings, with people asking each other... “what are you working on...?” Having this open communal space is important and it was done with this particular purpose in mind, to ensure that everyone mingles and communicates with other innovators and startup organisations...we want them to learn from, and help each other...we have seen situations where one gets a grant or funding and in turn signposts the other company to the same place... We also do monthly bio-breakfasts where we invite all of our companies, theme them and get some outside expert to talk about this theme or other and they will sit and listen to that. And sometimes they find it interesting to listen to something that is not in their own area of expertise...”

Following this perfunctory examination of Company C’s transcript, this block was selected and classified as, ‘**cross fertilisation**’ and ‘**value trading**’; cross fertilisation due to the mixing of ideas and customs which produce positive outputs in the other organisations and value trading, due to the exchange of valuable information which generated desirable outputs and benefits.

From this process, in a similar fashion to the previous company, other preliminary block codes identified from Company C’s data analyses included the following basic codes;

- Cross functional collaboration
- Knowledge creation and validation
- Technology integration and advancement
- Learning optimisation and management
- Future views/Forecasting/Futurists
- Socioeconomic trends/capability drivers
- Organisation structure/business model

Other than these transcribed documents which were carefully examined for valuable information, the other data collections were queried for information – towards reconciling data that had already been recorded or towards allocating any new header level codes. Notes from the interviews were re-examined and documents provided by the respondents were also probed. These notes, memos and documents were found to be an integral part of the research as they supported the budding ideas and thoughts about certain categories and budding concepts emerging from the datasets

4.4.3 Initial Data Clustering: First Pass

Following the previous sample, highlighting the process of analysing and capturing high level information from Company A, other transcripts were analysed immediately after the interviews, following which a comparison with the previous interviews were conducted and the grouping and/or further rationalisation of the codes were performed. Table 4.1 identifies the preliminary codes from all 13 interviews

From these collection of codes as well as the deeper interrogation of the interviews, an initial framework (see Figure 4.4) was also developed, taking into consideration some of the headline information being sought, such as; the identification of capabilities, how they are developed and how they contribute to the competitiveness of the HVM SMEs.

Elements & Categories	Comments and excerpts from 'blocks' of selected texts
Information challenges (brokerage, management, exchange)	Example taken from paragraph
Advanced Technology Identification and adoption challenges (Proprietary process and/or technology development, manufacturing, design, R&D intensity)	“we searched for solutions everywhere in all the universities but could not find any... None of the academics had time to help us...we suspect that they did not understand what we needed. Two of our engineers took on the challenge and within weeks developed a rough device, that solved our problem. The funny thing is that they took an everyday kitchen equipment apart and used some 3D printed objects...”
Knowledge development issues (tacit, explicit (and/or a combination of both), knowledge conversion, learning capacity, skills acquisition)	<p>“...next thing we need to do is to go on to the prototype stages and we recruited another PhD graduate from Swansea who is <i>very good at making things...he can knock things up quite quickly and he knows about moulding things, which is a useful asset to have..</i>”</p> <p>– the memo showed that the part in italics indicated some tacit knowledge of how to ‘build’ things and ‘knock them up quite quickly’. This was separate from his explicitly acquired knowledge which was the PhD and other formal education (memo). Similar occurrences were identified from other interviews</p>
Collaboration issues (identification, compatibility, management, multidisciplinary, value trading)	“it took us a while to find a team of entomologists who were not only scientifically qualified and interested in what we were doing, but were compatible enough to engage with our aims and objectives as well as with members of our team...this made the relationship easier to manage”
Forecasting/visionary	<p>“understanding what capabilities, with regards to human, technical, infrastructure we would need to maintain our edge has been quite difficult but interesting...I think this is a problem for most high value organisations because as you can see, it takes one small oversight...and then the company is history”</p> <p>- following the challenges the company had experienced when trying to find micro-electronics expertise, we had discussed some of the challenges faced by organisations such as Blackberry and Nokia, who failed to keep up with technology and/or the needs of their users (memo)</p>
Communication challenges (bespoke)	<p>“we always went back to the university to ask for further clarifications because we were trying to assimilate the concept...it seemed like they were unable to explain the concept in a simple way for us to understand”</p> <p>- this seemed to be a common challenge with organisations collaborating with some research institutes, especially at the initial stages of engagement (memo)</p>
Innovation/disruption (push and pull, incremental)	“we knew we had created something disruptive and very innovative...but then, getting it into the NHS has been difficult. We are now considering our export markets...this is after we invested so much in developing the product...”

Table 4.1: High level block codes combination from all 13 companies

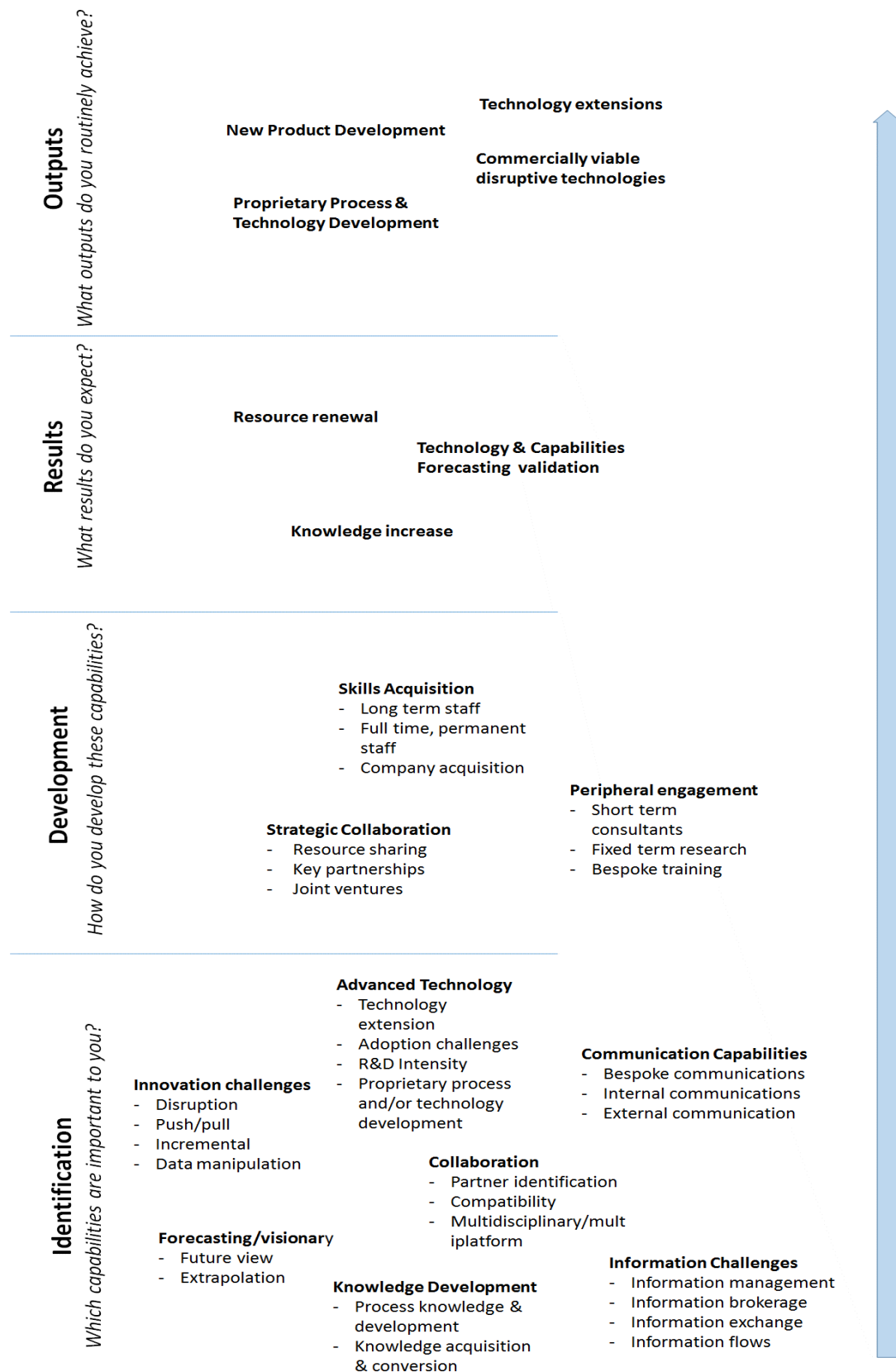


Figure 4.4: Conceptualised framework from Block Coding stage

This exercise, although time consuming, proved to be extremely helpful in providing a very early understanding of the data structure. Some order to the usual 'messy' mass of data collected during the grounded theory process was established and early patterns in the interview data emerged and was summarised, prior to the prescribed and more detailed process of open coding. It should be noted however, that there were a couple of attempts to revert to the relative safety of pre-conceived ideas, thereby negating the possibilities of developing new categories of information.

This slight adaptation to the grounded theory approach once again, was thought to be appropriate to enable the researcher understand, internalise and reflexively categorise the data without compromising the data analysis process. From the 12 interviews undertaken, including the memos from the observations as well as document analysis, 8 block outputs were identified from the first stage data, having compared all the interview outputs with each other to merge some of the categories

It was later observed that some of these block output codes supported the final outputs from the Open Coding stage, while others were basically remained the same code, or something very similar.

4.5 Open Coding

According to Strauss and Corbin (1998), the first level of analysis is open coding, which is the analytic process through which concepts are identified and their properties and dimensions discovered in the data. Glaser (2002) also indicates that the whole process of grounded theory is the generation of emergent conceptualisations into patterns which are denoted by categories and their properties. These conceptualisation and patterns of course, commence at the open coding stage and gradually morph into the foundations of the emergent theory.

The first stage of this data analysis process was therefore open coding, where the transcribed data was read line by line to identify the possible codes to be assigned to the different phenomena. It must be highlighted at this stage, that as far as it was possible, the researcher developed and prescribed codes that fell within the remit of the descriptions

within the interviews without consciously referencing specific and well-known theories within the body of knowledge¹⁵. Questions that were continually addressed included the following:

- What is happening in this data?
- What is the basic socio-psychological problem?
- What accounts for this problem
- What patterns are occurring here (Goulding, 1999)

In so doing, each identified and named code was described briefly to explicate the idea it was conveying to allow the swift allocation of any similar texts within this and other interview transcripts. As can be expected, especially following the constant comparison processes, some of these basic codes morphed into a richer aggregation of tentative codes due to the richness exemplified by other interviewees experiences and descriptions.

In addition to this, the initial coding developed from the transcripts was extended to both the notes and memos developed from the periods of observation as well as the analysis of documents, provided by the interviewees.

4.5.1 Coding Activity

Following the initial data analysis process where blocks of the transcript were defined, the grounded theory prescribed first-stage of analysis, the Open Coding stage, was embarked upon. Unlike the previous block coding which was done for the purpose of getting familiar with the data, this Open Coding was achieved by performing a line by line analysis, thereby generating a large number of codes.

¹⁵ It must be mentioned that at the start of the research, after the first few interviews were transcribed, analysed and coded, the researcher fell into the trap of trying to develop the research with preconceived ideas using well known theories within the body of knowledge. This applied to the initial 'open coding' stage where blocks of text consisting of the initial findings and phenomena within the interviews were ascribed 'known identities'. For example, when the interviewees spoke of a renewal of resources within the firm, the first thought of the researcher was to use the code, 'dynamic capabilities', rather than more sensible or straightforward texts such as 'resource renewal' or 'capability renewal', which is easily understandable by non-specialist stakeholders. This error was however pointed out during the EurOMA 2015 conference when 2 delegates in my session, a Professor from a European university and another from Portugal, pointed this out and advised the researcher to develop his own subjectively descriptive codes to enable the development of possible new theories, derived from a combination of basic codes

(a) Sample paragraphs from Interview related to advanced manufacturing related capabilities	
Interview B, 25 th March	
Block 1 So we worked in the field of micro fluidics for about 7 or 8 years and then we needed to make slight adjustments to our, basically the level of our throughput and we made a slight diversion from that, actually using very similar concepts in fact, but just no longer micro fluidic...the (new) technology is based in the sort of combination of polymers, chemistry and fluidics...our product is the actual manufacturing of equipment which we seek to license to the likes of more big pharmaceuticals who will be interested in using it as an alternative to existing slightly old fashioned technology...”	
Block 2 “...we have to make sure that what we build meets a need. So actually, a great deal of our time is spent speaking to scientists in the sorts of companies that might be likely to either acquire the whole company or take controlling shares...what we’ve really done is come up with a disruptive technology which we hope will supersede the manufacturing techniques that are already available...we also have to deal with certain amounts of technical presentations to the rest of the industry...and then obviously try to work with them to try it out and use it...”	
<i>Source: Chief Scientific Officer, over 10+ years in industry with experience in micro fluidics, polymer science and drug delivery science. Chemist by training (PhD). Been with current company since 2004</i>	
(b) Initial codes from selected blocks	
Block 1 Resource renewal (Evolution) Group mentation, self/internal assessments Specialist technology/knowledge Multi-technology-based product/process development Change – Calibration Change - Reconfiguration IPR/Licensing	Block 2 Informed Ideation Multi specialist/technology collaboration and integration Internal process development New product development, new technology Information exchange Pilot studies/testing

Table 4.2: Examples of initial open codes generated from transcript (line by line coding)

The codes were created with the intention of being transparent and easily understandable by non-research or non-specialist participants. This in fact, was a core tenet from grounded theory – that for ease of continuity and inclusiveness, data and coding should be self-explanatory. This transparency also aided the research process due to its complexity, regarding the large amounts of data that needed to be reconciled especially after an extended period of time. The transparency also aided deeper analysis because in the early stages of the coding activity, there were some challenges in assigning codes resulting in some blocks being allocated more than one code. This brought into question, the interpretation of that particular block and how any future substantive theory could be developed from ‘unclear’ code assignments. For example, the building block, “...but we have also been working with Professor XXXX in Swansea University to develop cost

effectiveness evidence and that is almost on the point of being published as well which shows that against our competitors, in terms of debridement therapies, we are the most cost effective option...” was initially coded as ‘improved competitiveness’ (due to its cost effectiveness), ‘cross functional collaboration’ (they had been working with a Health Economist Professor in Swansea to develop cost effectiveness evidence for a medical device), ‘specialist support’ (the Professor also offered specialist support). Owing to these multiple interpretations generated by this coding activities, there were initial doubts as to whether this coding technique was correctly done in its description of the block of text. Owing to its subjectivity, it was decided that because the chosen codes made some common sense, they were left as they were in order to create a robust selection when entering the Selective Coding stage, which was to choose one category to be the core category and then relating all other categories to that one (Glaser and Strauss, 1967; Strauss and Corbin, 1990)

These codes generated from the preliminary data analysis were organised into groups of similar codes. These were representative of the ideas and elements that appeared out of the first stage of clustering. Meanings were ascribed to codes which did not immediately have a general meaning in English. In Table 4.2 for example, ‘Pilot studies/testing’ did not need any further definition before assigning portions of the transcript to that category. On the contrary, some of the examples of ‘new’ definitions laid down were:

Group mentation, self/internal assessments – this category was created to represent processes where teams or groups within organisations, or indeed, the organisation as a whole, sat together to consider certain issues relating to the organisation

Informed Ideation – according to Goel (1995) ideation is the process of generating, developing and communicating abstract, ambiguous and imprecise ideas. Fryer (1926) states that ideation is the process of putting details into the motive. These definitions and others indicate that ideation leads to more of product led innovations rather than customer led. Informed ideation therefore assumes more of the customer led, or informed, ideation.

A second example of the open coding activity was carried out, before the constant comparison activity was done

(a) Sample paragraphs from Interview related to advanced manufacturing related capabilities	
Interview B, 4 th May	
Block 1	
<p>“...we needed to look at how we make the surfaces more biocompatible, which was not something they had previously been done in Swansea. Working together, we had ideas of how it would be done so we recruited another graduate who had a PhD in Chemistry.... he had been looking at Nano-medicine, looking at deep wound healing. With very numerate skills, we got someone who knew about interactions between bodily fluids...he had been developing a novel polymer which you could seal a deep wound and it was structured such that natural flesh will grow through it and gradually dissipate the polymer...”</p> <p>“Our next bit of research project...a joint one between ourselves, Swansea University and Morriston Hospital, AMBU Health board was to look at the control characteristics...how could we control a device like this so that it responds or mimics the behaviour of a healthy lung. We got funding from the NHS through one of their schemes. This was completed just over a year ago. We developed an algorithm for this using computer programs and we were able to show that it works”</p>	
Block 2	
<p>“The next stage now is that....we have been sort of fortunate because a big American company that does cardio pulmonary bypass, basically heart lung machines....we thought they made quite nice blood pumps...so we contacted them and said can we get a pump for blood....they became interested in what we were doing, they liked the novel design we had and asked if they could enter into a co-development agreement with us....so what we are trying to do at the moment, it is not exactly what we set out to do originally, but it is something which puts us into the market. We do not have to get a marketing force, because they sell around the world...if we meet their performance criteria by early next year, then they will give us firm purchase orders for 5 years and then we can set up a manufacturing facility somewhere in South Wales to make it...”</p> <p><i>Source: Co-founder & CEO, over 40+ years in industry & academia with experience in Chemical Engineer (Mass and Heat Transfer) by training, (PhD). Co-founded company in 2005</i></p>	
(b) Initial codes from selected blocks	
<p>Block 1</p> <ul style="list-style-type: none"> Deep Interrogation – search for knowledge Innovation - disruption Collaboration/working together Group Ideation/mentation Specialist skills/explicit knowledge Simulation/modelling Outward engagement 	<p>Block 2</p> <ul style="list-style-type: none"> New designs - technology Technology combination Future view/mapping Change – Adjustments Co-development Collaboration – symbiosis Manufacturing Infrastructure

Table 4.3: Examples of initial open codes generated from transcript (line by line coding)

Having run through all the interviews, categories were created with each code serving as a heading and lines/sentences were assigned to that code. Following this, after all interviews had been coded, the lists were examined to identify any areas of inappropriate coding. A

negligible number were once again moved into more desirable categories or combined with others to densify as well as reduce categories.

4.5.2 Core Categories

Having completed the Open Coding phase, core categories were developed through the process of densification, combinations and refinements which explained most of the variations representing the participants major concerns. More importantly, this activity was carried out, following which it was discussed with a colleague before presenting it to two of the original research participants, Respondents H1 and H2. Table 4.4 for example, represents some of the codes extracted from Company A's interview script

Going by the constant comparison direction, these codes had to be combined, densified and refined first, before proceeding to the next interview whose codes will also have to be combined, densified and refined before comparing with Company A's codes. The process of combining them had to be carried out. Initial findings from this company included:

- **Finding Direction/Pathways**

Some of the codes that fell into this category included those that were highlighted in **green**: *Future view/mapping, outward focus, voyaging, exploration guidelines, finding ways to progress, sensing direction, overcoming challenges, finding directions, technology-based prospecting and venturing, projections, navigation*

- **Complexities/complex situations and solutions**

Some of the codes that fell into this category included those that were highlighted in **yellow** *Balancing complexities, complex solutions, integration process difficulties, bypassing complexities, deconstructing complexities, complex negotiations, problem solving complications,*

- **Social Awareness and appreciation**

Some of the codes that fell into this category included those that were highlighted in **red** *Trends, outward engagement, needs analysis, outward → inward, social awareness, manage expectations, social awareness/emotional intelligence*

Codes	Codes	Codes	Codes
Resource renewal	Group mentation	Internal assessments	Specialist knowledge
specialist technology	IPR/Licensing	Persuasion	Informed ideation
Creativity/reflexivity	Frequent agreements	Knowledge development	disruption
NPD	Intellectual/ambidexterity	NPD, new technology	Information exchange
Value trading	Deep interrogation	Knowledge search	Voyaging
Pathfinders	Innovation, disruption	Working together	Group ideation
Specialist skills	Explicit knowledge	Projections	Exploration guidelines
Decision making	Simulation/modelling	Outward engagement	New designs
Technology combination	Future view/mapping	Co-development	Navigation
Trends	Social mapping	Novel thinking	Knowledge extension
Process improvement	Outward focus	Outward → Inward	Needs analysis
Peripheral knowledge	Skills change	Flexibility	Open mind
Necessity mapping	Multi-disciplinary	Collaboration benchmark	Best practice – collaboration
Skills transfer	Proprietary technology	Platform development	Negotiation
Future view/visionary	Coaching	Coaching, mentorship	New know-how
Opportunity cost	Balancing complexities	Social awareness/EI	Complex solutions
Data management	Manage expectations	Technology fittings	Integration of systems
Social awareness	Complex systems	Integration processes difficulties	Bypassing complexities
Sensing - direction	Finding ways to progress	Overcoming challenges	Regulatory complexities
Customer feedback	Client focus	Complex situations	Finding directions
Technology based prospecting and venturing	Maintain equilibrium with environment	Internal products and processes	Internal process development
Multi-technology product and process development	Change – calibration and reconfiguration	Multi-specialist technology collaboration and integration	Complexity deconstruction
Problem solving complications	IQ	Advanced education	Communication brief

Table 4.4: Codes generated from Company A's interview script (line by line coding)

- Technology Concerns

Codes that fell into this category included those that were in purple *Specialist technology, NPD, NPD – new technology, technology combination, new designs, proprietary technology, platform development, integration of systems, internal products and*

processes, internal process development, multi-technology product and process development, multi-specialist technology collaboration and integration

- **Knowledge development issues**

Some of the codes that fell into this category include those that were in **blue** and include *Peripheral knowledge, advanced education, IQ, new know-how, specialist knowledge, knowledge extension, knowledge search, knowledge development*

Following this process, one more core category was developed, namely; **Collaboration concerns**, where some of the codes that fell into this category included *co-development, best practice – collaboration, working together, technology collaboration and integration, collaboration benchmark*

Overall therefore, these 6 codes were developed from Company A's transcripts and taken forward to be compared with those from Company B and so on. While not all codes were combined with others to form higher level codes at this stage, the process of continuing the comparison with Company B codes still went through.

Following the completion of all the data combinations, densification exercises, refinement activities (see Figure 4.5), the following core capabilities (themes) were arrived at:

- **Navigating complexities** – which was a direct combination of finding directions and pathways through the complex situations which exist across all categories and issues in HVM SMEs. This category was however, more relevant than first described. Having sought for feedback from some respondents, following the emergence of this core category, two of them provided some feedback: According to Respondents G1 and H2 respectively;
 - *“...just think of it...as a small company everything we engage in has complexity issues for us...recruitment, marketing, supply chain...contract manufacturing...”*
 - *“I think this [the code] is very relevant for us...if you think of this project we are developing with ASTUTE, we see the benefits of this..your result about navigating complexity. This ASTUTE project is complex but because we see*

the benefits, we are willing to navigate through all the challenges....hopefully we will come out smiling...”

- **Proprietary process and technology development** – which included technology integration, platform development
- **Knowledge Formation** – which included all things to do with the creation of new knowledge. This was another core issue with organisations, especially those in the HVM sector.
- **Intellectual benchmarking** – this core category included things to do with knowledge transfer and the processes involved with continually. This was different from knowledge formation, which was more focused on creating new knowledge as opposed to learning, knowledge acquisition

These core categories were presented to Respondents H1 and H2 and discussions around their suitability as capabilities to contribute to competitive advantage were highlighted. During the discussions, both respondents ‘approved’ these categories as critical to their success, as well as that of other HVM SMEs.

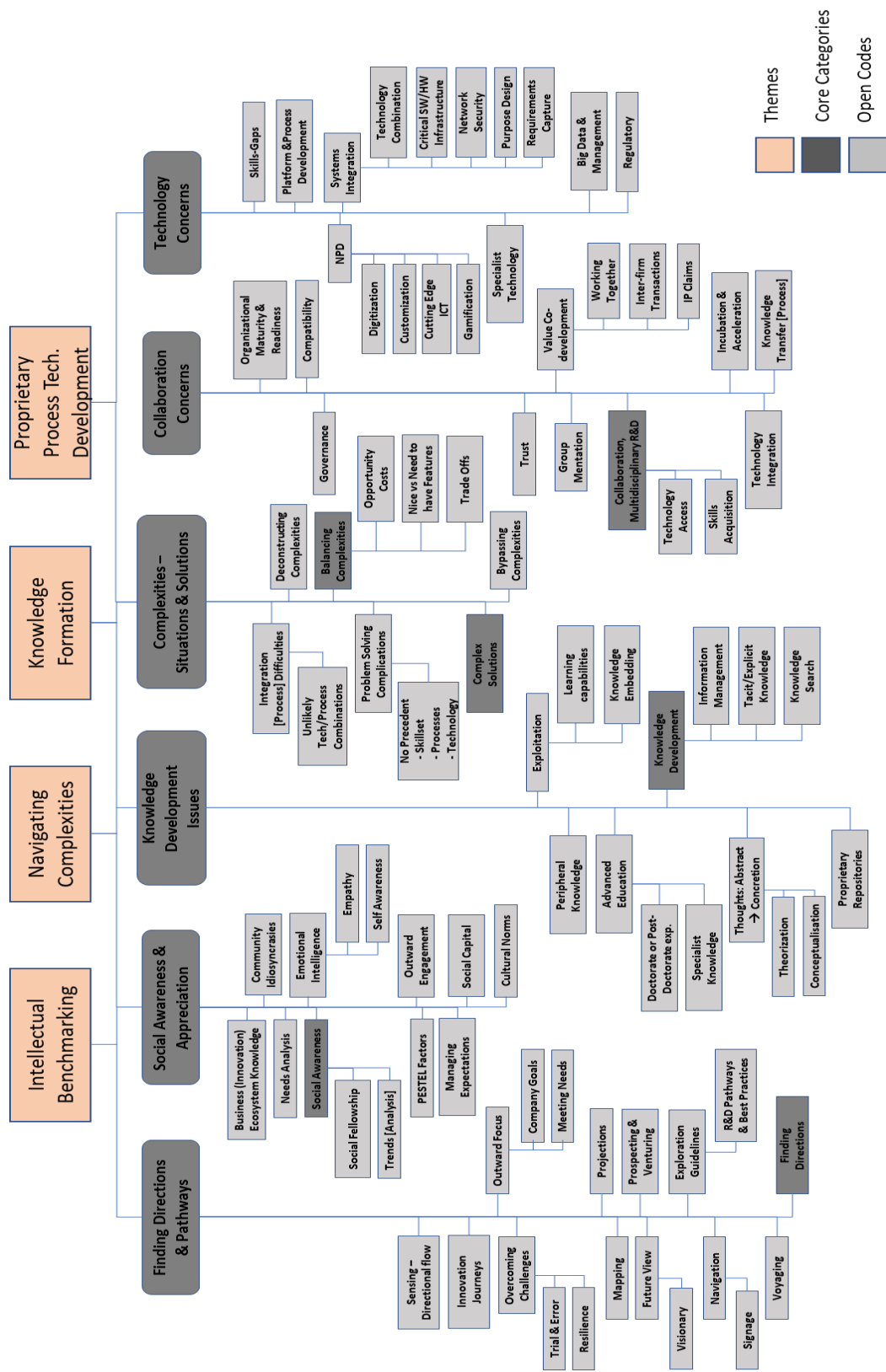


Figure 4.5: Coding structure tree for Core Category Development

Traditional GT Approach Glaser and Strauss 1967	This Study's Adoption	Notes
<p><u>Initial (Open) coding</u> After transcribing each recorded interview every line of data is examined and interpreted following which definite actions and events are assigned a descriptive (open) code. Commencement of 'memoing', or personal reflections, about the descriptive ideas around the gradually developing open codes occur at this stage to enable a logical clustering of budding ideas</p> <p>As data is continuously generated, constant comparisons are made with previously coded data in an effort to compare meanings as well as densify all [open] codes into substantive higher categories</p>	<p>1. Developed 'start lists' (Miles and Huberman, 1994) and 'sound bites of voices and images' (Garvin, 2000), from periods of observation gathered as 'nuggets', or 'chunks' of data (Miles and Huberman, 1994) from each interview, without attempting to interpret them too deeply such that their apparent 'descriptiveness' is lost. The 'nuggets' were made up of phrases, which were less than, equal to, or more than a single line, and sometimes up to a paragraph</p> <p>2. 'Nuggets' were clustered into similar logical groups or 'families by constantly comparing them, within and across interviews, towards fulfilling the theoretical sampling tenet of the GTM</p>	<p>A thorough process whereby the line by line, or eventual transcript clusters produced hundreds of 'open' codes. Further clustering and densifying helped identify and understand the social processes which the subjects considered as critical to their operations.</p>
<p><u>Selective Coding: Core category stage</u> Codes are woven into categories which commence the process of 'umbrella' representations of majority of the data as well as some higher level socially related occurrences taking place within the subjects' ecosystems. These selective (or Core) codes contain sub-categories which are the lower level descriptive properties of that category (Glaser, 1992)</p>	<p>Grouping of codes through a process of densification, examining them critically and validating them through open discussions with subjects</p> <p>Supporting analytic memos were written to critically examine the relationships starting to emerge from the data collected, analysed and densified. Discussions around the 'sensitivity' of emerging themes were held with subjects on a frequent basis to elicit their thoughts as well as validate our findings</p>	<p>Memos provided a 'diary' like repository of thought patterns which helped subjects understand the subjective thinking patterns behind the researcher's ideas</p> <p>More than one core category was identified from this stage demonstrating multiple relationships between concepts</p>
<p><u>Theoretical Coding – Theme(s) generation</u> Conceptualization of how Core categories codes are related to each other – eventually, how they are integrated into the theory. This should demonstrate, or be seen to be providing some resolution to the main concern of the subjects (Glaser, 2001)</p>	<p>Close examination of all categories that have been created towards identifying relationships, if any, between them. Patterns created began to build theoretical concepts, themes (Glaser, 2001)</p>	<p>As seen from results shown, relationships were too complicated to be reduced to one single category. Themes were produced and relationships between them described.</p>

Table 4.5: Summary of Coding, Analysis and Interpretation processes

4.6 Chapter Summary

The main aim of this chapter was to introduce the case studies which highlighted some of their on-going projects, thereby ensuring their suitability for this research. This chapter also delved into the data collection and analysis activities, where different kinds of coding were applied (see Table 4.5), in order to conform to the GT tenets. First of all, the block coding was just an initial but quick way for the researcher to understand the information provided by the participants – sort of a quick diagnosis of all the respondents transcripts. It is stated clearly, that this block coding is not a part of the grounded theory process. Secondly and more importantly, a line-by-line coding activity, which is the first stage of the grounded theory process, was carried out thereby providing brief details of how the codes were generated as well as how they were densified and combined to form more encompassing categories. In so doing, categories and their properties emerged. This was the first stage of taking the analysis beyond a descriptive stage.

In addition, this chapter also introduces the outputs following the densification of the open coding stage, leading up to the higher-level categories and themes. This is shown in Figure 4.5 and highlights the coding structure tree representation for the first stage of the data collection process. The next chapter will build on these 4 themes namely Navigating Complexities, Intellectual Benchmarking, Knowledge Formation and Proprietary Process Technology Development. The case study methodology will be used henceforth.

Chapter 5: Data Collection and Analysis – Phase 2

5.1 Introduction

As established in the previous chapters, this study has identified and followed the orchestrated process of the grounded theory methodology which emphasizes the need for the accurate representation of the participants' views and observed behaviours. These views, captured through the respondents' words, actions, business documentation as well as social media accounts such as YouTube, culminated in the open codes, or first level findings, which represented some of the critical issues that were important to them with respect to their operational capabilities and other management related issues. Following the GT processes of theoretical sampling as well as constant comparison, some core categories emerged after which a process of densification, where the open codes were analysed, clustered and combined with the core categories, was undertaken

This chapter therefore, enters the Selective Coding phase and builds on the outcomes and findings from the preliminary interviews and observations undertaken with the twelve (12) companies in the last round. These findings include 'navigating complexities', 'intellectual benchmarking'; 'proprietary process and technology development' and 'knowledge formation'. In continuation of the GT process, further exploratory questions concerning the relationships between the core categories and the firms' pursuit of competitive manufacturing related capabilities is explored. This chapter presents the findings from four organisations, namely Companies A, E, F and H, that were queried using the more detailed Case Study approach which involved semi structured interviews and some further observations. The continued construction of theoretical categories takes place, as the core categories are queried and firmed up by comparing them once again, to open codes.

As expounded in the methodology chapter, the choice of critical realism as the epistemology acknowledges the concerns of the research are to map the ontological character of social reality, combining explanation and interpretation with the aim of developing an historical inquiry into artefacts, culture, social structures, persons and what affects human action and interaction (Archer et al., 2016)

As the aim of GT, and indeed this research undertaking is to propose a theory consisting of interrelated sets of hypotheses generated through the constant comparison of data during

increasing levels of abstraction (Glaser, 1992), this chapter takes this research a step closer to this goal (see Figure 5.1 for current positioning in the process). The importance therefore of ensuring that data saturation has been reached and the right categories have been generated is necessary.

Finally, because all the selected case study companies were involved in the first phase of interviews, access for this round was easier and the interest shown in the research at hand was increased. The respondents chosen for this case study stage felt that they would be able to learn from the consolidated outputs generated from companies of like nature.

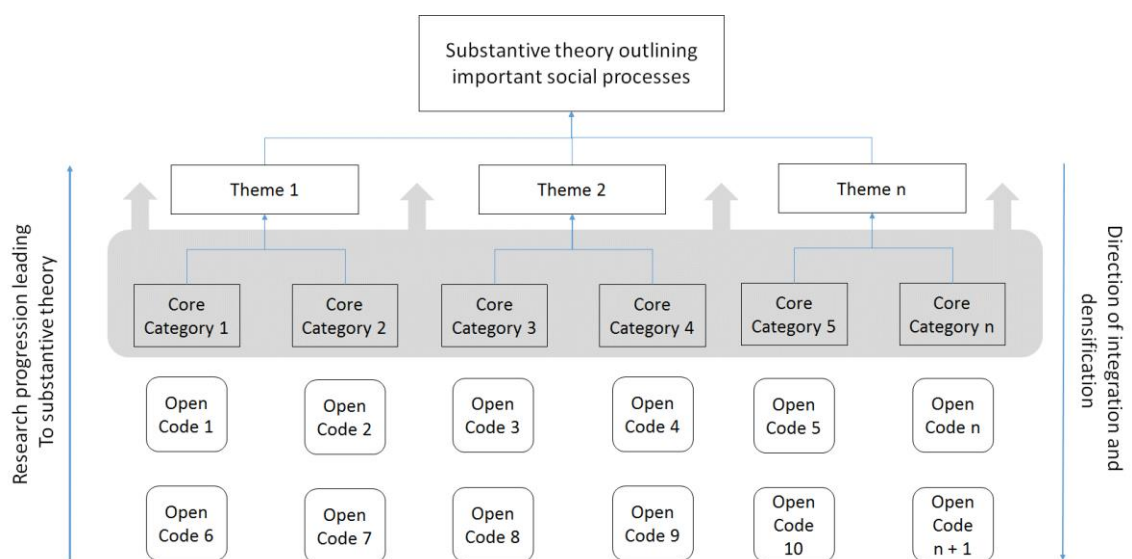


Figure 5.1: Structure of the research framework & coding process of the Grounded Theory Method

5.2 Construction of Thematic Categories

According to Strauss and Corbin (1990) category development provides critical insights into how phenomena operate at higher abstracted levels, thereby providing insights into action, interaction and the handling of tacit social processes. Insights into the phenomena are gained through the construction and reconstruction of multiple narratives, where the aim is to combine as many of these narratives into stronger categories or concepts, having ascertained the underlying characteristics such as causation and influencing effects. With the challenges associated with interpretive analysis however, deep periods of critical

thinking and reflexivity, as highlighted in the methodology chapter, were frequently undertaken.

While a comprehensive report of how these categories were constructed will not be feasible due to the multiple iterative processes and steps that were undertaken manually, this chapter endeavours to account for how the analysis developed and how the findings emerged. To commence the process of analysing the suitability of the identified core category for their possible inclusion into the substantive theory, they were presented to the case study respondents to elicit their thoughts and opinions concerning its importance in the consideration of competitive capabilities. The questions which opened up the discussions surrounding the core categories for their respective stages included, “***what do you understand by '[core category]', 'is this an important concept in your organisation and why'***” and “***how has this concept been implemented'***”? The main aim of these questions however, was to channel the discussions to the point where the themes being discussed began to touch upon the crux of the research endeavour – what is the relationship between this theme and competitive manufacturing capabilities?

5.2.1 Introducing “Navigating complexities”

To commence the research study, the case study respondents were asked the preceding questions concerning definitions, the importance of this concept and the implementation of the concept within the individual organisations (see Table 5.1 for paraphrased answers). Respondent A for example defined navigating complexities as a process of avoiding and moving around obstacles while trying to understand the multiple layers of different systems towards arriving at a desired end - be that the development of solutions for problems, the attainment of particular skills and expertise or the achievement of a much sought-after goal. It should be noted however, that during discussions which ensued, the ‘obstacles’ spoken about, for example, in Respondent A’s definition were not solely hindrances in the true sense of the word. Often, the respondents mentioned that these were sometimes stepping stones, or opportunities to acquire some new knowledge which they needed during the later stages of their operations.

Complex ecosystems, or complexities in this case, can be defined as a whole entity that consists of several elements or phenomena at different levels which may be related to, but certainly interact with, each other in many different ways. It is understood that these many

interdependent elements within these complex ecosystems interact continuously to reorganize themselves into increasingly elaborate structures over time. The metamorphic nature of these activities therefore present certain challenges to stakeholders interested in understanding these systems namely; defining these complexities adequately, developing constructive metrics for measuring their characteristics and developing the tools for responding to, and managing these complexities satisfactorily. Grasping the dynamics of complex systems towards accounting for the contribution of each element to the variations of the whole system has therefore been an important area of study in different subject areas from engineering to healthcare and from philosophy to economics.

As expected therefore, the processes which support the creation of new solutions, or new products as the case may be for constantly evolving systems, often end up capturing momentary outcomes at a static point on the continuum of the constant system modifications. This often presents a great challenge to solution providers, who encounter situations where they sometimes seem to be playing catch-up due to their positioning which is situated behind the ever-changing needs of society.

Regarding navigations, Watkins (1999) rightly suggests that very few objectives in life can be achieved solely through the use of authority or coercion and instead, people negotiate following which they navigate challenges to advance their interests and those of the institutions they represent – which in this case will be the need to navigate through ‘roadblocks’ and obstacles to advance their organisations value propositions through their products and services. The concept of navigation is therefore thought to be the process of finding all possible ethical and financially sustainable ways to reach a given position, having navigated through challenges and obstacles along the given pathway(s)

Company	What do you understand by 'navigating complexities'?	Is this an important concept in your organisation? Why?	How do you implement the concept?
A	Navigating through, and trying to understand and/or overcome the multiple layers of different systems in order to arrive at a desired end.	It is very important to us. It is the basis for all the work we do and frankly, how we survive daily. The reality is that we need to combine multiple inputs to use in the creation of single outputs.	We have boundary spanners..., whose roles it is to link our internal teams with external networks and sources of information. These boundary spanners are located across different departments in the organisation – and what this does is that we are able to acquire different kinds of information to enable us chart specific paths
E	A simple explanation as it applies to my company is understanding the infinite needs of the clients, selecting (sometimes in collaboration with the client) those that are both achievable and in line with generally available technical capabilities and finally, satisfying the clients with a viable solution	Yes. The results from our daily interrogation of various levels of society provide the motive for the creation of certain products and services. Our relationship and interrogation, for example, with surgeons in the medical sector necessitated the need for this product. We could not meet every need due to limitations beyond our control, but we developed something acceptable to and identified majority.	We have multidisciplinary 'go' teams that are responsible for different specialist areas. Because our skills and capabilities lie within the life sciences areas we have to partner with others, such as universities and market research companies, who provide us with the data, knowledge and resources we need to implement and deliver solutions to our clients. Our most important partner is a data science group
F	Being able to understand and combine the most favourable features and variables of science and technology towards creating solutions that meet the greatest number of patients/users.	Yes. Informs our value creation for the benefit of our customers and the society. Because we are customer led, our 'negotiations', which include those with society and technology, have to be precise	A part of our organisational strategy includes organisational level 'shared responsibilities'. For example, we thrive on collaboration where we partner with different organisations in order to acquire the continued skills and expertise to thrive and not just survive
H	Navigating complexities for us brings to mind looking for direction in the sometimes uncertain, murky waters and interlinkages between multiple dimensions such as society, technology, healthcare; towards identifying 'trade-offs' which lead to new products and services.	Yes. Helps us continually create products and services which [will] appeal to a wide range of clients, whether businesses or individuals	As a B2B business, we have what we call our business roadshows. This is where for two to four weeks every year, we visit a few of our largest clients to engage in ideation workshops to identify challenges as well as possible solutions. We discuss trends in industry as well as the technologies that are needed to overcome the critical issues on ground.

Table 5.1: Navigating Complexities

The process of navigation, for our context, is therefore thought to comprise four major components: a) a two-way exchange of information concerning the needs, concerns and/or proposed actions of each stakeholder, (b) the evaluation and assessment of the information provided, especially with regards to the benefits realisation from each stakeholders own

perspectives (c) an action plan or roadmap which identifies the pathway to be taken towards arriving at the desired destination (Due to the intricacies inherent within the roadmap, trade-offs and compromises may be involved to ensure the maximum benefits possible to each stakeholder are achieved), and (d) the arrival at a final destination where an objective has been met (a product, service, even in its prototype stage for testing is developed). One such case for example, was highlighted in the very first discussions with Company A, during the initial sampling phase. According to Respondent A;

“...So our main difficulty in terms of our operations and manufacturing strategy for the future is that in the UK and Europe, the project is regulated as a pharmaceutical...there is quite a lot of regulatory requirements and things that we need to do...the European directive says that there is a directive on medicines for human use. It says that you can only supply or use manufactured medicines if they have got a license. So all medicines need a license of some kind. But individual countries within Europe can make their own arrangements for special use for medicines that have not been through this licensing process. Now it is different in every country in Europe but in UK there is something called specials. If your product is designated as an unlicensed medicine, it can be used on patients under very specific circumstances, while you are going through the route of getting the license. So obviously, we've started that process, it started with our German organization and we are eventually coming to the UK. But at the moment we have to have a facility that is fit for purpose, its inspected by the MHRA, Medicines and health products regulatory agency, they come every 2 years and we have an inspection for good manufacturing practice...”

The complexities experienced by Company A involved regulatory issues, especially those surrounding the licensing of their 'drug'. While this in itself was a challenge, the regulations across different countries presented extra layers of complex challenges to the company. Having therefore identified an ambiguous opening in the law with regards to a drug category in the UK called the 'specials' category, they have categorized their drugs as those that can be used under special or specific circumstances. To do this however, certain criteria needs to be fulfilled - they need to have production facilities that are inspected above and beyond the normal standards or regulations, which is every two years

Respondent A continued, highlighting other complexities that needed to be negotiated and navigated through to ensure their products reached the end users without breaching the legal restrictions placed upon them:

“...a doctor needs to write a prescription for that particular patient for the product so it’s a prescription only medicine as well...there are some restrictions on our activity in terms of advertising and promotion because you are not allowed to advertise and promote medicines that are unlicensed. So our real opportunity for growth comes when we have a licensed product. At the moment we have to wait for people to come to us to say that we are really interested in our products and we have some patients. Can you give us some more information? As soon as they have come and asked, because we can’t go out looking for customers, we have to, they have to come to us. But luckily the therapy is so interesting, the word of mouth...and it works...”

Having identified their product as a ‘special’, these drugs can only be used following a doctor’s prescription. In addition, further complexities that need navigating are that because these drugs cannot be promoted or advertised to prospective patients, other means of validating them and ensuring the effective commercialisation need to be explored. According to Respondent A, strategies adopted by Company A to ensure adequate visibility, without openly advertising included;

“...we develop joint research activities with clinicians towards improving their knowledge of the benefits of our solutions. We allow them use our solutions as clinical case studies and allow more than the normal amount of [academic] publications...using these methods, we circumvent certain regulations, legally, and still get our products to the market...”

The narratives and definitions above provide the background to the way in which the concepts of ‘complexity’ or ‘complexities’ and ‘navigation’ are approached in this thesis. The process of ‘navigating complexities’, with regards to the contextual nature presented in this thesis, concerns the recognition of an end goal, or destination and then charting a path through multiple obstacles to get there. Following these agreements, the organisation (Company A in this case), charts a path or course to enable them arrive at the desired

destination, be it the development of a product, the achievement of its regulatory approval or its unrestricted market commercialisation. Of course, conflicts regarding individual, organisational and even national preferences will potentially exist due to the multiple and varied external pressures exerted upon such systems such as safety concerns, the rapidly changing technology options, shorter product development cycles and globalisation. Developing multiple communication channels towards trying to understand the intricate and compounded structures that exist within these systems or complexities is therefore paramount.

It should be noted that in one of the **memos**, portions of this same excerpt were identified in an earlier section (see Section 4.3.2, Block Coding) and allocated the code 'bespoke communications'. Through the process of densification however, this became 'navigating complexities' as other sub-categories had been combined with it. It must be remembered, that logically, bespoke communications will remain a subset of navigating complexities as it is known that communications, both internal and external, have to be tailored towards successfully negotiating for things at different points in time while on a journey to reach the final destination

To set the scene for the further development of this category, some excerpts from the interviews and activities undertaken with the respondents are highlighted. For example, when approached with the general question, ***“what is your understanding of the category known as navigating complexities?”***

According to Respondent A, who was the first respondent;

“...to conceptualise, develop and test our in-house capabilities, which eventually lead to innovations in products and services, including their fit for the different markets in which we operate, it is necessary for us to develop responsive communication channels with the society in general towards engaging in two way discussions and information exchange with our potential clients and customers...we have to learn their language...understand their pain points...to enable us understand what they need and how they need it...to meet them at the exact point of their needs...and in so doing, we develop and continually upgrade our knowledge of multiple technologies to create solutions which help in ameliorating their health conditions...”

This initial excerpt from the transcript, alongside many others, provided the basis for which the concept of navigating complexities was further delineated into ‘navigating social complexities’ as well as ‘navigating technological complexities’. Interestingly, having identified these two categories, it was easy to pick up very similar undertones in the other following interviews and observations. These codes were identified as sub-core variables and considered as key findings from the initial data analysis – key sub-core variables with the potential to be important moderators in the final substantive theory.

Other excerpts from the interviewees answers to the question, “what do you understand by navigating complexities” include Respondent F who stated:

“Understanding that healthcare is one of the world’s biggest economic challenges is the first step in trying to find solutions to the multiple challenges societies face...to meet these challenges, we need to understand the structural make up of our societies....we sometimes need to split up our society into categories such as culture, ethnicity, religion, age, lifestyle and so on. As you may have heard, some medical conditions are prevalent in certain neighbourhoods, restricted to age groups, ethnicities and so on...we have to understand these things before we develop our products and services...especially in multicultural societies like the United Kingdom...and the US, which is our next target....”

Respondent F’s statement, which demonstrates elements that are akin to the market segmentation model in marketing strategy, discussed the division of a market of potential customers into groups, based on different characteristics such as age and ethnicity. This segmentation models required the simplification of complex elements to facilitate the identification of high yield segments that will provide a high growth potential using minimum inputs. The segmentation also made it possible for Respondent F and his team to navigate through some of the challenges easier than would have been done if they had attempted to deal with these segments as a whole entity

Further in the interview, Respondent F continued;

“...we also need to understand what drives us as a society...to understand what our needs are, what our opportunities are...for

example, there is an ongoing problem within the health sector at the moment with regards to antibiotic resistance and the limited pipeline of new antibiotics development...which is causing a major public health issue. What this example demonstrates is the need to develop new solutions outside antibiotics to keep infectious diseases at bay...secondly, we need to take advantage of the opportunities available...new technologies, access to detailed data and databases, clinical trials, results. The antimicrobial additives we develop are therefore a product of our understanding of the society, and its needs which we all know is the protection against dangerous microbes...as well as the ideation, and combination of the different technologies that will create a product and/or service to meet that need..."

In addition to the data from Respondent F's interview, other respondents alluded to the fact that understanding social phenomena was important to the development of competitive manufacturing capabilities within High Value enterprises. According to Respondent E;

"we have to keep our eyes on the trends that are currently shaping our societies to enable us develop products, whether market led or product led. This involves the critical analysis of the different phenomena which not only affect the users, but us [the company] as well. For example, some trends include the changing demographics such as an aging population, advanced technology, which sometimes drives digitization, tighter regulations and [new] ethical considerations, healthcare spending and opportunities"

Respondent E opened up discussions surrounding another aspect for understanding social complexities. According to him, there is the need to understand the trends currently shaping societies, where trends are assumed to be a prevailing tendency or inclination or line of general direction of movement (Merriam-Webster). Trend analysis for markets/societies, which often involves the collection and analysis of data, is the analysis of past and current market behaviour to identify dominant patterns in consumer behaviour as well as market dynamics. Valid questions to be answered by all manufacturers during the analysis and negotiation of complexities:

- What trends are driving the industry in which you operate? In this case, the healthcare sector? Are trends such as demographic changes, demanding and distrustful consumers, empowered consumers, mobile technology applicable to you? Can these further the understanding of simplifying and navigating complexities?
- What methods can we use to identify trends in our markets and how? Quantitative, qualitative, mixed?
- Do your products meet these needs and how? Do they, or will they empower the consumer, reduce anxiety, monitor ailments discreetly?

Lastly, in very simple terms, Respondent H simply mentioned that;

“As a company, our most important capabilities are built around our abilities to analyse the complicated structures we have in our society and offer matching products and services to meet some of their needs...we are totally driven by our analysis results (of both societies’ needs first and then the availability of technologies and their possible combinations towards developing....ethical solutions), so any errors will have huge financial repercussions...”

The general consensus from the interviews, demonstrated by some of the excerpts, indicated that understanding the proposed and emergent concept of navigating complexities on the part of the respondents and their organisations was necessary for them to make progress. Each of the excerpts also identified a further breakdown of the “navigating complexities” category, into navigating social complexities and navigating technological complexities. On the one hand, navigating social complexities within the context of this study entailed the company’s ability to rapidly understand their positioning in the wider arena of the society and business sectors and not only that, but due to the dynamic nature of these entities, continually navigate through, and find their best fit within this complex system as evolution occurs. In other words, how capable is the company to evaluate trends and socio-economic activities that drive societal changes and behaviours, whether individual or collective. In addition to this, how capable are they in their communication exchange with their potential customers due to the potentially rich customer information that can be provided through the communication. How capable also, is the company to acquire and manipulate any data collected to their advantage, while again, simultaneously

communicating this to their potential customers for the purpose of pre-product development and launch. Lastly, how capable are they in their drive to navigate through all the challenges, to beat pathways through hitherto unexplored territories towards their organisational objectives?

Navigating technological complexities on the other hand involved the company’s ability to develop and manage multi-disciplinary projects within technology areas; understand the different technologies relevant to the development of their solutions and to work out the integration parameters for these technologies to ensure the smooth functioning of the technologically complex solutions or devices. More importantly however, the ability to involve the end users in these ‘navigations’, a sort of co-innovate journey, is of utmost importance in ensuring the successful uptake of these solutions.

Considering a practical application of navigating complexities, fitbits and other similar wearable devices are examples of products that can adequately describe how navigating complexities support the development and even evolution of these devices (See Table 5.2)

Navigating Complexities (drivers for the design, manufacture and commercialisation of Fitbits and other devices)	
Social Complexities	Technological Complexities
Government Policies: Government cutbacks on Health Funding. Calls for obesity reduction. Drive towards healthy population	How can technology meet these challenges? How can technology support the personalisation of healthcare?
Personalised Healthcare: Individual health monitoring possibilities. Taking responsibility for own healthcare and shared decision making. Ability to develop goals, monitor progress	Unobtrusive technologies, lightweight, digital. Smart technologies. Easily understandable notifications and seamless operations in tandem with client databases
Food & Drinks Monitoring: Push for healthier eating, sugar and fats reduction, less calories	Ability to log food towards measuring calorie intake and calorie burn
Health care monitoring and data collection: Health monitoring for those with long term conditions	Compatible with heart monitors, mobile phones and other devices e.g. for wireless transfer, downloading and analysis
Elderly patients (aging population), highly mobile patients etc: Remote monitoring & data collection possibilities	Wireless transmission capabilities, remote communication between client and medical personnel

Table 5.2: Fitbit example: Navigating Complexities

Regarding the relationship(s) between navigating complexities and manufacturing related capabilities, further questions were broached with the case study companies regarding the influence of the core concepts on the identification and development of competitive manufacturing related capabilities. The question thus, “**how does this core concept of**

navigating complexities, as well as its recognisable sub concepts, influence and affect any manufacturing related capabilities within your organisation?” was the basis of the following answers, which also moved the research a step closer to a substantive theory.

According to Respondent F, who provided a quote from a yet to be published paper they were working on internally;

“...having understood the importance of navigating through the complexities surrounding social, economic and technological challenges, the abilities required for start-up and SME successes should be structured first of all, around developing ideas from a combination of variables acquired from the contextual analyses of these socio-economic and technical situations...at a stage, the ideas have to be visualised and shared...possibly through abstractive methodologies, the ideas have to be valued...or maybe before then, developing simulations and models might be possible to enable a proper visualisation of the abstract thinking...this builds the organisations ability...”

This interview with respondent F generated some categories that were considered important to answering the question that was posed. Codes such as abstraction, ideation, creativity, visualisation, all supported by the data from the contextual analyses were considered to be important capabilities for Company F in their quest to develop competitive capabilities. A single category, Constructive Venturing, was therefore developed as a combined output from these codes. Constructive Venturing in this context, was thought to represent the undertaking of a bold course of action, in this case, disruptive innovation, with the intention of this innovation having immediate beneficial purposes.

Respondent F continued:

“...in our case for example, we came up with a particular idea we thought was worth exploring...our co-founder was a Postdoc Fellow in a clinical research program with Swansea University...he identified respiratory health problems that were continually mis-diagnosed, therefore causing problem not just for individual patients, but for the NHS as well. He then looked at the social issues

surrounding the effective identification and management of the conditions; early diagnosis challenges, cost of diagnosis, cost of treatment, waiting times in the clinics, discomfort for aging patients....we then looked at the trends driving industry; knowledge expansion and availability, technology, miniaturisation, personalising healthcare, non-invasive adoptions....in line with the personalisation agenda of not only healthcare but other things as well, we wanted to make this [the product] a low-cost, hand held point of care device to be used at home or in a clinic, rather than a diagnostic unit within a hospital...we looked at the opportunities provided by policy...multiple project grant funding opportunities, investment opportunities...all these and more ...we can consider all that and more as the analysis of social complexities that went on, even before the establishment of our company..."

Respondent F continued;

".....we also considered the technological complexities and possible barriers; how do we identify biomarkers from bodily fluids, making the technology consideration both a function of biological and digital specialities; how do we miniaturise what has hitherto been a huge desktop device, what technology can we use to achieve our conceptualisations for low-cost, hand held devices, what combinations of technology are we looking at...we considered electronics, software development, chemical engineering and biological sciences...we understand that to do this there will have to be trade-offs...it is these potential trade-offs we sort of negotiated, for example, if we include this, we cannot include that..."

Following these excerpts from Respondent F, it is instructive to note that the demonstration of *constructive venturing* or *smart prospecting* (as we began to call it) was evident in his organisations quest for the development of manufacturing related capabilities for competitiveness. Starting out with challenges such as 'identifying biomarkers from bodily fluids', and 'the miniaturization of a hitherto bulky device', set the tone for the exploratory activities required to bring these abstract ideas to fruition.

It is important to note again that with the naming of codes, there was always a play on words by the researcher to identify the best possible words to describe the categories that were being developed. In these situations, it should also be noted that two or more codes (such as *constructive venturing* and *smart prospecting*) were given to the same category that was identified. These would later on be combined with others during the process of densification. These issues were noted in the **memos**.

Other responses to the question also generated similar concepts. Part of Respondent A's discussion for example was captured below;

"...most of our organisational capabilities are built around the vision and strategy that the business has adopted....which are in turn structured around the needs of the society and maybe the availability of scientific and technological knowledge to meet these needs. We put out feelers through our outward facing staff....our nurses who interact with patients, our liaison officer who supports me in my interactions with policy makers and regulators, our PhD researchers and others who interact with outside academics...we all try to understand what our clients, customers and other stakeholders need...we bring this back into our company and try to internalise these within the organisation...sort of trying to feel what your external stakeholders are feeling..."

Respondent H on the other hand referred to more product driven opportunities, rather than taking the cue from the society in market driven solutions. His analysis however indicated some overarching results from a general societal analysis before their new product development. This new product development was then 'pushed' to specific customers, who had no idea that this product was needed but subsequently adopted it.

"...our end users did not really know that they needed our products before we conceptualised and developed them...a typical example we love to use is Apple's iPad...did you know you needed an iPad before Apple created it....No. Apple created it and then pushed it across to us, same thing with the iPod and iPhone and their related software, iTunes....their products were built on the identification of some hidden...unspoken needs of society which they acted upon. We have done something similar....We however have to educate our

potential users through multiple trusted channels as well as partner organisations...”

Respondent H however went on to warn that;

“...regardless, we have to maintain some sort of equilibrium between our company and the society...our internal system and purpose (Company H) has to be in sync with the external system and their purpose (Government, Society) to ensure our survival and competitiveness...”

While the need to maintain some sort of equilibrium between the companies and society was a major topic, in different forms and contexts, throughout the interviews, the discussions brought to the fore another theme-changing subject. Most interviews, in one form or the other, referred to the balancing of expectations, especially when considering the relationships between social complexities and technological complexities. According to Respondent H;

“...it is necessary for the innovator to understand that it is impossible to provide solutions to all the problems in the world...at a stage, technology may be a limiting factor and at other times, the limits may be the availability of knowledge...we therefore have to manage expectations and develop a balance between social and technological complexities...as well as between these combined and the society”

In addition, Respondent E spoke about managing expectations thus:

“...as with all kinds of negotiation, especially with potential clients, a major part is to manage their expectations and not promise what cannot be achieved...this is very similar, if not the same as the concept of benefits realisation in project management where benefits have to be actively managed through project cycles...”

Other case studies from their interviews referred to the balancing and management of expectations and emphasized the need for this to be included in the final findings in this

study. On much deeper reflection, it was identified as a major requirement in the achievement of competitive manufacturing capabilities.

The combination therefore of these excerpts from the case studies generated codes such as maintaining equilibria, managing external stimuli and boundary spanning. These were combined and captured into a category we called *sensing*. Other codes for example developing internal alignment and maintaining equilibrium were categorised as *organisational resonance* (see Table 5.3)

Major Categories in this Theme	Low Level Categories
Balancing complexities	Active negotiation, managing expectations, benefits realisation
Smart/informed prospecting (constructive venturing)	Abstraction
	Ideation
	Creativity
	Data Management
Sensing (external)	Maintaining equilibrium
	Managing external stimuli
	Boundary spanning
Organisational resonance (Building internal resonance)	Developing internal alignment
	Maintaining equilibrium

Table 5.3: Navigating complexities low level categories

As part of the engagement with the data and its continued interrogation, Figure 5.1 was also developed conceptually as part of the thinking process, during some of the reflexive periods.

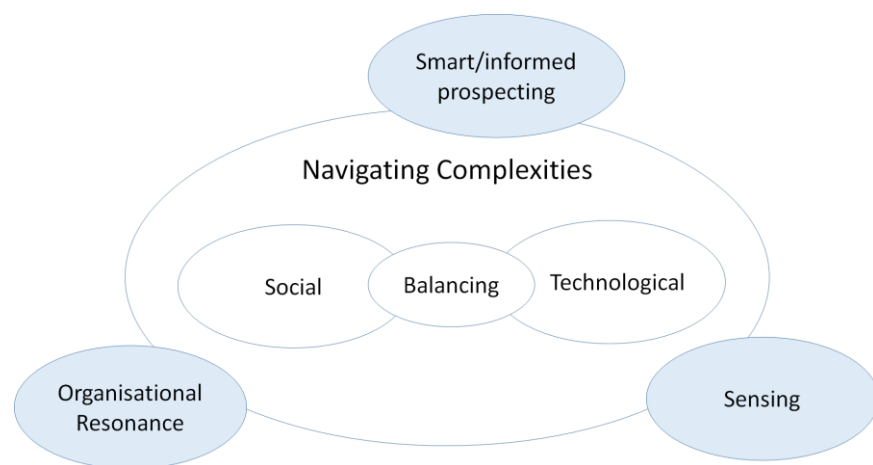


Figure 5.2: Initial conceptualisation of Navigating Complexities core category

5.2.2 Introducing “proprietary process and technology development”

Upon first thought it is, perhaps, quite easily overlooked that the efforts undertaken by organisations to ensure levels of differentiation between their products and services from those of competitors takes a lot of purposeful effort and strategic planning. The basis of this competition is often down to [new] product development and the effectiveness of its related processes, which in management literature covers a multitude of activities that fall between the spectrum from ideation to product launch and commercialisation. This indeed, is a critical area that is often the centre of the firms’ operations. Although this is often recognised as the basis for the legitimacy of high value start-ups and spin-outs, whose launch is often built around a unique product which offers a unique value proposition, the competitive capabilities needed for maintaining their differentiation and specialisation is not, and has not been made clear to many enterprises.

After a series of interviews, observations, data collection and analysis therefore, this section highlights one of the factors that many respondents see as critical to the competitiveness of firms. Proprietary process and technology development emerged as a substantive core category following the processes of constant comparison and theoretical sampling.

To ascertain the respondents’ understanding of this theme and to enable the appropriate pitching of the discussions, the initial discourse followed the same process as the first theme and revolved around theme definitions, importance and methods of development. Following the core category findings from the first stage, this stage commenced with the questions; ***“what do you understand by “proprietary process and technology development”, and how does this influence your competitiveness?”***

In addition to this question, a second was asked thus, ***“what is the relationship, if any, between this category and the capabilities your company needs to develop to ensure its competitiveness?”*** The two questions were asked simultaneously to give the respondents ample opportunities to provide overarching answers.

Respondent A for example, while conducting the initial observational tour around the research facilities for the company and emphasizing the uniqueness of their processes and technologies development processes, provided his understanding of what ‘proprietary process & technology development’ meant to his company. According to him;

“...when an organization combines different technologies, capabilities and organisational know-how into developing processes or technologies that serve as the basis for their unique product development which sometimes leads to their competitive advantage...advantage because these processes and/or technologies are often used exclusively by the company and protected by intellectual property rights...”

Respondent F on the other hand, mentioned that in the field of medical, biological and life sciences, the development of proprietary processes and technology often culminate in the establishment of a platforms to facilitate the development of new products. Said he:

“...proprietary process and technology in the medical field are often platforms which are built around a combination of scarce scientific competencies to facilitate the development of a succession of new medical products...it is sort of...like a bespoke production line...the production line represents the proprietary processes and technology within the companies...”

Other respondents provide their definitions of this thematic category, as shown in Table 5.4. What is noticeable from the definition is the fact that platforms provide frames for the building of products and services which are then commercialised. The respondents also state categorically, that these platforms form the basis of their competitiveness in that their business models are built around these platforms. According to Respondent F;

“...the company’s business model is centred around this platform and the processes and products it facilitates...”

Company	What do you understand by 'proprietary process & technology development'?	Is this an important concept in your organisation? Why?	How do you implement the concept?
A	This is when an organisation combines different technologies, capabilities and organisational know-how into developing a process or technology that serves as the basis for their product development. This process or technology is often unique to their company	Yes – it is important because it is the basis of our competitiveness. It is our unique identifier in the healthcare field as we are the only ones that have developed such detailed capabilities	Through collaborative R&D and project engagement with advanced science and technology multidisciplinary teams we ideate, design and create these unique processes and technologies that support our product development
E	The development of commercially viable solutions which are for the exclusive use of an organisations product development activities. These solutions are often IP protected	Thinking like an investor, it is important to the company because it contributes to its IP portfolio. They are assets. This IP of course adds to the value of the company and can sometimes be monetized or used as collateral	Through our internal R&D function, who sometimes achieve this in collaboration with our R&D partners
F	The proprietary processes and technologies in the medical field are often platforms used to facilitate the development of a portfolio of product	Yes, it is important because the company's business model is centred around this platform and the processes and products it facilitates. We would not be able to develop our final products without these underlying processes or technologies	Through both internal - our in-house technology team, as well as external - collaborative work with partner companies.
H	Proprietary processes and technologies are structures that provide frames that can be built upon. They provide a unique functionality which supports the building of something bigger, better, more functional and more valuable.	Yes. We initially intended it for a particular purpose but we are suddenly finding out that it provides other functionalities that were not originally thought of during its initial design. It is multifunctional and it provides quick commercialisation abilities	Through focused multidisciplinary R&D projects where the different disciplines come together to create unique processes and technologies. These are often a combination of disciplines, underpinned by advanced technologies

Table 5.4: Proprietary Process and Technology Development

As expected also, various periphrastic references to the well-known *Resource Based View (RBV)* theory were broached during the extensive discussions with the respondents. This theory, according to Barney (1991), emphasizes a situation whereby firms differ in a multitude of ways due to the differences in their bundle of unique resources. The alignment of this theory to the respondents' experience was captured in some of the responses. Respondent F for example, stated that;

“For companies to remain competitive and relevant, it is important to accumulate as many valuable, unique and unconventional resources within their firms as possible....we have for example, created our own unique platform upon which we continually build products and services...this has helped us develop a unique organisational identity upon which our value proposition is built...”

This statement identified the need to develop resources and assets that are difficult to duplicate by firms providing similar products and services which may or may not be operating within the same sector. At the heart of this endeavour is the need to achieve sustainable competitive advantage

Respondent A on the other hand, stated that;

“...the goal is to ensure that we have capabilities that continually evolve to create processes that other firms, which may or may not be similar to ours, cannot understand and reproduce within a given period or season of operation...this puts us ahead of others who may be direct or indirect competitors...”

In addition, Respondent E, who had managed an extensive start-up investment portfolio, excelled in an academic background, in addition to various stints as an academic consultant to industry and policy makers, made direct reference to the fact that his company needed to abide by the RBV theory to ensure that their competitiveness was based on evidential data.

Said he;

“...in my experience over the past 15 years or thereabout, I have always recommended the Resource Based View approach to all the companies I have ever consulted for, especially those with high innovation tendencies...this has helped in distinguishing their products and services from others, especially when trying to gain a foothold in a target market that provides alternatives of some sort...”

These initial excerpts once again, confirmed the core category, proprietary process and technology development and emphasized the need for organisations to create and/or identify processes unique to the organisation, which aid the development of products and services. One key finding was identifying or creating a platform or base from which value could be provided to the clients in the form of novel products and services. Due to the novelty and complexities of medical breakthroughs required for the management of modern healthcare challenges, respondents alluded to the fact that their products were mostly disruptive and the processes through which these were developed were bespoke processes many of which had to be developed specially through collaborative efforts. For example, Respondent F mentioned;

“...through a collaborative project, we identified the potential to use infrared spectroscopy as a non-invasive technology to identify specific biomarkers we will use to diagnose certain conditions...this is the platform upon which we want to build our miniaturised, hand-held products...there is currently no other state of the art technology available for these purposes and we have filed a patent application to protect our investment...”

Respondent F, having collaboratively identified the potential to utilize a particular process to develop a unique proprietary process, has spoken of protecting their proprietary process through intellectual property rights. This again indicates possible financial value of proprietary processes used for product development. What Respondent F also identified later on, was the need to incorporate advanced technologies in the development of these proprietary platforms and processes, as a means to ensure some state-of-the-art considerations. Once again, said he;

“...we found out that we needed certain technologies to ensure the development of our platform as well as products...this was a further incentive for collaboration with universities, to acquire not only their specialist knowledge, but to use their laboratory and workshop equipment...”

In continuation of proprietary process and technology development category, a core theme in question, an excerpt from Respondent A's discussions included;

“Yes basically, it (the company) spun out as a private company and moved into this facility here...this was purpose built...including some of the laboratory equipment we currently use to develop our products”

Field Note, Company A.

Introduction: *The observational tour of the company site especially the operational sections such as the R&D laboratory, library and packaging sections included the sighting and close examination of a few contraptions that were purpose built for their bespoke processes such as the incubation and lifecycle management of their products. I questioned the Laboratory Scientist extensively and asked a few questions. One of the questions asked pertained to how the lab was equipped. The reason for this question was to find out whether the company was developing proprietary processes for their products and services and how these processes came about. His response was that their product was so novel and bespoke that a sizeable number of their laboratory equipment was custom made for their production processes. He mentioned that at the start of the project, the company did not even know what equipment they would need but having consulted with entomologists, and other ‘insect specialists’, various proposals surrounding the development of solutions were ideated. His response however went further to indicate the importance of collaborative activities towards actualizing this goal of developing the equipment.*

As part of the tour, I was introduced to a Research Fellow from Swansea University, who was working with the lab scientists at Company A to develop proprietary processes and standard operating procedures for the platforms on which the products were eventually developed. When questioned, he mentioned that his role was to develop Company A's capabilities through knowledge transfer mechanisms such as coaching, direct instruction, job shadowing and the development of manuals and reports. I observed a process of instruction where the Fellow talked two junior scientists through a process of larval development monitoring.

I also had a brief discussion with an Associate Professor from Swansea University who was instructing two Laboratory Officers concerning a procedure that he (the Associate Professor) had developed as part of the collaborative research partnership between

Company A and Swansea University. This procedure was developed to monitor and optimize the lifecycle of the fly and included processes to incubate the eggs up to the adult fly stage where they are nurtured to lay eggs again to commence the lifecycle. Various specialist equipment, combined with proprietary processes were used for these purposes.

The apparatuses observed included those for which patent GB0605XXXX had been granted and GB2436XXXX was pending. These were awarded for the processes and technologies used in 'Apparatus and an improved method for the production of, and growth of sterile XXXX' and 'Sterile XXXX production'.

During this tour, a part of our discussions centred around the importance of this IP acquisition and it was mentioned that it could form a new revenue stream for the organisation. They could license their technology out to others in similar industries and gain some financial benefits from this.

Findings: *Findings from this field study included*

- *Safety and security were of topmost importance due to confidentiality of the novel equipment and possible contamination of their products. My request to take pictures was denied, as was my request to record the tour as well as discussions. Indications were that the processes were meant to be kept confidential.*
- *Multidisciplinary collaboration was an important activity, especially for the development of in-house, bespoke processes for product development. These were instrumental in the establishment of competitive advantage*
- *Collaboration supported knowledge transfer processes such as learning and absorptive capacity.*
- *Knowledge was gathered from multiple sources and 'cleaned' to extract the needed information for the development of technological equipment. This resulted in some 'wasted' ideas, which due to the company's immediate needs, were not necessary*

Upon further exploration of the concept of 'purposely building' a platform from which the development of new products and services can take place, Respondent A continued:

"...of course, we started with a vision of what we wanted to achieve, we had some conceptual ideas having consulted specialists...with a peripheral knowledge of what was at stake...to bring these to advanced stage fruition however, we had to engage in exploratory projects with different specialists who used their individual specialties in their advanced areas to create near prototypes of what we needed..."

Following this interview as well as the field observations, it was identified that a major facilitator for the development of proprietary product and technology development capabilities was the use of advanced technologies as a moderator, or go between, between

different advanced specialities. According to some of the respondents, particularly A, F and H, using advanced technologies assisted the integration of different science and technology-based solutions.

In addition, collaborative partnerships were equally identified as a moderating factor for the development of proprietary process and technology development capabilities. The reliance on collaborative partnerships, especially those with academic institutions and research organisations, where multiple specialist knowledge streams were readily available facilitated the quick uptake of new and hard to copy processes and indeed, capabilities. These collaborative partnerships took the form of long-term relationships such as Knowledge Transfer Partnerships, which served to embed specialist knowledge within the organisations as well as produce 'new' knowledge to inform breakthrough solutions for difficult conditions. On the other hand, other collaborative partnerships were of short-term duration, mainly to solve a quick problem which was in an area of knowledge that was not core to the company or of sufficient importance to ensure the embedding of that knowledge. It was suggested by a Respondent A that;

"...these types of short-term activities are often meant to fill gaps in critical knowledge areas...are not core to our organisation...and are often referred to...we refer to as peripheral relationships".

During these collaborative partnerships, different activities and processes were put in place to ensure the optimization of knowledge transfer between both the university and the company. Identified first of all, was the fact that the organisation needed to be at that level where they were not only willing and able to receive the knowledge but also to put it to good use. According to Respondent E;

".... luckily for us...or not maybe, we do not have problems with acquiring and transforming knowledge into usable products. For such a small company, just over 50% of our key operations employees have a PhD, plus some experience in one biological science area or the other, while the others have at least a Master's degree...this was not intentional because we advertised for people with the required experience stating that higher degrees were an added advantage..."

Respondent E continued in a later paragraph;

“...we therefore depend on the basic or background knowledge of our experienced employees to build the required structures and frameworks [platforms] that are needed for our innovative products...we have observed that the more experienced the person is, the more likely he or she is to find some common ground for the integration of completely different technologies...”

The discussions surrounding the rapid development and evolution of manufacturing in general, and the specific related capabilities needed to keep firms competitive, brought to the fore the importance of both tangible and intangible assets and their part in facilitating the development of competitive advantages for the firm. For these advanced technology and high value start-ups and SMEs, their competitive advantage, as noticed from the interactions with the respondent firms, was usually established from a combination of both tangible and intangible assets which were very often developed following very intensive and rigorous operational as well as R&D activities. These activities were often as a result of collaborative R&D partnerships with academic institutes who, as knowledge partners, established knowledge transfer mechanism into these technology and high value organisations. Indeed, the universities and research institutes were not agreeing to collaborate out of any altruistic agenda. According to Respondent F;

“...these are win-win situations as all parties get something out of this...organisations develop new competitive capabilities, new cutting-edge products, money...while the universities get to publish cutting edge papers that provide them some recognition as research intensive universities, for which they can get more money for research...and so on. The cycle continues this way...”

Outcomes from these relationships often culminated in the launch of new products, services and/or processes, where some of these processes served as proprietary platforms from which further new products and services were launched. Outcomes included, but were not limited to assets such as medical devices, components of medical devices, methods of manufacturing, mobile applications and treatment methods amongst other things.

Referring back to the earliest interviews in Phase 1 for example, one of the earliest interviewees, Respondent B, emphasised their position within industry and stated thus:

“Our main products and services are that we are a platform technology developer...we have high-tech platforms which are designed to serve the pharma industry, specifically around the formulation of sustained release acting drugs...one of our most high research concerns is taking drugs that are known and have been approved and re-formulating and repackaging them so that they can have a much longer duration of action in the body.”

Similarly, Respondent D in his own arguments stated;

“...our unique platform, which I believe is the first of its kind anywhere in the world, will offer a base from which post-operative support for cardio patients can improve recovery rates thereby reducing hospital stays...”

These interviews from Companies B and D, who were not included in this case study stage, were recalled just to emphasize the importance of this platform technologies. This **memo** identified 7 of the 12 organisations who actively developed platform technologies.

Platforms are modular commodities that combine hardware and software combinations into a new base upon which other products and formulations are attached and organised to produce completely new products and services. In digital forms, these platforms facilitate connection-based activities and incorporate connection-based activities such as digital marketplaces and data repositories.

What was noticeable from these discussions with all the respondents was that the platforms being described were proprietary, wholly owned by the companies and covered by intellectual property rights towards guarding against uncontrolled use by external organisations. Oft times, these proprietary platforms were backroom enablers and only functioned for the purpose of creating innovative and disruptive consumer products which were then commercialised

In conclusion, the category of proprietary process and technology development capabilities, based on the interviews, were formed of sub-categories namely; Advanced Technology, Collaborative partnerships. Building capabilities therefore, around the adoption and integration of these advanced technologies, as well as, building and developing capabilities

around collaborative partnerships; knowledge transfer, learning, absorptive capabilities, were necessary for establishing sustainable competitive advantage.

Major Categories in this Theme	Low Level Categories
Advanced [Manufacturing] Technology Management	Proprietary technology knowledge
	Multi-Technology Integration
	Technology stretching and forecasting
Collaborative Partnerships	Knowledge Transfer
	Multidisciplinary & Collaborative R&D
	Learning Development
	Creativity development

Table 5.5: Proprietary process and technology development low level categories

5.2.3 Introducing “Intellectual Benchmarking”

It is pertinent to note that a consistent occurrence in this research was the fact that first of all, the need to negotiate for different technologies as well as navigate between and around them was a topmost priority. At the start of this research and up until its advanced stages, issues surrounding multidisciplinary collaboration, the integration of different knowledge and technologies, the most effective methods of acquiring new knowledge and the development of cross functional R&D relationships were topmost on the minds of the respondents. Most importantly however, were the discussions around the best way to balance all these challenges, as it was thought that the benefits of excelling in one or two areas, over any of the others was in no way beneficial in the long run. This was emphasized by most respondents, such as Respondent F, who argued that:

“...managing a high growth, high value SME...towards ensuring it is profitable and competitive, is a balancing act which needs people who know a little about a lot of things...and for emphasis, not the other way around”

With respect to the theme in question, the approach adopted in opening up the conversations surrounding this category was to first of all explore the respondents’ definitions and understanding of ‘benchmarking’. The questions, “**what do you understand by benchmarking**”, “**is this an important concept in your organisation**” and “**how do you implement the concept**”, were first of all explored with each of the case study

companies before delving into the core category of 'intellectual benchmarking'. Table 5.6 represents the results from the brief discussions in this area

Company	What do you understand by benchmarking?	Is this an important concept in your organisation? Why?	How do you implement the concept?
A	Positioning. A way of knowing where you are at every given point in time on a given scale	Yes. Helps us improve our performance through the improvement of our capabilities or the development and adoption of new ones	Developed a dynamic framework for organisational improvement of our people, processes, organisational units
E	Measurement against a given standard for example, GMP, Quality, knowledge management, good laboratory practice	Certainly. It provides performance indicators for our organisation. Informs our acquisition of capabilities to ensure competitiveness	What do we want to benchmark; quality, skills, knowledge → what metrics → methodology → Data collection & analysis → model developments → testing → implementation
F	Ranking according to a set out measurement plan.	Yes. Assists in the identification of organisational gaps, whether individually or collectively. Helps to prioritise actions against company objectives and strategies	We have developed learning capabilities and organisational development frameworks to ensure that any gaps identified are adequately closed
H	Benchmarking provides results from a measurement activity in comparison with selected and agreed standards	Yes. It supports the building of our competences because through benchmarking activities, we are able to update our capabilities towards achieving our strategic aims	Determine situational position → measure against standard → determine gaps, areas for improvement → design methodologies to close gaps, achieve goals → collect data, analyse → develop roadmap, construct framework → execute

Table 5.6: Benchmarking

The general consensus concerning the definition of benchmarking from the respondents' points of view involved identifying the position, measuring the level of attainment and/or the identification of an individual or company's situational position with respect to a previously defined frame of reference or general standard. It was also generally agreed that the purpose of this identification or positioning was for comparison purposes – to analyse how other organisations achieve their levels of performance and excellence and to use this information to improve own operations. Therein lay the first indication of how benchmarking informed and supported the development of capabilities

Regarding the implementation of the concept, the respondents' answers pointed to the fact that the development of improvement frameworks, driven by the collection and analysis of data was key to the closing of whatever gaps had been identified or whatever goals and aspirations needed to be reached. These frameworks were applicable to individuals within the company, for example, with regards to learning and competence development, or the frameworks were applied to the organisation as a whole for example, the adoption of lean and agile capabilities which are applicable throughout the organisation. Respondent H for example stated that;

“...have you read the books...the Lean Startup and The Goal...by Goldratt...we benchmark ourselves against a lot of the continuous improvement frameworks and concepts they propose...and use them to measure our progress towards success...”

Having therefore established the companies understanding of the concept of benchmarking and the issues surrounding its adoption and implementation, the next stage was to provide an understanding of the word 'intellectual' following which the concept of 'intellectual benchmarking' was then aligned with the identification and development of competitive manufacturing and organisational capabilities.

Following the definition of 'intellectual' as, “the use of mental powers and logical reasoning to provide objective categorizations of issues” (Respondent F) and “a person's ability to offer sound reasoning in areas pertaining to daily issues...and use the acquired knowledge as tools to discuss and proffer solutions to social, economic and business challenges” (Respondent A), laying the foundation for a definition of 'intellectual benchmarking' was more straightforward than expected. It was generally believed that intellectual benchmarking described the ability to “determine one's positioning, with respect to certain problem-solving criteria, in their individual areas of expertise”. These positioning measurements and activities were often carried out in collaboration with organisations possessing identified standards or models such as universities, research institutes and/or some professional services firms, where subject matter experts were on hand to offer mentoring, training and skills development in areas such as 'critical thinking and problem-solving techniques' and 'creative decisions and effective cognitive analyses'. These courses supported the use of cognitive processes, knowledge, facts and data to effectively solve problems, in different areas of speciality. The ability to think on the go and develop well thought out solutions within reasonable time frames were areas where skills were

developed and honed. As expected, other issues within this category included the development of knowledge transfer mechanism, learning capabilities and the improvement of the absorptive capacity of the organisation.

With the understanding of the general concept of intellectual benchmarking, the question and main point of departure was then tabled. ***“What do you understand by ‘intellectual benchmarking’ and how does this influence your company pursuit of competitive manufacturing capabilities?”***

Earlier on in the study, before the phase 2 interviews commenced, Respondent B mentioned that certain standards for High Value, advanced technology SMEs could not be circumvented. During his discussion, he stated that,

“of course, you train people in an organisation.... but if you need an engineer, you can’t train an engineer without making him go through an engineering course at a university”.

These discussions also progressed into areas concerning collaboration where he stated that the intellectual capacity of employees and indeed the organisation, has to be at a level where they have the ability to acquire relevant knowledge that is being transferred to them – the respondent was referring to knowledge being transferred specifically from academic researchers to industry. If the level of understanding in the organisation is not up to a certain level, knowledge leakages will take occur. It is this ‘certain level’ of understanding that necessitated the ‘benchmarking’ theme and therefore highlighted the need for certain members of staff to attain agreed foundational levels of knowledge before any further competence development could be planned and achieved in the long run. It also highlighted a ‘totem pole’ of standards upon which intellectual achievements were benchmarked and etched to provide a standard for the onward acquisition of improved competitive capabilities.

This however presented further challenges, especially with the multidisciplinary and cross functional nature of the different organisational structures. While intellectual capabilities served as an important role for tempering both the internal and external concerns of the organisations sampled, the need to engage in cross functional critical thinking, especially with regards to multidisciplinary R&D, new product development, product commercialisation, innovation and other intellectually stimulating and demanding activities was necessary for competitiveness and survival. Going further, the need to measure and

evaluate these intellectual capabilities was identified as a critical factor for the respondents and their companies.

An example of this intellectual benchmarking was with regards to recruitment and competence development. Respondents spoke about developing internal intellectual benchmarks through which individual and team assessment activities could be measured and therefore improved. According to Respondent F:

“Since we started [the company], our hiring has always been purposeful and strategic. We based our hiring on certain key factors... alignment with company positioning and direction, qualifications, knowledge, skills...these were the things we looked out for... a lot of our hires are at PhD level where some have completed their studies and others are near the end...because you would expect that as bioscience or engineering graduates, they have acquired certain skills and knowledge based on rigorous training...”

This excerpt from one of the interviews identified the standards the company set towards the recruitment of new intakes towards maintaining and improving upon the performance of their internal operations. This was especially important when R&D activities were thought to be a major part of a company’s operation and the main driver of the company’s value proposition, products and services as well as general knowledge base.

With respect to the initial benchmarking definition, Respondent F went on to emphasize that:

“As an organisation whose products are wholly R&D based, involving long periods of collaborative activities observational studies, calculated activities and experimental trials....all across different specialities such as biosciences, engineering, computer science, product design...we need to have standards through which all new intakes are measured...this also includes and affects the experienced staff who are at all levels within the company because we expect that at different stages in both their careers and the company’s development, certain milestones have to be reached...”

Analysing Respondent F's thinking suggested that for the identification and development of competitive manufacturing capabilities, some form of intellectual benchmarking, moderated by the organisations resources, activities and capabilities, needed to be achieved. Respondent A on the other hand had earlier provided reasons for the intellectual benchmarking; to enable the achievement of the objectives and value proposition for which the company was set up, which in the long run provided the ability to gain competitive advantage.

The respondents quotes above demonstrated that this benchmarking capabilities may be as a result of collaborative activities with groups or organisations external to the immediate research area. In addition, benchmarking may also be as a result of external influences on an organisation such as hiring new specialist staff to increase the knowledge capabilities of the organisation. For example, Field Notes for Company F identified their reliance on simultaneous collaborative partnerships with different universities, as well as research institutes within a single university. During the observation activities, it was observed that the shared benchspace in the laboratory promoted knowledge sharing and transfer which allowed some benchmarking to take place between companies.

Field Notes: Company F

Introduction: An observational tour of the company, whose operational space consisted of a couple of laboratory benches in a shared incubator/laboratory building, involved a survey of some laboratory equipment as well as some brief discussions with three other members of the company research staff; Fa, Fb & Fc. As highlighted earlier, two of the three research staff were experienced PhD holders while the last one was in her last year of studies in Aberystwyth University.

Located in this shared laboratory space were 7 other start-ups/SMEs with varying biological and scientific capabilities, products and services. According to Fa & Fc, although all the companies in the shared space were independent and put processes in place to protect and maintain their organisational boundaries for the purpose of Intellectual Property protection, there were opportunities for collaboration, knowledge exchange, fertilisation and transfer between the companies especially when their operations were focused in non-competitive sectors, operations and activities.

As expected, Company F had advanced collaborative partnerships with Swansea University across different institutes and faculties namely Institute of Life Sciences, the Medical School and the School of Engineering. The research proposals accessed demonstrated their joint partnership across these three groups, having received research funding from Innovate UK

Respondents Fa & Fc mentioned that indirect benchmarking activities often occurred between the companies, due to the incubator/laboratory layout which enabled both direct and indirect comparison between organisations. This comparison therefore enabled companies understand their individual positioning at given times. For example, Fa mentioned that he had attended a course on

Findings: Findings from this observation study included:

- The shared spaces helped people from different organisations share opportunities, information and ideas. More importantly, they shared company challenges, as well as possible solutions, as long as these were not confidential information that would affect their intellectual property applications and claims
- This ability to discuss openly, “especially in the absence of direct competition”, according to Respondent Fb, supported the intellectual benchmarking of organisations as well as individuals within the organisation
- These intellectual benchmarking capabilities allowed the organisations to measure performance, i.e., identify areas where an improvement in performance was needed. It also helped in the development and adoption of best practice areas, commonly referred to as Good Manufacturing Practice
- Each member of staff was given a handbook of laboratory rules and etiquette prompting the need for the staff to have a base level of understanding. In addition to this, some basic courses, delivered by the host institute, were made available to every new member of staff. This of course, ensured that everybody using the workspaces was at the ‘same level’ of understanding
- Having completed the first round of a particular funding from Innovate UK, the company had developed some new knowledge via academic research activities. They claimed that some new models and frameworks had been developed which were fundamentally different from any other research output. This finding formed the basis of the organisation’s innovation.

These levels that were spoken about, regarding the recruitment of PhD level graduates was also reflected in part of Respondent A’s interview, where it was stated that;

“...we realised earlier on that to achieve the objectives and value proposition for which this company was set up, we need to set a standard for the people we engage, especially those that are going to work as part of our core operations...they need to understand mid to advanced research principles and laboratory practice...because of what we do, they need to understand advanced techniques in molecular biology and computational biology, biochemical structural characterisations... We have found out that most biological science PhD students, or those close to completing their studies, have developed these as part of their 4, 5 or however many years of study...they are as comfortable, and as familiar in the lab, as a

surgeon...and not a GP is in theatre...even though they are both considered doctors, they are trained differently..."

In addition to this, Respondent A highlighted the need for regular intellectually stimulating and ideation workshops internally within organisations and externally between these organisations and their collaborators - to enable them remain innovative and competitive. The purpose of these workshops according to her;

"specialist research institutes provide the opportunities for us to benchmark ourselves and our organisation on an intellectual scale. With many years of advanced laboratory training and experience, these institutes and the researchers in them provide an easy measurement standard by which we are able to understand where we are, what we need to do, or the skills we need to acquire, to enable us move ahead..."

It must be remembered however, that earlier on in the first phase of this research when the 11 organisations were interviewed, a few references to ideas surrounding Intellectual Benchmarking were highlighted. For example, Respondent B emphasized that:

"...because as a small company, every hire, particularly in the early days...was key. If you bring someone who is not at the same intellectual level as everybody else, that person will really struggle to adapt...they are not really likely to fill much of a knowledge gap and we don't hire people unless there is a knowledge gap or we need more support"

He went on further to mention that:

"Yes, everybody here has, everyone on the technical team has at least one degree. I would say that another third, if not half, have a Master's degree or higher"

Having therefore explored the concept of intellectual benchmarking with some cross functional context, the core concept and its sub-categories were therefore identified in the Table 5.7 and Figure below, with the diagram representing a substantive sub – theory for development;

Major Categories in this Theme	Low Level Categories
Cross functional pollination (Collaborative Partnerships)	Technology & Knowledge Profiling
	Knowledge Transfer
	Boundary Spanning
	Knowledge acquisition
Advanced Education	Scientific Expertise (Specialist)
	R&D Competence
	Advanced (higher) degrees
Coaching (mentorship)	Motivation
	Knowledge Catalysis
	Navigating Complexity

Table 5.7: Benchmarking low level categories

5.2.4 Introducing “Knowledge Formation”

Knowledge management plays an important role in the achievement of management objectives in organisations, such as the development of a spectrum of capabilities that form the basis of a firm’s operations and competitiveness. Following the earlier findings from this study as well as the general discussions entered into with the respondents during both phases, knowledge was found to play a key role in the development of organisational capabilities, which lead to competitiveness. Starting from the basics of course, which in this research has been identified as the ‘negotiation and balancing of complexities’, knowledge, data and information and their effective handling all play a key role in the creation of value, for both the SMEs as well as the clients. Having therefore accorded ‘knowledge management’ the dues it deserves, a more specific knowledge construct was identified and classified as a core concern for the respondents.

As with the general process observed in the preceding themes, the respondents were approached with the last core category, knowledge formation, and asked the questions that were asked earlier. Once again, these questions opened up the conversation and put the respondents at ease. In addition, the answers enabled both the respondents and researcher agree on a point of departure, which for the purpose of the interviews and observations, was important.

Company	What do you understand by 'knowledge formation'?	Is this an important concept in your organisation? Why?	How do you implement (develop) the concept?
A	This is the careful selection and combination of different and possibly well-known scientific constructs to form other completely new constructs that have value. This is often the basis of new products and services that are commercialised for profit	It contributes to our intellectual capital, which leads to the development of internal organisational know how concerning the creation of value for our clients and partners	In our work we deal with a combination of advanced scientific knowledge and gather information from different people and disciplines. We therefore create internal repositories which show the processes used in creating any new knowledge
E	The creation of completely new ideas and concepts of value that are based on other ideas or concepts. The aim of the formation is to solve a critical problem, that is incapable of being solved through the application of 'regular' or conventional knowledge	This was, and still is, our route to generating intellectual property. Wearing my investor hat, this is one of the contributors to the valuation of start-ups and SMEs when investments are being considered	This is achieved through a combination of collaboration, learning, practical activities, such as laboratory experiments and ideation workshops. These can also be a combination of both formal and informal learning and education. Data collection, manipulation and
F	Knowledge formation is an enterprising activity that requires some prior expert knowledge of not only advanced scientific principles, but also some basic knowledge of other peripheral scientific or technological understanding.... This is because this creation is based on the combination of one or more technologies to form an entirely new knowledge	Yes, it is important because it forms part of the basis of our competitiveness. As you know, living in the knowledge economy dictates that if we have knowledge that others do not have...knowledge that has commercial value...this puts us ahead of them commercially.	We develop this concept through experimentation, combining already accepted theories with new technologies, scientific inferences, creative ideas...above all, data collection, analyses, iterations and interpretations are also a major part of knowledge recombination developments
H	Knowledge formation is the development of new knowledge from the organised arrangement of different elements in a prescribed way, for a particular purpose	Yes. In the knowledge driven economy, knowledge, information, data and of course, the ability to manipulate, understand and 'reconfigure' for your specific purpose is the most important capability any organisation can possess.	Part of our good research practice dictates that we keep detailed laboratory notebooks of our daily activities. This provides reliable references for writing up the materials and methods used, as well as the number of consumables and ratios used that have resulted in the formation of the new knowledge

Table 5.8: Knowledge Formation

Regarding the definitions therefore, companies were encouraged to provide definitions from their companies' points of view. This added some kind of personalisation to the process and elicited a sense of ownership. Respondent A for example defined knowledge formation as;

“For us the formation or creation of knowledge is the very careful identification, selection and combination of different concepts from different knowledge areas to form a completely new construct of value...which in our business case often leads to a new product or service that solves a certain problem”.

Respondent F on the other hand, while providing his definition of knowledge formation first of all argued that the word, 'formation' implied that some prior knowledge of a particular subject was already known to a large degree. On further questioning, he emphasized that in most areas of endeavour where knowledge formation was predominant, the person configuring the knowledge and forming it into a particular structure had to possess some specific expertise, specialism or authority in his field to enable him understand the attributes and features which would allow him 'reconfigure' certain aspects of it.

According to him:

“Knowledge formation which involves the reconfiguration of structures is an activity that requires some prior expert knowledge in the areas where the reconfiguration is going to take place. In our case, where we depend on the multidisciplinary knowledge of many different science concepts to develop our product, it is mandatory for those configuring this knowledge to have some prior knowledge of not only advanced scientific principles in their immediate subject areas, but also some basic or peripheral knowledge of other scientific or technological areas that are going to be integrated with theirs...this is because for the purposes of knowledge integration, it is necessary to understand where different subjects...meet...or possibly share some similarities...so they can be connected at those points...”

Respondent F further emphasized that;

“... the act of knowledge formation is an enterprising activity...a lot of creativity, imagination and initiative is required to make this reconfiguration a success, especially when trying to meet a particular need...”

With similar definitions coming from the other respondent as well as similarities as to the contents that make up knowledge formation, it was established that a good understanding of the concept was reached by both parties; the interviewer as well as the interviewee. Other discussions then ensued and were around the content and processes leading to knowledge formation as well as the relationships of this category to the development of competitive capabilities.

Starting with Respondent A, who mentioned the following;

“...for our particular offering, the combinations we have are between constructs and theories from disciplines such as entomology, chemistry, biochemistry, healthcare sciences, microbiology and a host of other subject fields...”

The process to the development of new knowledge for the competitiveness of their organisation was tabled and discussed. According to him, a deep understanding of available disciplines in whatever fields or endeavour the organisation was pursuing was necessary. His argument also emphasized the impossible situations where a single person was able to understand the different scientific areas needed to create one solution and so, the need to engage in multidisciplinary team work was important. According to him;

“...due to advancements in science and technology, most challenges can be solved through the combination of multiple subjects which sometimes do not have much in common. It is up to the scientists or solution providers to discover the different areas and theories that may contribute to a particular solution. This is how innovation happens and this is how competitive capabilities are developed...”

While these issues surrounding multidisciplinary knowledge had been discussed in a previous theme, its contribution to the creation of new knowledge also emphasizes the need for the combination of different subject areas.

While all respondents alluded to the fact that knowledge formation requires the combination of different disciplines, various challenges were also brought up and discussed. Knowledge integration, for example, was one issue brought up by respondent H. According to him;

“while our solution required the combination of different science processes, the integration of these was a huge challenge for us, especially as it had never been done before...we had to design and create an entirely new process in which we had to consider all potential scenarios and interactions that could take place between the chemicals...”

Respondent F, while speaking on the same issue, provided an example and spoke about integrating engineering and biological sciences. In his particular case:

“...because we are creating a device, we have to think about combining biological sciences with electrical engineering, for example. Although this is now a subject in its own right...bioelectronics...it is an area that keeps advancing due to the rapid changes in technology...we can never really say that ‘this is it’ because the configurations will change the next day and what you think you have achieved becomes semi-obsolete”

Other challenges to knowledge formation were around the execution of the tacit kind of knowledge, which is full of subjective insights, intuitions and hunches, and therefore highly personal and hard to formalize, making it difficult to communicate or share with others. Respondent E, alluding to this, mentioned that;

“...a certain kind of skill is needed to create something that has never been created before...how do you draw a picture of something you have never seen...you probably need an active imagination, and some creativity that enables a person bring an abstract thought into reality...”

Respondent A on the other hand said simply;

“...to be competitive, a company needs creativity, imagination and most of all, boldness. When a person or team or company say they are going to do something and people... people say that they are mad, it takes a lot to continue down that path...”

This finding however, was not new and had come up at earlier stages, during the Phase 1 interviews. During the open coding phase, this was highlighted by Respondents B and D1 who mentioned respectively, that,

“some level of intuitiveness and creativity are needed to achieve successful...”

as well as

“one of our PhD technologists is very good at imaginative thinking and is able to creatively...”

These discussions surrounding the tacit forms knowledge demonstrated by creativity and imaginative thinking being brought up once again at this stage, and emphasized by the respondent for further clarity, indicated that its importance in the creation of competitive capabilities could not be overlooked and must be included in the final outcomes. During the first stage, leading up to the densification from which the core categories emerged, issues surrounding creativity, imaginative and artistic cognition were not taken into great consideration. At this stage however, this will be used as part of the densification of this category.

In addition to this, various pointers to the contribution of the creative and/or imaginative mind-set towards developing competitiveness were identified during the observation stage of the company tours that were carried out. According to Field Notes for Company H, employees were actively encouraged to develop projects and/or products that could be developed into those for commercial value. The employees proposed projects they had personally thought about and developed and 2 times a year, a winning project was chosen and funded. If he/she wanted it, the employee who suggested this was given the responsibility to manage the project from its inception until its product or process launch, following which the employee was awarded a bonus.

Field Notes, Company H.

Introduction. The observations in this company totalled 3 visits over a period of 3 years, the first and second visits were done alone, while the third was done with two colleagues. The first two visits were in the first year while the third was done in the last year. The reason behind the visits was to understand how the ASTUTE project could support the adoption and embedding of advanced and sustainable technologies into the company through collaboration with the university. This case study was particularly revealing due to the opportunities presented to watch the company acquire particular competitive capabilities from ground level and grow through the acquisition of new partnerships, development of new innovative products and services as well as expansion into new markets.

Visit 1 & 2 (January and July 2013): Having recently moved into a new and larger facility on an industrial estate allocated for B1, B2 and B8¹⁶ uses, the company was made up of 3 employees; the two founders and an administrative assistant. Other than basic office equipment such as desktops, printers, a shredder, filing cabinets and office furniture amongst other things, the office space was bare. Various raw materials for small experimentation processes and manufacturing runs were noticeable, and littered around the office space.

Internally, the 2-storey office unit which was allocated for production and warehousing of goods was made up of 5 rooms of different sizes, as well as a male and female WCs and a kitchen. With only 3 employees and very few equipment and furniture in the office 60% of the office space was unused. The rooms were allocated thus: one large open plan office for all three staff, with space for three more (fully furnished), one equipped meeting room (with modern AV connections for video conferencing), one proposed in-house laboratory (empty), one small production room (proposed to house manufacturing equipment such as extruders, and tensile testing equipment).

Findings: findings from the observation and guided tour included

- The company had a strategic plan for growth, including the development of new capabilities, products, services and markets through collaborative R&D partnerships
- The move to this new site was to support the actualisation of this plan. Having previously contracted out all R&D as well as production activities, part of the plan was to gradually internalise all these processes to manage costs as well as commence the development of assets such as IP and other resources
 - The company understood the value of collaborative R&D partnerships
 - The company, through various means, continually updated their intellectual capital, even with their finite resources
 - They were in the process of recruiting and funding a part-time PhD student to lead a project to develop a new product.
- As a small company, all unused space within the property had been designated for an in-house laboratory for small batch testing and chemical combinations. In addition, further space had been allocated for a small manufacturing site

Visit 3 (August 2015): The company had grown to 6 employees of varying skills and new capabilities. The 3 new employees included a Development Chemist, Laboratory Technician and Logistics Manager. Since the first and second visits the number of clients had increased and new partnerships had been developed. A collaborative partnership had also been set up with University of South Wales to part-fund a PhD studentship in Chemistry and Pharmaceutical Sciences. To support the new product development through the new partnership that had been developed with USW, the in-house laboratory had been set up

¹⁶ B1 facilities are for business offices, research and development of products and processes as well as light industry concerns which are also appropriate for residential area dwellings. B2 facilities are for general industrial purposes/processes other than those that fall within class B1. Exclusions include incineration purposes, chemical treatment or hazardous waste. Lastly, B8 facilities are for storage or distribution of goods that may have been developed and manufactured on site.

As part of the observation programme, I sat in, and observed a brainstorming session which was held with 3 major clients for the purpose of creating a collaborative road-map towards finding creative solutions to the challenges faced by the clients. It was proposed that this will be achieved through ideation, combined with deep interrogation of possible solutions available or possible solutions that could be developed into R&D activities towards yielding creative solutions. Part of the solutions involved the planning for product integration between Company H's solutions and the clients' products.

Findings: Findings from this recent observations and tour included:

- With the advanced partnerships set up with USW, some previously outsourced activities had been brought in-house. The PhD student, in collaboration and consultation with university expertise, had set up the lab to mirror the needed processes for the new product development.
 - Process of knowledge transfer was being effected from USW to Company H
 - Capabilities were both acquired and developed. Short term 'gap-fillers' were used to plug peripheral needs of the organisation
- In addition to consultations, the PhD student had access to USW equipment and expertise for further consultations should the need arise
- Ideation, creativity and general company ethos, which encouraged creativity, intrapreneurship and innovation were promoted within the organisation. Employees were encouraged to come up with projects that could enhance the company's offerings. If these were chosen, the employee was given the responsibility to manage the project from its inception stage to its product or process launch. A bonus was awarded for its completion.

Following the observation stage where a few laboratory staff were briefly discussed with, it was revealed that since the launch of this company incentive, three members of staff had been awarded the extra bonus. According to them, this not only increased the amount provided to the recipient, but increased the bonus amounts for the other members of staff. According to them, this encouraged all members of staff to participate in the project. They felt like partners on the business and supported all projects where they could.

Major Categories in this Theme	Low Level Categories
Knowledge Sorting and Coding	Knowledge Reconfiguration
	Group Mentation
	Proprietary Repository (Data Management)
	Specialist Ideation
Creativity Capabilities	Mind Stretching
	Reflexivity
	Ideation
Evidential Mapping	Data/Data analysis
	Practical applicability

Table 5.9: Knowledge formation low level categories

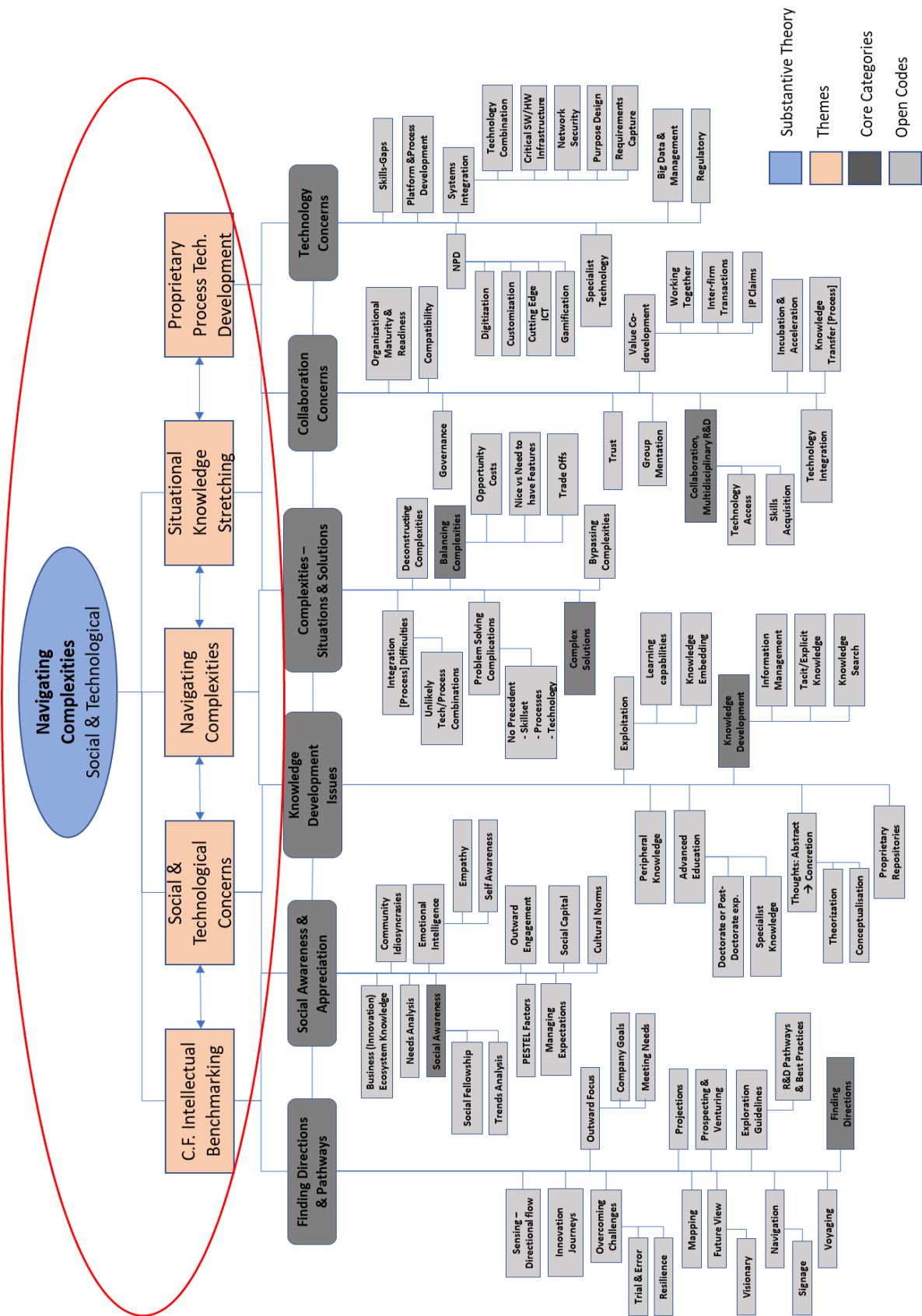


Figure 5.3: Coding tree and theme changes based on case study findings

5.3 Discussion

Following these 'case study' interviews, conducted through the process of the constant comparison methods, various memos were taken, while the interviews were both ongoing, as well as while the data analysis was developing. In addition to this, during periods of reflexion, various ideas went through developmental stages. For instance, it emerged, once again, from the interviews that the core concern of the organisations was their ability to find directions towards their goals and objectives, even amidst the challenges faced. Although not specifically mentioned, respondents spoke about being agile, nimble, to enable them find pathways through 'challenges' without the encumberances organisations often face such as overheads, organisational inertia, bloated staff numbers and so on. Some of the respndents therefore highlighted the importance of not just developing organisational and corprorate strategies for this purpose, but implementing these strategies carefully to ensure careful follow throughs. These arguments and more therefore, placed a strong emphasis on Navigating Complexities as the core or central category to which others will be related during the last stage of the theory development called the Theoretical Coding stage.

Other developments came up. For example, while the constant comparison was going on, another issue was emerging, regarding the development of knowledge within the organisations. Various respondents spoke about the 'situational aspect' of knowledge development highlighting the need to quickly 'take advantage' of market opportunities and situations which their skills and capabilities could build upon and exploit for profit and/or impact. Respondents spoke of these as momentary occurences which could change the course of the organisation's trajectory. According to Respondent E1;

"...the foundations of most disruptive opportunities last for very brief moments...if they are recognised and grabbed with both hands, it may lead to huge successes for the organisation and if not...well...you can imagine the consequence of missing such opportunities..."

Similarly, Respondent A1:

"...opportunity spotting needs to be the responsibility of every member of staff due to its abilities to impact positively on the organization when these opportunities are taken seriously....finding

that opportunity is something that happens at a given moment sometimes...and it is gone before you know it or taken by another organisation”

This was in line with empirical findings from researchers such as Choi et al. (2008); Hmieleski and Baron (2008); Foss et al. (2013) who in their individual research endeavours, identify the exploitation of opportunities and the challenges surrounding them.

Respondents spoke about how the knowledge acquired from collaborators supported the development of this new knowledge which, they in turn had to apply to the opportunities they wanted to take advantage of. The **memo and notes** developed during this analysis conceptualised the diagram (Figure 5.4) and highlighted the situational properties of these ‘opportunities’ and hence, the category, ‘knowledge formation’ was changed to ‘situational knowledge extension’ to demonstrate how the knowledge formed between the collaborators and the HVM was used to create a process, where situational knowledge was ‘extended’ beyond its initial uses, to capture market opportunities.

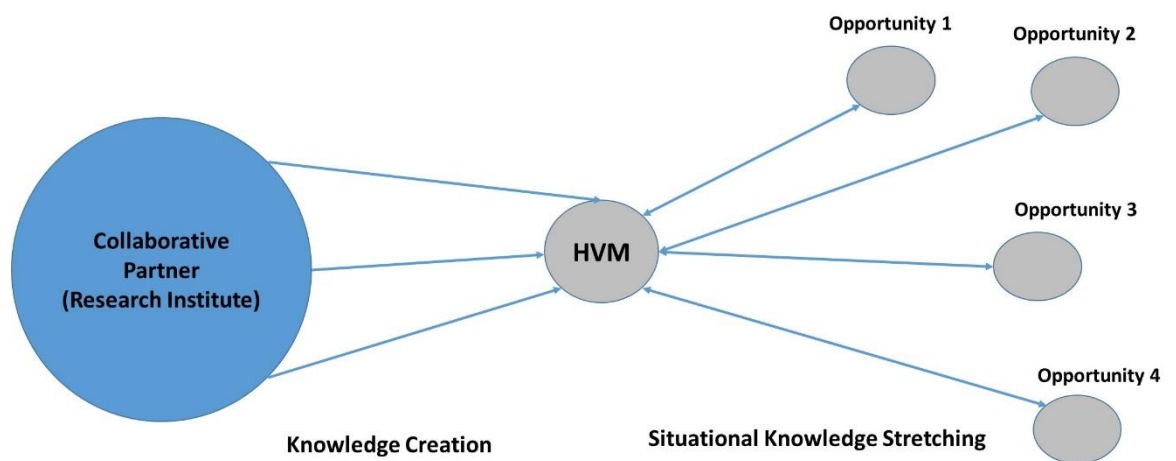


Figure 5.4: Initial conceptualisation of relationships between HVM, collaborators and market opportunities

5.4 Chapter Summary

Following the previous chapter where the core categories were generated, the aim of this chapter was to engage in the Selective Coding phase where data collection and analysis continued, still using the constant comparison methods, until a 'central' core category was selected and other categories related to it. The case study methodology was selected for use in this phase and 4 firms, out of the initial 12 were chosen as case studies. Using this methodology, Navigating Complexities emerged as the core theme and its relationship with other categories were identified. For example, it was found that Navigating Complexities, according to the case study findings, was better split into both socioeconomic and technological complexities as these were the most complex challenges faced by the HVM organizations (see Figure 5.3 for updated code structures and themes). Another example of changes to the themes indicates that Intellectual Benchmarking was better captured in the case studies as Cross Functional Intellectual Benchmarking, due to the cross functional nature of the activities that HVM organisations had to engage in while Knowledge Formation morphed into Situational Knowledge Stretching as indicated by the case studies. The respondents argued that the situational aspect of knowledge capture and formation was a critical issue worth capturing in the research outcomes.

Chapter 6: Literature Review – Part 2

6.1 Introduction

Having arrived at this point in the thesis following multiple instances of data collection and analyses from interviews, observations and documentation from the organisations, some of the findings which we can confirm constitute major issues of concern for entrepreneurs and innovators across advanced technology manufacturing SMEs have been identified. At this stage, one may begin to wonder, “what field exactly does this research endeavour fit into?” Having commenced this exploratory enquiry in the well-researched area of manufacturing capabilities with a bias towards how these are related the competitive capabilities of the firm, the readers will be kept wondering how logical or valid the traverse is across all the data, to arrive at categories involving navigation, multiple types of complexities and their derivatives, benchmarking of intellectual capabilities and proprietary technology development amongst other things? Indeed, these questions will be presented for discussions in our efforts to provide answers to another question that may be posited, “how does, or will, this fit into the already complex body of business and management knowledge?” While I cautiously progress on this journey, I believe that the puzzle will come together in the end, probably in this and, the preceding chapters.

To summarize our progress so far, the previous five chapters have outlined the narrative supporting an emergent grounded theory around the development of competitive manufacturing capabilities in high value manufacturing SMEs. Although previous chapters may refer to ‘the dynamics of manufacturing capabilities for competitiveness...’ as the focus of our core research, we make no distinctions between the two titles due to the fact that the respondents and their firms were all classified as ‘manufacturing’ firms and the discussions all commenced from the focus point of manufacturing capabilities. The outcome is geared towards proposing a foundation consisting of the main theoretical output of this thesis made up of a core category which is *Navigating Complexities* as well as other closely related, or tangential categories; intellectual benchmarking, situational knowledge extension and proprietary process and technology development. Worth mentioning also, are sub categories consisting of social and technological complexities, negotiation, mapping and matching complexities, situational learning, pattern recognition, problem solving.

The objective of this chapter is to commence the comparison of the emergent substantive theory with the already existing body of literature. As a post-fieldwork review of literature,

this chapter differs significantly from the initial literature review in Chapter 2 which was carried out at the beginning of this research endeavour. While the discourse concerning the use and timings of literature reviews in GT are heatedly contested amongst global scholars, and not the purpose of our current pursuit, our decision to explore and engage in both reviews is based strictly on the recommendations of the GT originators. Glaser and Strauss (1967), while encouraging researchers to remain theoretically sensitive to their research topics, directed these researchers to only embark on the process of writing literature reviews after completing their analyses. Our understanding therefore, was that remaining theoretically sensitive to our research topic involved understanding the general structure of the manufacturing capability cum competitive capability literature but not allowing it to determine the overall research directions or outcomes of this study. As will be observed later in this chapter, references will be made to various theories within management and social science research towards abiding by the core GT tenets.

The key distinction between the pre and post fieldwork review in our case is that in the case of the pre-fieldwork review, the themes of the preliminary review are set to be general and broad towards providing a more comprehensive awareness of the literature. It is generally expected that this awareness will have guided and guarded this research endeavour as well as that of other researchers against building upon familiar observations. This is emphasized by El Hussein et al (2017) who argue that “emerging GT researchers should acknowledge the importance of some level of literature review to guide scholarly exploration and generation of new knowledge”. The post fieldwork review on the other hand, is driven by the need to situate the emergent research outcome within the body of documented knowledge to ascertain its newness and contribution. It is expected therefore, in the case of this thesis, that the relevance and utility of this grounded theory submission within Operations Management as well as the wider management theories and topics will be established.

The first section of this chapter begins with a recap, in the form of a vignette, which reviews the journey towards the identification and development of the core categories. Some critical decision points will be highlighted which introduce these core categories as the main points of concern for organisations, regarding the development, use and sustenance of competitive capabilities.

Following this, the second section will outline the body of complexity research, seeking to identify and locate navigating complexities within this relevant literature area. Understandably, being one of the most critical elements in the growth of a business as well

as the establishment of its competitiveness, navigating complexities will cover different fields of endeavour.

The third section will compare the navigating complexities process with theories offered within the identified areas of speciality. This section will be presented in two parts with the first part aiming to integrate negotiating complexities within the established theories. In the first instance, the Resource Based View of the firm is highlighted in an attempt to relate the 'bundles' of routines to the competitiveness of the HVM SMEs. As highlighted in Chapter 2, discussions surrounding organisational capabilities are based on strategic initiatives of the firm, with the purpose of creating unique capabilities within the firms. Secondly, the Dynamic Capability theory is also tabled for discussion. As the emerging theory, Navigating Complexities, is seemingly predicated on the organisation seeking to arrive at a named destination, according to their operational plans, a certain level of dynamism is required. This therefore, situates the emergent theory of Navigating Complexities within the Dynamic Capability family.

6.2 Recap: Journey of an HVM entrepreneur

To many, especially those on the outside looking in, it is assumed that the interventions that are developed by innovators as well as new product developers happens in a linear and straightforward way. In reality however, these processes which are complex, highly dynamic and unpredictable often drag on for extended periods of time. This is especially challenging due to the unpredictability of business and operational environments, which are often subject to the 'trends-driven' individual whims of potential and actual consumers as well as government (regulatory and policy) changes.

Take for example, the types of narratives that confronted the researcher during the data collection phases of the research. The different scenarios can best be imagined thus: consider what might happen after a few years of active research when a Bioengineering Post Doctorate researcher, who we shall call Dr A, discovers a viable value proposition in his just concluded research findings. He has achieved these initial successes through the combination of advanced technologies and processes following which his research has birthed strong outputs in the form of proprietary technology – and yes, it has been assessed by IP auditors within his university research group and has been found to be patentable. This is a unique platform which has the potentials to meet the challenges of a well-known,

well researched but complicated medical condition. He therefore wants to commercialise the idea by turning it into a new medical technology product. He realises however, that the platform is not complete and he would need some further building blocks of 'something' to 'productize' and commercialise the idea.

During his planning and ideation stages, he speaks to a few trusted colleagues about the technical complexities (regulations, multi-technology platforms and knowledge, systems integration) encountered during the research; he speaks to family and friends about the social fit, needs and feedback of potential users; as well as business advisers about the issues concerning financing, marketing and strategic considerations, following which he documents the highlights of their conversations and maps out all the likely scenarios for progressing his idea towards commercialisation. His conclusion is that he needs adequate resources to progress his ideas which includes finance, staff, collaborative and multidisciplinary partners, office/lab space, accounting, legal and business support, intellectual property advice and most of all, medical and healthcare partnerships. We shall focus some of these at a later stage.

He decides to commence the process of developing and taking his product to market. Having gained advanced levels of technical knowledge and expertise due to his numerous years of immersive experience in his field of research, he remembers that results from previous phases in his studies flagged off another researcher (who we shall call Dr B) in a different department and field, fluid dynamics, who has developed a compatible process which can fast-track the development of his medical device towards 'productizing' and commercialising it. He reaches out to Dr B to discuss collaboration and partnership opportunities. Initially, Dr B is sceptical, but decides to give the discussions a chance. They meet and over a few months, engage in discussions covering the complexities of their individual research activities, how resources such as IP, finances and responsibilities will be shared in potential partnerships and other general discussions concerning the future operational aspects of the business. Eventually, after finding some common ground, they negotiate a partnership, navigate the intricacies leading up to this union and become co-founders of a start-up focused on medtech innovation, development and commercialisation

To develop their minimum viable product (MVP)¹⁷ it is important that they source for adequate monies to finance their R&D activities. Sourcing for adequate monies involves

¹⁷ Minimum Viable Product (MVP) is a product with enough features to attract early-adopter customers and validate a product idea early in the product development cycle. The MVP can help product teams receive user feedback as quickly as possible to iterate and improve the product.

keeping a pulse on grant providers, angel and equity investors, business loans and so on. These R&D activities include renting adequately equipped office or bench space in a laboratory to commence and complete their initial basic R&D activities, engage in new product development processes, locate and engage other necessary and compatible technologies for the product as well as develop and engage in some other senior professional relationships (especially with those in the medical field – due to the fact that their product will be classified a medical device with very specialist requirements revolving around its development. In addition, it should be noted that the company owners will need these relationships as they are not medical professionals themselves). Due to the fact that the start-up founders eventual goal is to commercialise this medical product, they have to ensure from the onset, that they observe the strict regulatory requirements, which will guide the product development from the start and continue to fine tune the product to meet the regulatory as well as patients' requirements. This in itself presents challenges wherein certain levels of complexities arise.

Finally, fast forward to a few years of active problem solving through networking, collaborative R&D activities, new product development, financing and re-financing options, science/technology solution assessments – all of which have been achieved through continuous negotiations and navigation, the product has been tested, certified and cleared for use by the medical products council. The researchers now have to decide on who will manufacture the product, how they will be transported and stored, who will retail them and how they will be sold. Once again, certain conditions and regulations have to be observed for all these stages, from manufacturing to transportation to storage. They will once again engage in the necessary pre-negotiation planning, manufacturing and quality standards, preferred materials (plastics or new materials) and manufacturing time frames. Regarding the finances, the innovators will need to determine their upper and lower acceptable profit margins, and thereby negotiate on an agreed payment plan with the manufacturers. To be thorough, the innovators may put themselves in the shoes of the contract manufacturers to determine counter strategies for their own arguments. This is one of the methods to 'becoming a complete negotiator' according to Gates (2006) who suggests that creativity, as a negotiator, involves by understanding the other party and putting yourself in the other person's shoes through thorough research and preparation. Finally, the process advances through to the offer and counter offer, where the contract manufacturer lays his cards on

Available at: <https://www.productplan.com/glossary/minimum-viable-product/> [Accessed 14th August 2019]

the table for consideration. This process continues until an agreement is reached or the negotiations are abandoned. If abandoned, this negotiation will have to commence with a different contract manufacturer.

Regarding the later stages of commercialisation and scale up, further challenges once again, await the innovators and their companies. Bauman (1989) for example, (cited in Law and Mol.), argues that the process of scaling up poses certain complexities. Said he;

“Large scale technologies usually grow out of laboratory experiments, but the process of translation is tricky because laboratory experiments are simplifactory devices: they seek to tame the many erratically changing variables that exist in the wild world, keeping some stable and simply excluding others from the argument”

Different processes involving navigation, decision making, negotiations and problem solving continues into the logistics, warehousing, distribution and retailing stages where the product is now ready to be distributed, sold used and discarded, when necessary. As expected, further complexities will be experienced, navigated through and overcome as these activities will also impact on the success of the product in the marketplace.

These seemingly commonplace situations can erroneously be thought of as simple negotiations and business agreements which occur sequentially and involve a few parties namely the innovative product owners, the potential contract manufacturers, retailers, research collaborators, the regulatory bodies investors, grant funders and the medical personnel. The issues covered in these negotiations include the determination of the cost price, sales price, manufacturing quantities, product name, colour, size, collaboration agreements, technology and systems integration issues, regulatory requirements and so on. While it is expected that one of the keys to success is to develop adequate plans and pre-negotiation arguments while developing strategies for making and responding to offers, it must be emphasized that some of these negotiations are continuous and occur simultaneously and over a period of days, weeks or even months. There is a need therefore to either develop and/or observe certain advanced negotiation capabilities

In practice however, it is not this simple as anyone who has been remotely involved with product development or any closely related activities knows all too well that things tend to be a lot more complicated. Take for instance, what happens before the product has been

'cleared' for manufacture. Both internal and external conditions have to be made right before embarking on this NPD journey. Internally, the right resources, levels of financing and market structures have to be taken into consideration – trends affecting product choices and success, regulatory requirements highlighting the products safety for use, material types, strategic partnerships, R&D validation activities and so on. All these have to be negotiated and a settlement arrived at, before the other stages of the manufacturing process happens.

One critical stage, especially during scale up that all respondents considered a boom or bust situation was the stage where they had to considering potential manufacturers because for many, the possibilities of setting up their own production plants to manufacture their own products was a possibility. This in itself presents different levels of negotiated choices to be made. If owning a production plant is not viable in the short term due to its financial implications, it is possible that the researcher may be considering not just one contract manufacturer but multiple contract manufacturers as a way of comparing offers. At the same time, the contract manufacturers may be considering other jobs, which if selected will reduce their capacity to accept the researchers job. Secondly, owing to the fact that this is a new medical product, the researcher may be constrained by regulations concerning where and how the product is manufactured, as well as what quality standards it must adhere to. This regulatory 'hurdle' will therefore limit the pool from which contract manufacturers can be chosen. Thirdly, the new product will have to pass regulatory standards, even before its manufacture. This 'simple' product development, production and commercialisation of an innovative idea is actually a multi-stakeholder, multi-issue negotiation involving stakeholders, deadlines and linkages among sets of negotiations.

Such were the narratives and examples that were discussed all through the data collection and analyses stages which demonstrated the layers as well as levels of increasing complexities that organisations experienced during their daily operations.

6.3 Complexity: Introduction and Definitions

Whether we chose to acknowledge the facts or not, complexities are an everyday occurrence in both our public and private lives, whether we are at work or at play. Very recent works across intellectual disciplines in the social sciences, technology, healthcare and medicine, the arts and political sciences have been a revolt against simplification of

life's issues, due to arguments emphasizing the complexities inherent in world affairs (Law and Mol, 2002). Their argument emphasizes that the complexity of the world should not be tamed too much, especially to the point where efforts to simplify issues become an impediment to understanding. In similar fashion, Montuori (2003; citing Morin, 1977 - 2001) argues, "a thought that privileges simplicity and reduction and is predicated on the elimination of complexity is not suitable for addressing many complex phenomena because at the heart of their complexity lies precisely the irreducibility of that complexity". Morin's argument however was not against simplification towards understanding, but against simplifying to the extent that decontextualization and disjunctive ways of thinking are imposed on complexities for the purpose of gaining an understanding. Once again, Montuori (2003) arguing Morin's point, states that Morin "proposes the need for a thinking that recognizes both part and whole, contextualizes, and connects..."

Similarly, scholars across multiple disciplines have highlighted the importance of understanding and clearly identifying complexities, often concluding that competence in this capability can make a huge difference between an organisation's success and its failure. Take for example, Funke (2010) whose research explores the emergence of complex problem solving (CPS) states, "complex cognition deals with all mental processes that are used by an individual for deriving new information out of given information, with the intent to make new decisions, solve problems, and plan actions".

It is therefore pertinent to consider for a moment, following which it is discussed, what the definitions of 'complexities' are, for the benefit of management researchers, business practitioners, and to the extent to which they wish to engage, policy makers.

To commence this process, the etymological roots of the word complexity were identified, which eventually lead us to its modern-day definition. It was decided that embarking on this activity was crucial due to the perceived uncertainties surrounding its definition. References to the subjectivity surrounding its definition coupled with the fact that scholars such as Pigagaite et al. (2013) had identified at least "31 definitions of complexity", due to the lack of a more appropriate expression describing the interrelated features which affect a project's life cycle (Botchkarev and Finnigan, 2015) prompted the exercise. Derived from 14th century Latin words *complectere*, meaning embrace, encircle, comprise, and *complexus*, meaning plaited, woven together, it was further adopted from the mid-17th century modern French word, *complexe*. Similarly, Perona and Miragliotta (2003) provide their etymological findings in which they argue that 'complicated' and 'complex' both come from Latin words where the first one originally means 'of things knotted, entwined with each other, while the second one

means 'of things which interact among each other'. Complexity therefore arises from the intricate intertwining of components in a system and between that system and its environment. According to Etymology (2005), the meaning, "involved, intricate, complicated, not easily analysed" was first recorded in 1715.

Modern day definitions, such as those from the Merriam-Webster (2019) dictionary define complexity as "a whole made up of complicated or interrelated parts", where complicated is broken down to mean "consisting of parts intricately combined" and/or "difficult to analyse, understand or explain". The Cambridge Dictionary (2015) also defines complexity and complexities as "the state of having many parts and being difficult to understand or find an answer to" and "the features of something that make it difficult to understand or find an answer to". The Business Dictionary (2019) on the other hand, provides a three-pronged definition, two of which are relevant to this research endeavour. Firstly, they look at complexities from the organizational context and define it as a condition of having many diverse and autonomous but interrelated and interdependent components or parts that are joined in some form through dense interconnections. In this case of the organisation, complexity is therefore associated with interrelationships between individuals, the effect of these on the organization as well as the organizations interrelationships with its external environment. Secondly, and looking at it from the physical point of view, complexities is defined as the "extent to which spontaneous-order (self-organization) arises in a system (when certain critical requirements are met) and allows the system to make a transition from one state to a very different state".

Following a brief analysis of these definitions, to set the pace for the preceding activities and analyses, consistent with the above definitions is the fact that:

- (1) complexity can be broken down into smaller 'parts' that can function independently of the whole but do not in certain cases, thereby giving meaning, and adding tangible value, to that whole – sometimes to the extent that the value of the whole is greater than the sum of the parts. This can be imagined when considering the complexities involved in the development and operational workings of an information system, made up of many parts. Backlund (2002) exemplifies this by highlighting a simple information system as composed of computers, information handling tools, and people where information is created, received, analysed, following which decisions and perceptions are made. Each computer, each handling tool and each person can be separated and made to function independently of the other items and engage in

data analysis and decision making. Pooling all these together however creates a more powerful system/server and processing unit.

- (2) The parts are joined in some form through interconnections. These interconnections will of course, introduce the 'domino-effect' concept into complexity, where a force introduced to one element affects all other elements, resulting in either positive or negative effects or outcomes. According to Mitleton-Kelly and Land (2004) the greater the interdependence between these systems, the wider the ripples of perturbation or disturbance of a move by any one entity on all other related entities. In such situations, Brewer (1973) has argued that complexities increase as a model's elements become increasingly interconnected. Suffice to say that complex systems or complexities can be susceptible to sensitivities, fragility and some levels of imbalance.

- (3) Complexity presents certain difficulties to the cognitive abilities of those that seek to understand its characteristics via the assessment and definition of its values. Various scholars therefore admit that complexities often times defy understanding. Simon (1962) for example argues that worldly systems that are classified as complex may to a considerable extent escape our observations and understanding. He concludes that trying to analyse their behaviour would involve a detailed knowledge and calculation of their elementary parts that it would be beyond our capacities of memory or computation. It should be noted however that while complexity is an inherent feature of systems, a system may be complex for one observer while not for another. This is not due to subjective observation, but due to the observers' scales of observation (Courtney, 2008)

- (4) There are possibilities for a change of state, or unwanted transition, from one level to a different one due to the 'random' combination of variables. This assigns the nature of unpredictability to complex systems. Indeed, Anderson (1999) has argued that the behaviour of complex systems is surprising and hard to predict due to its nonlinear nature. Anderson (1999) further describes nonlinear systems by explaining that interventions which change one or two parameters by a little amount can drastically change the behaviour of the whole system in ways not capable of being foretold.

Following these lay definitions of complexities that have been corroborated with some findings from a few academic scholars, the following paragraphs will explore and reference

the full suite of academic scholarship to provide empirical evidence to the discussions surrounding complexities and their derivatives from the point of this research.

Progress to this topic is made with Jensen and Aven (2018) for example, who define complexity as an acknowledgement of limitations in the understanding of the sociotechnical system in all its operational contexts as well as how risks can be assessed based on the available knowledge and assumptions about the system elements. Serrat (2017) on their part define a complex system as one in which at least two parts, which are interconnected where each is composed of a sub system nested within the larger one, interact dynamically to function as a whole. Edmonds (1996) on the other had proposed a definition thus, “that property of a language expression which makes it difficult to formulate its overall behaviour, even when given almost complete information about its atomic components and their inter-relations” (Edmonds, 1996). This definition by Edmonds was proposed as a general definition intended to provide different interpretations for different contexts. Relating their definitions to the earlier lay or dictionary definitions, we identify the major elements being: (i) “...difficult to formulate its overall behaviour”, speaks of the inability to identify or adequately explain the overall behaviour of the system even when, (ii) the complete information about its atomic components and inter-relations have been given. This statement also refers to the fact that any knowledge about the all the subcomponents of the system does not imply a simple cumulative action to understand the whole. The non-linear relationships between components is emphasized such that in trying to explain this to a layman, it may be suggested to him that $1+1$ does not equal 2, in such a situation.

Furthermore, according to literature findings, definitions are sometimes provided according to the contexts for which they are intended. These contexts are the fields of endeavour in which the scholar is domiciled, hence giving providing explanations from their points of view. According to Johnson (2009), understanding complexity is a challenge faced among scientists as it not easy to define and it can mean different things to different people. The meaning of complexity therefore has a subjective connotation and interpretation which is in the eyes of the observer (Baccarini, 1996). The consensus however is that although these definitions have been proposed for different purposes, a similarity in meanings, especially regarding similar characteristics such as uncertainty as well as complexity being the sum of many interrelated parts, is ever present to the discerning mind.

Vidal and Marle (2008) for example, propose a new definition of complexity from a project management view as, “...the property of a project which makes it difficult to understand, foresee and keep under control in its overall behaviour, even when given reasonably

complete information about the project system. Its drivers are factors related to project size, project variety, project interdependence and project context.” Similarly, Bakhshi et al (2016) define complexity as an intricate arrangement of the varied interrelated parts in which the elements can change and evolve constantly with an effect on the project objectives. They go on to state that complicated projects contain subsets of simple projects but are not reducible to them. Other definitions of complexity relating to project management have also been proposed from the organisational perspective. Baccarini (1996) also, offer their own definition of complexity within the project management context, as consisting of many varied interrelated parts and can be operationalised in terms of organisational differentiation¹⁸ and organisational interdependency¹⁹. This definition is akin to that of Tatikonda and Rosenthal (2000) whose definition states, “the nature, quantity and magnitude of organizational subtasks and subtask interactions posed by the project”

Likewise, Backlund (2002) provides a narrative which typifies complexity within the context of information systems. He uses the incomplex analogy of an information system within an organisation (consisting of computers, information handling tools and people) highlighting the difficulties of analysing relations between the information created or received at a certain point of time as well as the decisions and perceptions based on it. He argues that at every instance at which information is received, alterations occur causing some information to disappear as well as take on new forms thereby changing the ways in which the messages may be interpreted. With all these contributing to the understanding of complexities, Backlund (2002) therefore defines the complexity of something as, “a measure of the perceived effort required to understand and cope with a system”.

Further afield and within the domain of management and business studies, complexities within operations management, specifically in supply chains have been studied extensively. Bode and Wagner (2015) argue that complexity is an important theme in supply chain literature and conclude that supply chains have become increasingly complex over the last decade. This increasing complexity is accelerated with trends such as globalization, customization, outsourcing and flexibility (Serdarasan, 2013; Juttner et al, 2003; Perona and Miragliotta, 2004). It is argued however that this complexity is not a desirable feature

¹⁸ Baccarini.1996. Organisational complexity by differentiation posits that due to the fact that a complex organisational structure is one with differentiated parts, the greater the differentiation, the more complex the organisation. They explain further stating that the differentiation is two dimensional; Vertical, referring to the organisations hierarchical structure and Horizontal, organisational units and task structure.

¹⁹ Ibid. Organisational complexity by interdependency on the other hand, is the degree of operational interdependencies and interaction between the project organisational elements.

and should be viewed as a threat that either needs to be reduced or avoided (Wilding, 1998; Bode and Wagner, 2015). By way of definition however, supply chain complexity is defined as the level of detail, and dynamic complexities exhibited by the products, processes and relationships that make up a supply chain (Bozarth et al., 2008). They take a step further to define detail complexity as the distinct number of component or parts that make up a system, while dynamic complexity is “the unpredictability of a systems response to a given set of inputs, driven in part by the interconnectedness of the many parts that make up the system”. A similar definition has been proposed by Forrester (1961), cited in Perona and Miragliotta (2003) as a system made up by single elements which have intimate connections, counterintuitive and non-linear links which as a consequence present self-emerging, often chaotic behaviours.

As such, the definitions and relationships between complexities and other business and management disciplines are plentiful. For example, knowledge management (McElroy, 2000; Beesley, 2004; Cilliers, 2000), HR and Organisations (Conway and Monks, 2009; Lissack, 1999; Anderson, 1999) and Innovation (Damanpour, 1996; Hobday, 1998). Of course, some of these relationships and research submissions overlap, such as Damanpour (1996) whose research explores organizational complexity and innovation.

Having therefore sought to define the term, the following sections begin to look at ways these complexities can be approached and understood through some of their theories.

6.4 Understanding Complexity: Theories and Frameworks

In a paper on complexity theories, Manson (2001) argues that because a number of theories concerned with complexities gather under the general banner of complexity research, the exact nature of complexity research is hard to unravel due to the large degree to which complexity ideas are traded across disciplinary boundaries. While this has been argued in an earlier section, where reference was made to the definitions of complexity based on a discipline-by discipline basis, scholars have made several attempts to unravel the mysteries behind complexity, even though from individual specialist disciplines.

Manson (2001) argues further that while it is possible to examine complexity on a discipline by discipline basis, their breakdown of the concept into three major divisions offers a more coherent understanding of complexity theory. These divisions include:

- 1) Algorithmic complexity; this takes the form of mathematical complexity theory and information theory. This contends that the complexity of a system lies in the difficulty faced in describing system characteristics
- 2) Deterministic complexities deal with chaos theory and catastrophe theory. This posit that interaction of two or three key variables can create largely stable systems prone to sudden discontinuities
- 3) Aggregate complexity concerns how individual elements work in concert to create systems with complex behaviour.

Mitleton-Kelly and Land (2004) on the other hand suggest that there is no single unified theory of complexity, but several theories arising from various natural sciences which study complex systems such as biology, chemistry, evolution, economics and the social sciences (See Mazzocchi, 2008; Van Regenmortel, 2004; Rheinberger, 1997). Serrat (2009) on the other hand argues that over the course of the 20th century, rapid advances in fields such as physics and biology that highlight holism, uncertainties and nonlinearity (while de-emphasizing reductionism, predictability and linearity) have forged related, interdisciplinary intuitions and concepts that attempt to explain complex phenomena such as coevolution, chaos theory and systems thinking. These have formed the basis of complexity theory which according to other scholars, 'explains any kind of complex system – multinational corporations, or mass extinctions, or ecosystems such as rainforests, or human consciousness (Manson, 2001) and/or, is a theory of change, evolution, adaptation and development for survival (Morrison, 2008). A more encompassing definition is provided by Goldreich (undated):

“Complexity Theory is concerned with the study of the intrinsic complexity of computational tasks. Its “final” goals include the determination of the complexity of any well-defined task. Additional “final” goals include obtaining an understanding of the relations between various computational phenomena (e.g., relating one fact regarding computational complexity to another). Indeed, we may say that the former type of goals is concerned with absolute answers regarding specific computational phenomena, whereas the latter type is concerned with questions regarding the relation between computational phenomena.”

Mason (2008) declares further that complexity theory’s notion of emergence implies that given a significant degree of complexity in a particular environment, new properties and behaviours emerge that are not contained in the essence of the constituent elements.

Regarding theories and frameworks, some scholars have developed other sector specific frameworks. While admitting that coping with complexity still remains a challenge, Lessard et al. (2014) for example argue that recent work in the area of complexity theory in relation to large engineering projects has made advances by breaking down the concept of complexity into more specific concepts. Their findings, part of which includes the proposed House of Project Complexity (See Figure 6.1), present a conceptual framework for understanding and interpreting the core concepts of complexity in large infrastructure projects.

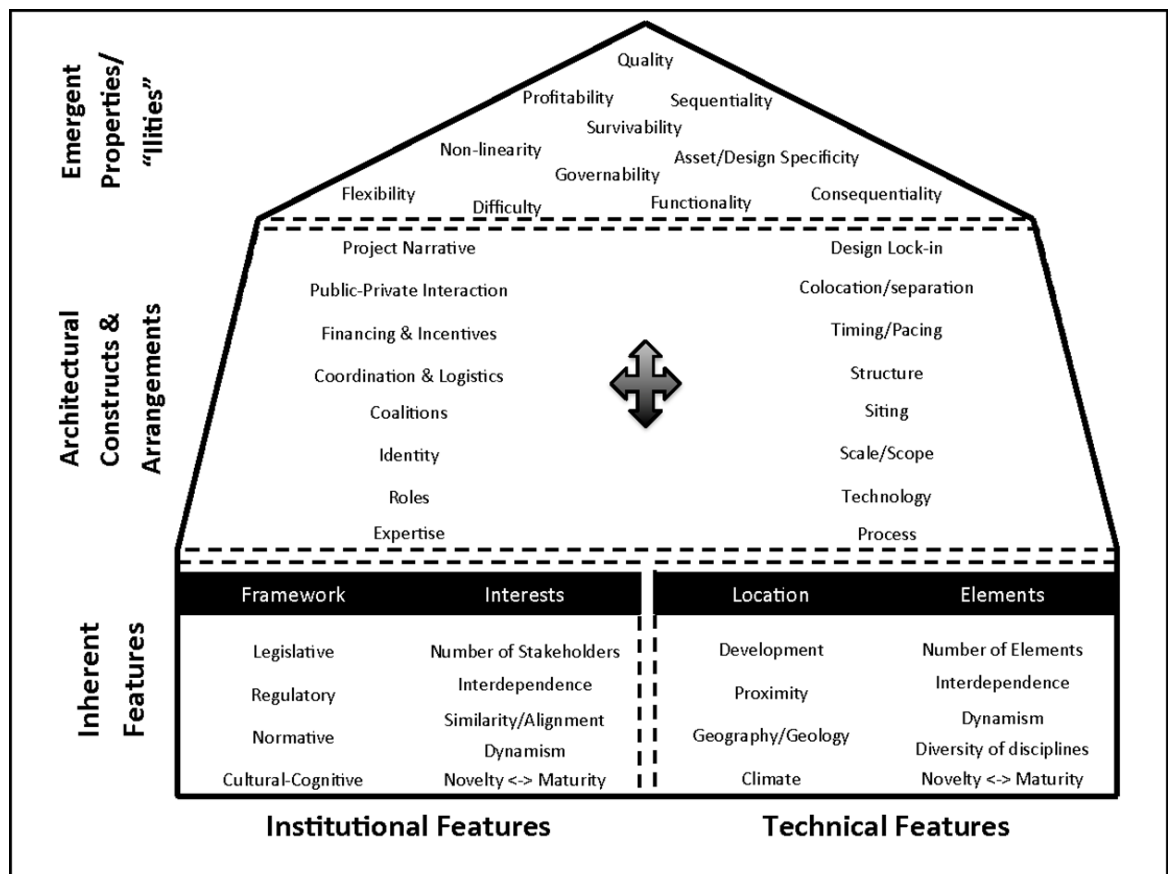


Figure 6.1: The Full House of Project Complexity

Another example shows Mahmood et al. (2015) who develop a conceptual framework which uncovers manufacturing complexity, having divided manufacturing complexity into five main components namely product behaviour, infrastructure capability, production planning, information management and personnel perception. Following a further division into twelve sub components, a final classification into two categories is carried out; internal complexity and external complexity (See Figure 6.2)

From these examples, the basic premise indicates a hidden order to the behaviour and evolution of complex systems. We get the sense that complexity and its related theories concern themselves with situations, such as environments, that are convoluted and difficult to understand, where very large numbers of constituent elements are loosely connected but interact in many different ways. These systems may be representative of organisations, a production line in a factory, the economy of a nation, the end to end processes of new product development – from ideation stage to product launch and even the interaction of different capabilities within an organisation to foster the development of sustainable competitive advantage. This provides a little insight into this PhD study where it may be possible to identify similar narratives which provide a little more insight into the challenges faced by the respondent entrepreneurs. If for example we take an entrepreneur whose situation is akin to the narrative of the first vignette (see Section 6.2), it is understood that to produce a new product, the entrepreneur must engage with multiple ‘systems’ and ‘environments’, each with its independent and unique behaviour. Take for example, the entrepreneur’s interaction with multiple environments namely, regulatory, technology, society, other organisations (which include the collaborative partners, contract manufacturers, distributors, retailers and so on). This is the point of departure for the identified core category which is Navigating Complexities. How does the HVM or entrepreneur deal with these situations? This is what the thesis seeks to answer

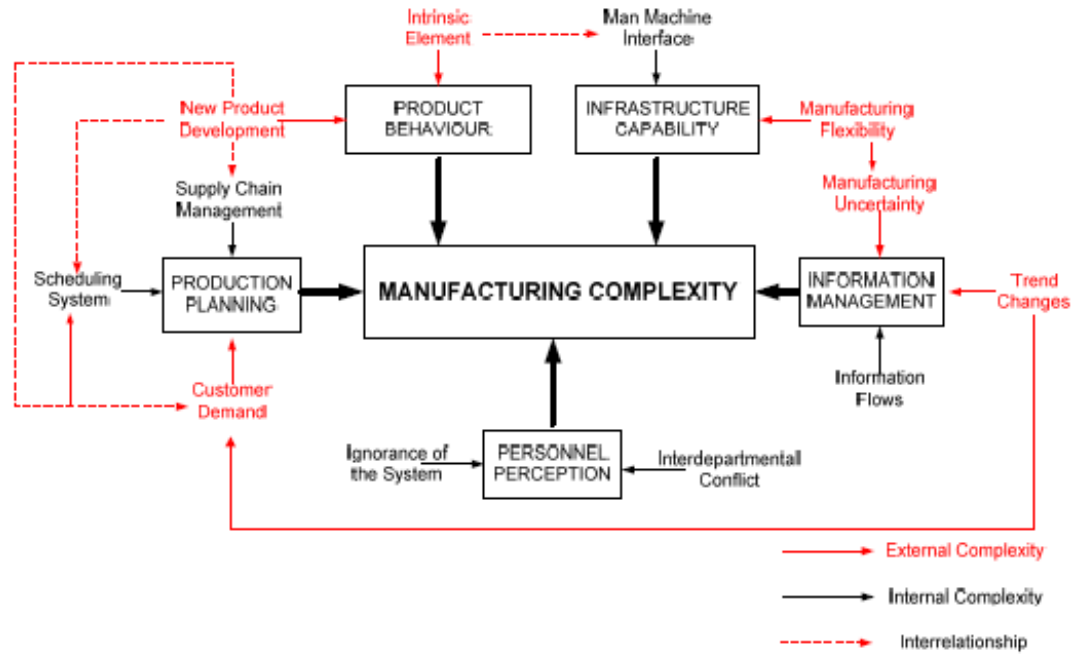


Figure 6.2: Conceptual Framework for Manufacturing Complexity

6.4.1 Social Complexity

Another theory which is closely related to our research endeavour, found within the social and economic contexts', can be identified as social complexity. This 'social complexity' was arrived at following the densified findings from the researchers earlier research which had major elements consisting basically of human beings located across various social and organisational entities, occupying various hierarchical levels in for profit and non-profit organisations such as government and policy, education and academia, commercial, healthcare and religious organisations. In addition to this, the challenges involved, especially considering the amount of data and information passing through these different organisations simultaneously, pointed to the complexities involved in the management of information.

The origins of social complexity and urbanism are of profound interest for social scientists. Being one of the core missions of anthropology, the investigation of social evolution is an important aspect of elucidating culture change and human organizational behaviour (Kim and Kusimba, 2008). Drennan and Peterson (2008) for example, chart a brief path from the early days of sedentary agricultural village life to advanced complex societies. According to them, complex social organisation sprang naturally from early sedentary agricultural village

life following which a close association with others, due to the elimination of mobility from daily living patterns, called for the development of new means of conflict resolution: agricultural surpluses promoted population growth and an abundance of close neighbours encouraged economic specialization and interdependence. These processes stimulated the spiralling development of complex societies, which soon expanded to encompass more than just single villages and homogeneous cultures, leading eventually, to centralized supra-local²⁰ communities. Similarly, Hayden's (2014) argument states that increasing levels of cultural complexity among complex hunter-gatherers is related to the ability to produce food surpluses and use them in a variety of ways to enhance individual abilities such as the production and gifting of prestige items, marriage payments and investments for family comforts. He argues further that this use of surplus economic resources led to the emergence of cultural and socio-political complexity.

While modern entrepreneurs and innovators in organisations hardly need the historical knowledge of social evolution and its related complexities to facilitate the development of their proposed value laden products and services, a well above average - if not advanced - understanding of the factors that drive and sustain their societies is necessary to remain competitive. In other words, entrepreneurs and innovators are driven to develop solutions based on the societal trends of the moment. Indeed, while this 'trends of the moment' captures another category within the findings of this research (situational knowledge stretching) it also forms the basis of Open Innovation which according to Chesbrough et al. (2006) is defined as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and to expand the markets for external use of innovation respectively". Chesbrough (2003) explicates further by arguing that "open innovation is a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as firms look to advance their technology".

In addition to these references to open innovation, scholarly references also indicate that general trends analyses should be the foundational background to developing relevant products and services. Dearing (2000) states that leaderships task is to harness economic and social trends as well as capture the tremendous amount of knowledge and experience that exists in networks worldwide and combine these in ways that generate enterprise and create value. Chen and Kuo (2017) also give reference to the importance of trends analyses. They propose that social media constitutes a great source for big data which can meet every information demand of enterprises. This big data can be analysed to understand

consumer behaviours, buying tendencies and social trends which will help the organisation provide value to its clients.

By means of definition however in the context of our study, one of the most robust definitions of social complexity has been provided by The Centre for Social Complexity at the George Mason University in the United States. According to them:

“Social complexity is the study of the phenomena of human existence – emigration patterns, armed conflicts, political movements, marriage practices, natural disasters... – and the many possible arrangements of relationships between those discrete phenomena. Social complexity reflects human behaviour as it is exercised in ongoing and increasingly broader and more complicated circumstances of individual and group existence. Social complexity has emerged as the conceptual and practical framework wherein these phenomena and their relationships can be studied”

Complex social systems are those in which the frequency of interaction between individuals takes place in many different contexts, with many different individuals and often repeatedly interact with many of the same individuals over time (Freeberg et al. 2012). In other words, social complexity relates to the number of interacting individuals, their different social roles, levels and/or positions in the society and the type and variety of interactions among these individuals.

As a means therefore, to understand complex situations, social complexity theory has been used to decipher some challenges within certain sectors. Tainter (2006) for example, shine a light on the sustainability challenges using the social complexity theory. Similarly, Antonacopoulou and Chiva (2007) after examining the social complexity of Organisational Learning, introduce two sets of principles of complexity that provide further richness to their understanding of OL as a social complex process. Eakman (2007) on the other hand, proposed that the study of occupation be informed by adopting a social complexity perspective emphasizing that the shift in analytic levels situates the study of occupation at the nexus of human-to-human interaction

6.4.2 Technological Complexity

A core part of our findings involved a major aspect wherein technology, especially in the multidisciplinary sense, played an important part in defining the dynamics involved in the

manufacturing and competitive capabilities of the organisation. Within these areas where the focus on technology was apparent, the ability to consider and synthesize different technologies, the ability to integrate these technologies, through systems integration, and the abilities to 'extend' these technologies beyond the use for which they were originally developed played a part in their complexities.

Regarding definitions however, technological complex projects have been defined as those that involve emerging or new technologies and for which the understanding of the technologies involved is low (Carbonell and Rodriguez, 2006). This of course, presents challenges to the organisations seeking to utilize these technologies for manufacturing and competitive purposes. Where the understanding of the technologies needed is low, technologically complex projects are prone to challenges such as delays and difficulties in production, which affect the organisations ability to deliver value to clients. Singh (1997) in previous research recognized this and stated that businesses developing products of high technological complexity face the risk of failure and in extreme circumstances, ceasing operations and exiting their industry.

A more detailed definition is however provided by Tani and Cimatti (2008). According to them, technological complexity is a wide term that includes different levels and approaches such as product complexity, process complexity and manufacturing system complexity. Their definition arises from the connection of all three terms; technological complexity indicates the needed technological level for the design and manufacture of an industrial product, considering its characteristics and performances.

6.5 Resource Based View of Firms

Among some of the foundational building blocks for capabilities research in the area of firm competitiveness as covered by management research, is said to be the theories which build on the resource-based view of the firm (RBV). The RBV is an important theoretical framework which identifies a firms resources as the drivers of sustainable competitive advantage and superior firm performance (Barney, 1991; Prahalad and Hamel, 1990; Teece et al., 1997). More precisely, the RBV assumes that firms can be conceptualised as bundles of resources (Amit and Schoemaker, 1993; Wernerfelt, 1984), suggesting that organisations take stock of their internal resources to find and/or develop the sources of competitive advantage rather than look at the competitive environment for them. Having identified

resources as the central theme of the RBV, management literature also suggests that resources are at the heart of every organisations operational competence and capability due to the fact that they are made up of specific physical, human and organisational assets that are used to implement value creating strategies, as well as exploit market opportunities which can create advantages for the firm (Barney, 1986). Regarding its definitions, Wernerfelt (1984) suggests that resources are anything that can be thought of as a strength or weakness of a given firm and at any given time, can be defined as those tangible and intangible assets which are tied to the firm. Helfat et al. (2007) define them as “something that the organisation can draw upon to accomplish its aims”, while Amit and Schoemaker (1993) define resources as “stocks of available factors that are owned or controlled by the firm”. These resources include local abilities or competencies that are fundamental to the competitive advantage of a firm (Eisenhardt and Martin, 2000) such as advanced forecasting and data mining skills for firms that develop supply chain and inventory management solutions or advanced skills and qualifications in biological and medical sciences for biotechnology firms. This implies therefore, a direct link between an organisations resources and its ability to develop and create products. Indeed, Wernerfelt (1984) suggests that “resources and products are two sides of the same coin” leading to their proposition that specifying the size of a firms activity in different product markets makes it possible to infer the minimum resource commitments, and vice versa.

Despite these diverse definitions from different scholars, assumptions common to all include the emphasis on the ownership of these resources by the firms and/or their ability to control them. Helfat et al. (2007) for example emphasize the fact that organisations can ‘draw upon’ these resources to accomplish its aims while Amit and Schoemaker (1993) specifically emphasize the ownership and control of these resources. It should however be noted and emphasized that modern day competitive and knowledge-based environments make it almost impossible for firms to acquire and/or retain all the resources needed to establish their presence and/or dominance of particular markets. Organisations therefore resort to participating in interfirm cooperative activities and network alliances, where these alliances are made up of organisational arrangements between two or more enterprises, established in order to improve each other’s competitive position and performance by sharing resources towards the co-development of products, technologies or services (Miles and Snow, 1995; Gulati, 1998). In fast paced and high growth business environments, such as the biosciences, healthcare (this research covers these two sectors) and ICT sectors, partnerships between SMEs and large enterprises have become standard practice. Park et al. (2002) suggest that alliances are a result of a firms adaptive response to rapid and

unpredictable changes in their business environments over time, especially as the decision to engage in these alliances are based on the resource condition of the firm

What is pertinent to observe here is the fact that organisations use their acquisition of resources as weapons or tactics to ward off the advances of competitors while designing strategies to enhance the willingness of customers to purchase the 'value' provided by their products. This is according to Capron and Chatain (2007), who argue that a firm takes actions to upgrade its own stock of resources in order to maximize the value offered by its own resources and in so doing, exerts control over its competitors' resources by reducing the quantity of those resources that are available to its competitors. They emphasize further that competitors whose stock of resources are restricted by this strategic move can no longer serve the same level of demand due to output restriction.

These arguments lead to Wernerfelt's (1984) research in which he provides another argument concerning how resources enable what he calls 'position barriers' in firms. According to him, "a holder of a resource is able to maintain a relative position vis-à-vis other holders and third persons, as long as these act rationally". Simply put, organisations create situations where their resources put them in enviable positions where it becomes difficult for others to catch up. Galbreath and Galvin (2004) suggest that resource position barriers act to protect the erosion of the economic benefits gained from the resources located in the said firm, especially those that offer the highest barriers to duplication. Again, this emphasises the RBV of the firm as a competitive framework as Doh (2005) explains that, "for a firm to be in a position to exploit a valuable and rare resource, it must have a resource position barrier preventing imitation by other firms". Various authors have provided examples of how this 'resource position barriers' have supported the competitiveness of firm operations. Hoffman et al. (2006) for example, suggest that one possible way to create a resource position is through the use of knowledge management towards the establishment of shorter life cycles of innovation within firms. Galbreath and Galvin (2004) on the other hand suggest that intangible assets such as patents and copyrights create barriers to competitive duplication.

These resources on their own however, do not possess sufficient potential to create this competitive advantage for firms as various scholars suggest that only when these resources exhibit valuable, rare, inimitable and nonsubstitutable (i.e. the so called VRIN attributes) characteristics, are they able to endow the firm with the abilities to gain and sustain competitive advantage through the creation and implementation of fresh, value-creating activities that cannot easily be duplicated by competing firms (Eisenhardt and Martin, 2000; Barney, 1991; Wernerfelt, 1984, 1995). Indeed, Teece (2018) emphasizes this by positing

that the concept of VRIN resources have been used to argue that the ownership of strategic resources, and their management thereof, are the key to competitive advantage. Bingham and Eisenhardt (2008) caution however, that VRIN resources *per se* are not the true sources of advantage i.e. the specific characteristics of resources *per se* are neither necessary nor sufficient conditions to establish competitive advantage. They revert to the earlier argument that it is the different types of resources as well as the linkages among them (bundles of routines) that lead to different sources of inimitability, distinct logics and hence competitive advantage. Wang and Ahmed (2009) sound the same warning by stating that VRIN resources do not persist over time in dynamic markets and therefore cannot be a source of competitive advantage. Having provided the arguments, which extol the positive characteristics of the RBV, it is indeed important to mention that it has been criticised for its static nature and its irrelevance in 'real world' dynamic markets as well as the evolution of the firm (Wang and Ahmed, 2007). This criticism however, identifies dynamic capabilities as a theory that builds upon the RBV.

6.6 Dynamic Capabilities

Although the concept of complexities has been examined due to its direct relationship with the core category and theme of the emergent theory, we next take a critical look at the literature towards identifying concepts closely related to the emergent core category of navigating complexities. Being a concept that is related to competitive capabilities that identifies with the process of constant and strategic change, learning, absorbing knowledge, extending it, exploiting opportunities and so on (see low level categories in Chapter 5) dynamic capabilities was identified as a concept closely related to navigating complexities. We therefore examined this concept in the following sections.

In line with this discourse, research has shown that the average period for which firms are able to sustain competitive advantage has decreased over time (Wiggins & Ruefli, 2005). Wang and Ahmed (2007) emphasize that relentless competition drives firms to constantly adapt, renew, re-configure and re-create their resources and capabilities to align with their environments, which often exhibit high levels of competitiveness (see Figure 6.1 for their research model). This dynamic business environments challenged the RBV which was considered to neglect this market dynamism (Priem and Butler, 2001). A concept therefore, which took this dynamism into consideration and termed 'dynamic capabilities' was first introduced in a working paper by Teece et al. (1990) and finally published in Teece et al. (1997). According to them, the development of this framework resulted from the recognition

that strategic theory, while replete with analyses of firm-level strategies for sustaining and safeguarding extant competitive advantage, has performed less well regarding how and why certain firms continue to build competitive advantage in regimes of rapid change. Teece et al. (1997) also argued that their efforts, though rudimentary, sought to identify attributes of firm-specific capabilities as sources of advantage and how combinations of competencies and resources could be developed, deployed and protected in changing environments. In like fashion, Zahra et al. (2006) argue along same lines by emphasizing that because research is yet to provide compelling explanations for the ability of some new and established companies to continuously create, define and exploit entrepreneurial and market opportunities, they propose that one source of these organisations' strengths lies in their ability to develop and apply different dynamic capabilities. They go on to define dynamic capabilities as "the abilities to reconfigure a firm's resources and routines in the manner envisioned and deemed appropriate by its principal decision-maker(s)". The assumptions identified in this definition are dependent upon the decision maker's knowledge, and understanding of the market forces that exert external pressures upon the organisation and their abilities to translate these into actionable recommendations for resource transformation. Other definitions emphasize the influence of the markets on these capabilities include those of Wang and Ahmed (2007) who state that dynamic capabilities are "a firm's behavioural orientation constantly to integrate, reconfigure, renew and recreate its resources and capabilities and, most importantly, upgrade and reconstruct its core capabilities in response to the changing environment to attain and sustain competitive advantage" as well as Eisenhardt and Martin (2000) who define them as "the firms processes that use resources – specifically the processes to integrate, reconfigure, gain and release resources – to match and even create market change. Further definitions, as well as discussions are provided in Zahra et al's (2006) review, model and research agenda for dynamic capabilities, as well as Barreto (2010, see Table 6.1)

Dynamic capabilities thus are the organizational and strategic routines by which firms achieve new resource configurations as markets emerge, collide, split, evolve and die". Dynamic capabilities therefore determine the speed, and degree to which the firms particular resources can be aligned and realigned to match the opportunities presented by business environments at any given point in time (Teece, 2012). These emergent discussions around the dynamism of [organisational] capabilities are in part, aligned to Nelson and Winter's (1982) evolutionary theory of the firm where they argue that the survival of firms are due to their abilities to cope with market uncertainties, using behaviours, skills and capabilities that have been 'routinized' over time. Indeed, this implies that the specificity of routines to particular organisations culminating in particular behaviours is needed to

ensure their abilities to keep up with, and even evolve at a faster rate than the dynamic markets in which they operate.

Study	Definition
Teece & Pisano (1994)	The subset of the competences and capabilities that allow the firm to create new products and processes and respond to changing market circumstances
Teece et al (1997)	The firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments
Eisenhardt & Martini (2000)	The firm's processes that use resources—specifically the processes to integrate, reconfigure, gain, and release resources—to match and even create market change; dynamic capabilities thus are the organizational and strategic routines by which firms achieve new resource configurations as markets emerge, collide, split, evolve, and die
Teece (2000)	The ability to sense and then seize opportunities quickly and proficiently.
Zollo & Winter (2002)	A dynamic capability is a learned and stable pattern of collective activity through which the organization systematically generates and modifies its operating routines in pursuit of improved effectiveness
Winter (2003)	Those (capabilities) that operate to extend, modify, or create ordinary capabilities
Zahra et al. (2006)	The abilities to reconfigure a firm's resources and routines in the manner envisioned and deemed appropriate by its principal decision maker(s)
Helfat et al. (2007)	The capacity of an organization to purposefully create, extend, or modify its resource base
Teece (2007)	Dynamic capabilities can be disaggregated into the capacity (a) to sense and shape opportunities and threats, (b) to seize opportunities, and (c) to maintain competitiveness through enhancing, combining, protecting, and, when necessary, reconfiguring the business enterprise's intangible and tangible assets

Table 6.1: Main definitions of Dynamic Capabilities (Barreto, 2010)

On its own, 'dynamic' implies the capacity to renew competencies towards achieving congruence with the changing business environments, while 'capabilities' "emphasizes the key role of strategic management in appropriately adapting, integrating and reconfiguring internal and external organisational skills, resources, and functional competencies to match the requirements of a changing environment" (Teece et al., 1997). Surely, Zahra et al's (2006) arguments hold in this case when they suggest that managers often hold back from creating 'once-and-for-all' solutions for their operations having recognised the dynamism of their environments. They continually reconfigure or revise the capabilities that have been developed internally to ensure they meet emerging and often unique environmental demands. From these definitions and discussions therefore, dynamic capabilities can be thought to fall into three categories; (1) identification of market opportunities relevant to the organisations mission, (2) assessment and positioning of the resources which may be used

to exploit the opportunity, and (3) the continued assessment of the market, leading to the renewal of the resources through transformational activities (Teece, 2012). In like manner, having drawn on existing empirical findings, Wang and Ahmed (2007) also identify three main component constituents of dynamic capabilities namely adaptive capability, absorptive capability and innovative capability, which all in their own manner explain a firm's mechanisms which link internal firm resources to create advantages in the marketplace.

Adaptive capability is a firm's proficiency at modulating its understanding of market expectations and positioning itself likewise, in order to adequately increase its footprint within that market. This is according to Oktemgil and Greenley (1997) who describe this capability as "a firm's ability to quickly identify and capitalize on emerging market opportunities". This concept has gained some ground in management literature, not only because it is thought to increase as firm boundaries increase (Lockett et al., 2011), necessitating the need for it to be understood especially for organisations that wish to grow, but also because it exerts a strong influence in different relevant areas such as on a firm's entrepreneurial orientation (Eshima and Anderson, 2017), innovation and product development (Akgun et al., 2012) as well as strategic outcomes (Chrysochoidis et al., 2016). As such, research has shown that adaptive firms tend to handle higher levels of environmental complexity (Chakravarthy, 1982) due to their ability to draw upon the richness of their external links through openness and diversity (Neil and Rose, 2007). That said, this concept of adaptive capability or capacity has received attention from various researchers including Staber and Sydow (2002); Randall et al. (2011); Friedman et al. (2016). Where this fits into dynamic capabilities is evident, as without the ability to adapt to new environments, the organisation's evolution will be cut short. It is therefore necessary for all firms, large or small, to develop and continually renew the routines which enhance this capability

Absorptive capability on the other hand was introduced by Cohen and Levinthal (1990) who argued that it is "the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends...". In simpler words, firms with higher absorptive capacity tend to demonstrate stronger abilities to learn from different sources, assimilate information and transform into usable knowledge by the firm. Cohen and Levinthal also argue further that absorptive capabilities mediate speed, frequency and magnitude of innovation in firms (Peeters et al., 2014), thereby contributing to the ability of the firm to generate revenue. This concept has been utilised by researchers in recent years in their analyses of very diverse but significant organisational phenomena. For example, it has been noted across fields such as knowledge management and learning (Escribano et al., 2009; Schmidt, 2010) product development (Stock et al., 2001), Innovation (Fabrizio,

2009; Spithoven et al., 2010) and operations management (Tu et al, 2006; Patel et al, 2012) among other fields. In line with the current discussions, absorptive capabilities have also been identified as being made up of specific routines. Lewin et al. (2011) argued that specific organisational routines that constitute absorptive capacity capabilities remain a black box, hence, their proposal of a routine based model towards operationalising the absorptive capacity construct. They identify these as Internal and external metaroutines necessary for the management of adaptive tension as well as the transfer of knowledge back to the organisation from external sources. The internal metaroutines are:

1. Facilitating variation;
2. Managing internal selection regimes
3. Sharing knowledge and superior practices across the organisation
4. Reflecting, updating and replication, and
5. Managing adaptive tension.

They also identified three external metaroutines:

1. Identifying and recognising the value of externally generated knowledge;
2. Learning from and with partners, suppliers, customers, competitors and consultants, and
3. Transferring knowledge back to the organisation.

Lewin et al. (2011) provided examples of these routines, for example, “brainstorming sessions organized to bring together persons with different technical or market knowledge” represents internal absorptive capacity practiced routines while “networking with outside organisations, universities, and research institutions in particular” are representative of external absorptive capacity practiced routines. While this research area is not as well developed as it should be, owing to its importance, other researchers who have identified with the concept and contributed to this area of proposing routine-based activities for absorptive capacity include, Enkel et al., (2018); Chalmers and Balan-Vnuk (2013)

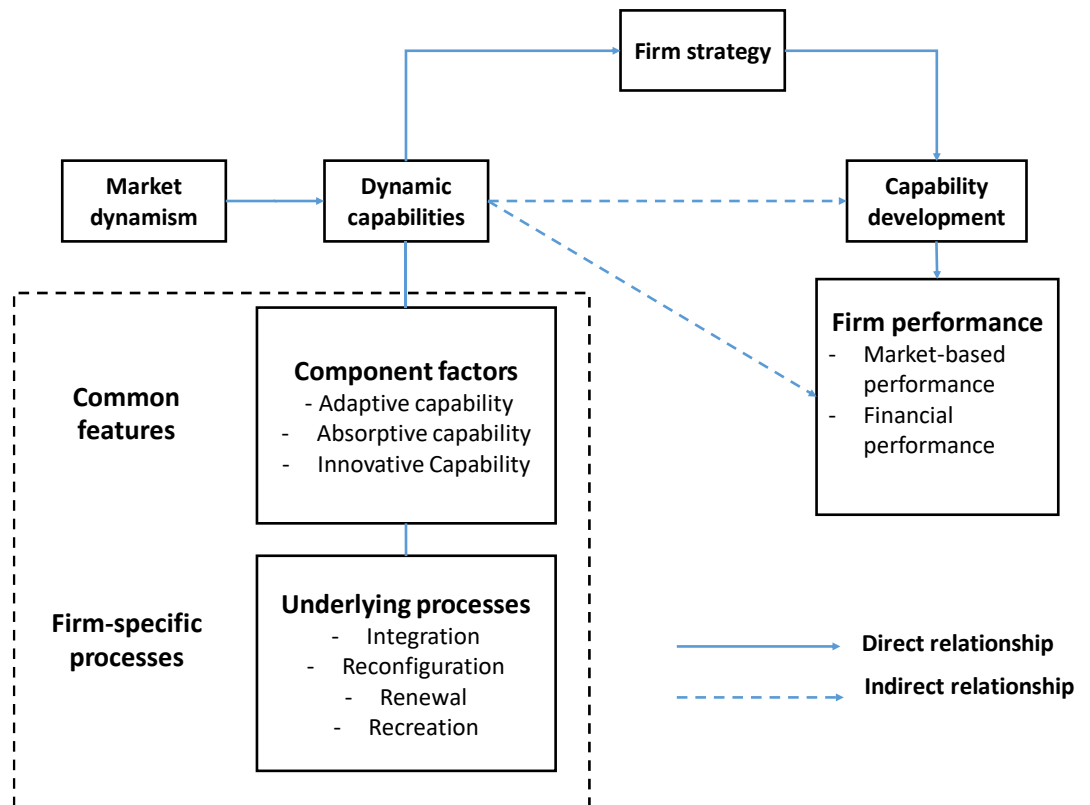


Figure 6.3: Research model of Dynamic Capabilities (Wang and Ahmed, 2007)

The discussions around dynamic capabilities is not without its critiques as many management scholars remain sceptical about the value of the concept (Winter, 2003). Kraatz and Zajac (2001) for example, have argued that, “while the concept of dynamic capabilities is appealing, it is a rather vague and elusive one which has thus far proven largely resistant to observation and measurement”. In addition, Arend and Bromiley (2009) identify four major problems limiting the contribution of dynamic capabilities including an unclear value-added relative to existing concepts, a lack of a coherent theoretical foundation, weak empirical support and unclear practical implications.

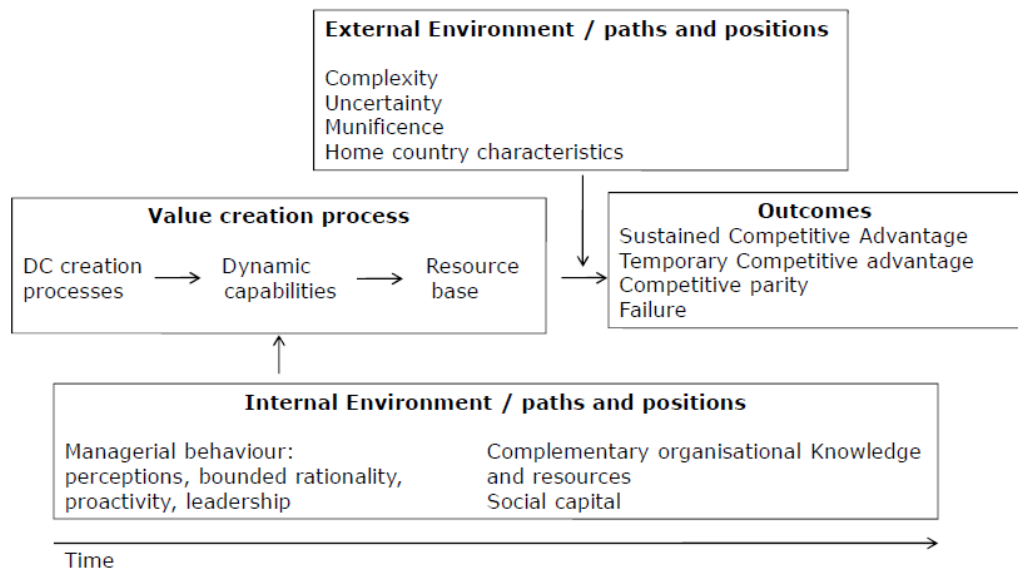


Figure 6.4: Model of Dynamic Capabilities (Ambrosini and Bowman, 2009)

6.6.1 Routines and Capabilities

In order to understand the arguments above a bit more, it may be necessary to backtrack, to take a deeper look into capabilities as well as routines and how these sit within organisations. This is because it has been argued that firms need both ordinary as well as dynamic capabilities to gain competitive advantage (Drnevich and Kriauciunas, 2011; Karna et al., 2016). In fact, Teece (2012) has argued that dynamic capabilities are ‘strategic’ and distinct from ordinary capabilities – firms maintain and extend competitive advantage by layering dynamic capabilities on top of ordinary ones. Ordinary capabilities in this sense, are those that allow firms to “make a living” in the short term (Winter, 2003) or better still, those that “enable a firm to perform an activity on an on-going basis using more or less the same techniques on the same scale to support existing products and services for the same customer population” (Helfat and Winter, 2011). Such capabilities are ordinary in the sense that they maintain things in the same state of affairs leading some scholars to refer to them as zero-level capabilities and operational capabilities. These capabilities are easily imitated by competitors and do not ensure any sustained competitive advantage. These ordinary capabilities, if well honed however, enable the firm to perform efficiently its current activities. However dynamic capabilities, when combined with a good strategy enable the enterprise position itself for making the right products and targeting the right markets to address the consumer’s needs (Teece, 2012). Indeed, the argument for comparing both ordinary

capabilities and dynamic capabilities to order qualifiers and order winners respectively seems in order, as ordinary capabilities and order qualifiers represent the basic processes and activities which ensure a business continues in operation while the dynamic capabilities as order winners ensure the competitiveness of the firm and the continual patronage from customers.

Following the arguments that ordinary capabilities are those that enable firms to perform activities on an on-going basis using similar techniques over and over again (Helfat and Winter, 2011) it is safe to assume, in agreement with Teece (2012), that ordinary capabilities are rooted more firmly in routines than are dynamic capabilities. These routines, according to Nelson and Winter (1982) are “all regular and predictable behavioural patterns of firms”, which play the role that genes play in biological evolutionary theory as well as influence the behaviour of the organisms they inhabit, whether biological or organisational. Likewise, Teece et al. (1997) suggest that these routines are made up of firm specific assets that are assembled into integrated clusters traversing individuals and groups enabling distinct activities to be performed over lengthy periods of time. As highlighted earlier, in the discussion about alliances and collaborative activities, these routines may extend beyond the boundaries of a single firm but still be identified as a core aspect of the particular firms core operations.

Routines, as identified in these arguments, can therefore be said to form the foundation upon which firms’ build their knowledge base. Nelson and Winter (1982) in their arguments around ‘routine as organizational memory’ proposed that the routinization of activities inside organisations constituted the most important form of storage of the organisations operational knowledge. Teece (2012) also suggests that “any routines underlying the enterprise’s dynamic capabilities need to be tied to real-time knowledge creation...”. This is because dynamic capabilities need to be aligned to the needs of the environment, in real time, as these needs change very often, sometimes without noticeable external influences.

6.6.2 Models of Dynamic Capabilities

This section discusses models of dynamic capabilities as developed and presented by scholars who seek to understand the concept. Ambrosini and Bowman (2009) for example, develop their framework (see Figure 6.4) from their review of literature on the dynamic capabilities literature. According to them, the centre of the diagram links the various elements in the value creation process, where the creation process, produces the dynamic capabilities, which in turn alter the resource base leading to the preferred outcomes. The

external environment which constitutes the complexities and uncertainties of the environment act upon the resource base to produce preferred outcomes. Ambrosini and Bowman (2009) acknowledge therefore, that “dynamic capabilities do not appear as a fully formed capability; they are typically the outcome of experience and learning within the organisation”. Similarly, Wang and Ahmed (2007) present their research model which also suggests that dynamic capabilities are influenced by the dynamism of the market as well as internal, firm specific factors underlying processes and component factors. Other frameworks, such as those from Madsen (2010) and Liao et al. (2009) show that a consensus has been reached as to the constituent factors which make up and influence dynamic capabilities.

6.7 Chapter Summary

In conclusion, this chapter provided a vignette which highlights some of the challenges that entrepreneurs face when attempting to develop and launch new products and services into the market. The purpose of this was to provide a holistic view of how the findings from Chapters 4 and 5 could be considered in a real-life situation. Following from the discussions, the chapter also highlighted the issue of complexities and identified some models of the concept to indicate any possible and/or potential relationships with the researchers' emergent theme. Lastly, and as a direct comparison, navigating complexities was found to be closely located within the dynamic capabilities literature due to certain similarities (these are discussed further in Chapter 8, Section 8.3). Having identified this, a brief discussion on dynamic capabilities was provided following which some models were discussed.

Chapter 7: Theoretical Framework: The Grounded Theory of Navigating Complexities

7.1 Introduction

In this chapter we not only present the study's constructed grounded theory of Navigating Complexities, we also offer detailed explanations of the proposed framework by bringing together the outcomes of the data analyses presented in Chapters 4 and 5. Our constructed grounded theory therefore evolves from the accumulative results extracted from our integrative and interrogative research, which lead to the categories discussed in previous chapters, specifically the following; 'Navigating Complexities' (See Section 5.2.1), 'Proprietary Process and Technology Development' (See Section 5.2.2), 'Cross Functional Intellectual Benchmarking' (See Section 5.2.3) and 'Situational Knowledge Stretching' (See Section 5.2.4). These categories are identified in the shaded portion of the complete diagram, as represented in Figures 7.2 and 7.3. These categories and their related codes are understood to be of key importance to High Value Manufacturing start-ups and SMEs concerning the identification and exploration of the dynamics surrounding competitive manufacturing capabilities. In other words, our research, along with the outputs have identified some of the underlying factors and critical processes that lead to improved competitiveness in HVM SMEs.

As indicated during the discussion of the results in Chapters 4 and 5, this study's grounded theory is thought to be the consequence of complex social interactions and multiple layers of compounded processes (See Figure 7.1 for current stage of research project). Included in the constructed theory therefore will be some of their Major and Lower Level Categories (See Section 5.2) which explain the dynamics involved in developing the new competitive capabilities as well as some of the relationships between each of the components. This of course, is a deliberate attempt on our part to demonstrate a high degree of transparency of the research flow during the process of conceptualisation and substantiation. In addition to the aforementioned concepts which have been moulded into the emergent theory, some further fine-tuning was also carried out, especially following the theories and ideas presented in Chapter 6, where we looked at the wider body of knowledge, concerning models and theories which relate to the individual building blocks of our overall substantive grounded theory.

As expected, especially following our literature review in the preceding chapter, literature within the general business and management research domain such as those from dynamic capabilities and knowledge management will be used to support the connections and theoretical interpretations of the findings. Other social science topics and theories, such as economics will also be touched upon.

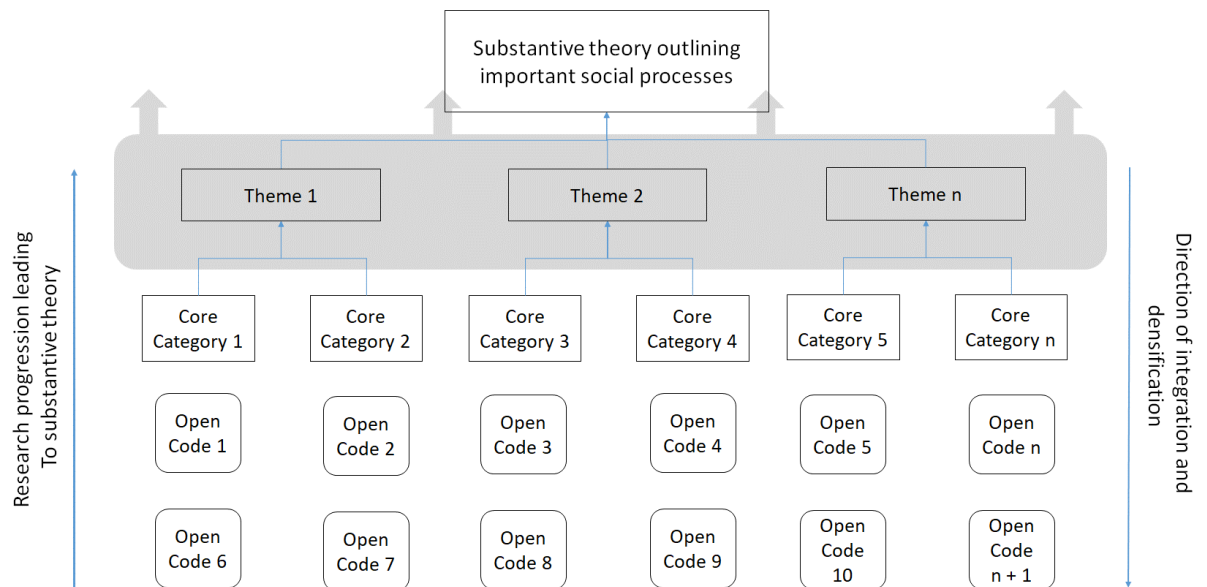


Figure 7.1: Current Stage of Research Project

7.2 The Grounded Theory: Emerging Issues in Competitive Manufacturing Capabilities Development

Although a discussion surrounding the identification of manufacturing related, competitive capabilities and the necessary dynamics involved in their operations is too large a research endeavour to do justice to in a single research exercise, our grounded theory undertaking provides a meaningful framework to address the key high-level aspects of developing and effectively managing competitive manufacturing capabilities in HVM SMEs. The theory therefore addresses the question that was set out at the onset of this project which is; (1) Regarding the identification and development of competitive manufacturing capabilities, what are the main concerns of MedTech HVM SMEs and entrepreneurs working in the innovation and start-up ecosystem in Wales?

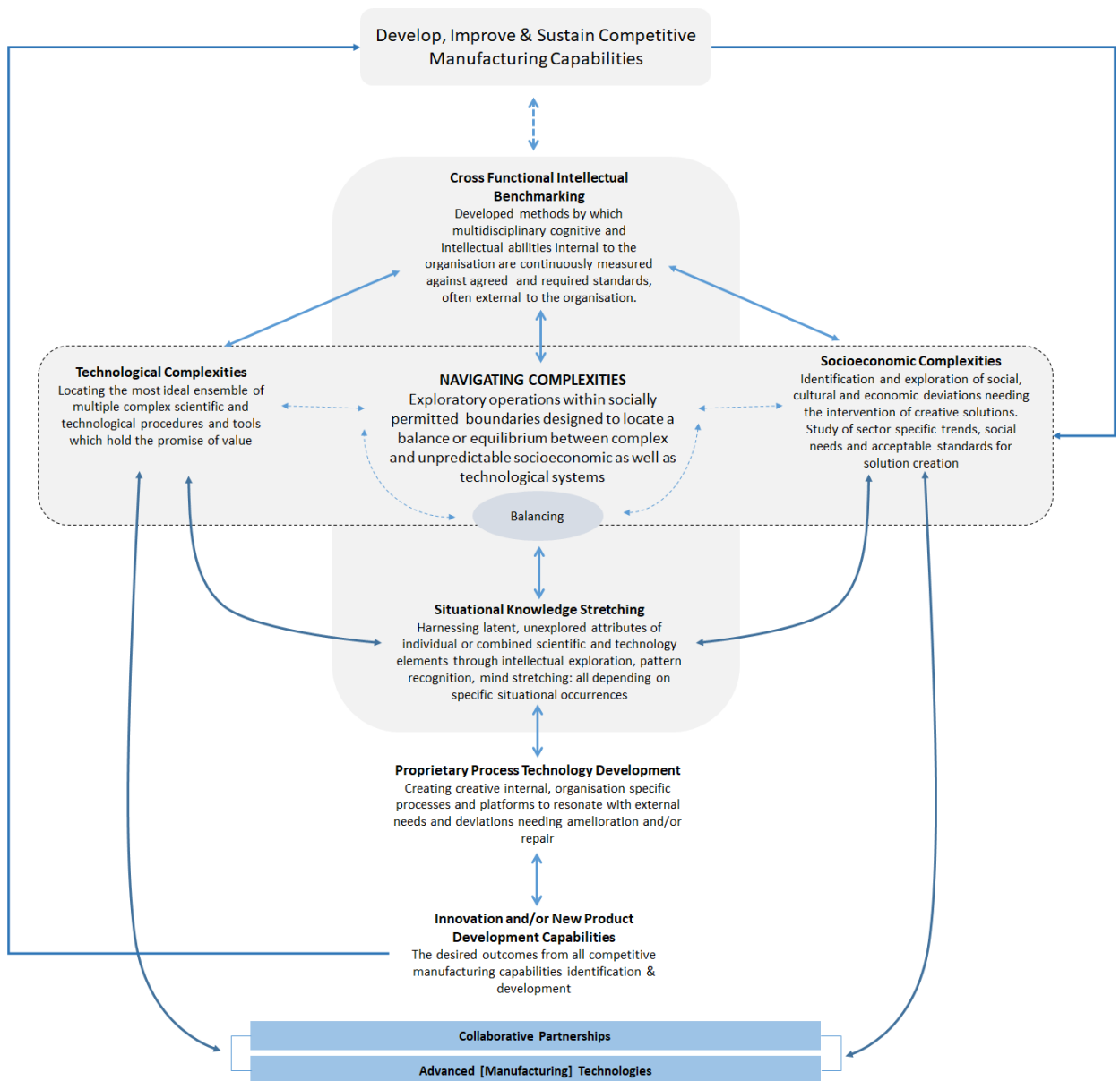


Figure 7.2: The end-to-end research framework including the Grounded Theory of Navigating Complexities

The study generally commenced with this question, following which the initial data collected was analysed yielding the first set of concepts, categories and of course, some other emerging concerns for the HVM SMEs (See Figure 7.1 for stages of project development). This therefore led to some other questions which were considered to be sub-questions of the initial one: (2) How are these main concerns resolved, developed and managed, And, (3) What activities are undertaken by these HVM SMEs to continually remain relevant, not only in Wales but globally as well? The pursuit of these questions also led us into an early

phase of discovery where the research objectives of the study also emerged. Although these objectives were not discussed at the start of the exploratory study, they were deduced during the simultaneous and cyclical data collection and analysis processes. As explained during the methodology discussion in Chapter 3, GTM stipulates that researchers enter into the subject of study without any preconceptions about what might happen in the area of interest because according to Glaser (1992), the issue of managing preconceptions makes the difference between forcing a theory in a particular direction or explaining hidden patterns of social behaviour.

Following the emergence of the objectives therefore further refinements were achieved through ongoing and subsequent discussions with the respondents as well as the constant comparison of both previous and new data sets. They were also used as tools to guide and support all subsequent data collection through theoretical sampling. These emergent objectives were to:

- Investigate and identify the capabilities considered to be most important to the organisations
- To explain the dynamics surrounding these capabilities
- To explain how the identified capabilities evolved into value and how these enhance competitiveness

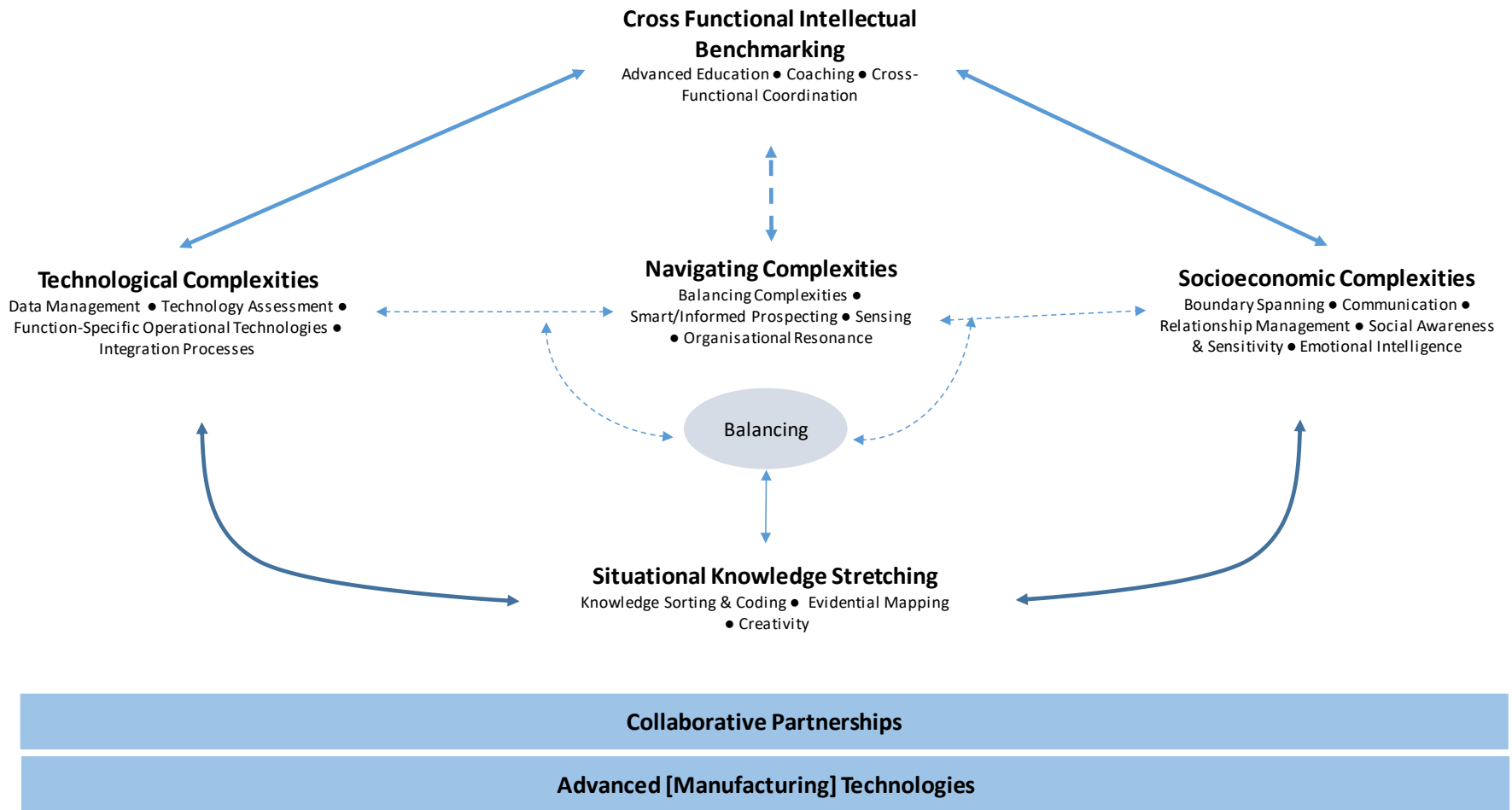


Figure 7.3: Emergent theory of Navigating Complexities

7.2.1 The Framework

Figure 7.2 presents the end-to-end framework from the analysis of the research data and proposes some of the answers to all the research questions regarding the main concerns of HVM SMEs, the capabilities most important to them as well as dynamics surrounding these capabilities. Figure 7.3 however is the model of the emergent theory of navigating complexities.

To kick off the research process, the purpose, which was discussed with the participants in some detail, was to identify and understand the emerging issues surrounding the identification and development of competitive capabilities for their manufacturing operations. The participants readily recognised and understood the rationale behind the research process due to the daily challenges they faced in their bid to develop certain capabilities towards remaining competitive. For some, the relevance of this study was a welcome one due to the uniqueness of the social environment in which they found themselves and their organisations, having worked in other regions in the UK²¹ such as London, Manchester and Cambridge which had more dynamic environments. The need for more detailed understanding of these capabilities was acknowledged as being important for the organisation, not only in their efforts to continually meet the healthcare and medical needs of all current and proposed patients, but also to ensure their unspoken contract with the society surrounding their economic responsibilities was executed.

Through the detailed interviews and coding process therefore, 'navigating complexities' was selected as the central or core category following which all others were carefully related. To further understand this category, this was achieved during the **Selective Coding** phase (demonstrated by the Chapter 5 discussions). It was split further into the constituent elements of 'technological' and 'socioeconomic' complexities, as a clear relationship between them was repeatedly raised and discussed during the data collection stages. Adopting an approach in which the written and spoken information provided by the respondents was assimilated, critically reviewed and analysed, it was then represented visually following which a proposed framework was developed. This framework identified

²¹ The uniqueness of the social and economic system in Wales was often a topic of discussion with the research participants. They spoke of the difficulties in finding, hiring and retaining skilled and experienced staff within their operations. This is explained further in Chapter 1.

the drivers of competitive manufacturing capabilities in HVM SMEs to include a process of a simultaneously benchmarking intellectual capacity across relevant multiple functions, another process of balancing and managing expectations through the development of technology solutions to meet socioeconomic challenges through the development of situational knowledge. A diagrammatic representation of this framework was created (See Figure 7.2)

7.2.1.1 Develop, Improve & Sustain Competitive Manufacturing Capabilities.

To maintain the ability to continually provide value to customers as well as generate profits • Effectively identify and respond to market opportunities • Improve upon, and develop competitive ideas, products and services to remain competitive

Following the first component on the framework, which is '*Develop, Improve & Sustain Competitive Manufacturing Capabilities*', certain assumptions were made at the point of the project kick-off. One of these assumptions was that as an HVM start-up or SME, the organisations were already in possession of certain core capabilities which defined their existence and established their relevance to society. This assumption sought to first of all, establish their organisational legitimacy in the society which Suchman (1995) referred to as a generalised perception or assumption that the actions of an organisation operating in a society are desirable, proper, or appropriately designed, based on socially constructed norms, beliefs and values. In addition to this, it was also assumed that these HVM organisations understood, at least in part, the types of other competencies they needed to move forward. Indeed, it was not uncommon during the data collection stages to hear the owner-managers speak of the need to acquire a particular type of skill or competency to enable them complete the development their products or commence the development of other new products. With the understanding that whether or not the HVM SMEs had successfully commercialised their products and/or services, it was expected that some level of operational activeness was ongoing. With this understanding, another assumption made was that all organisations that were approached, as a matter of urgency, sought to differentiate themselves in the marketplace, hence were actively seeking to develop and evolve their current capabilities, or simply acquire new ones.

Following the establishment of these assumptions, it was identified that the participating firms in this study understood that they operated in dynamic market environments which impressed upon them external pressures that forced them to change their internal strategies and operations. These changes of course, posed certain challenges to these firms, thereby

forcing them to identify and implement ways to cope and stay operational. This realisation spurred them into understanding their environment whilst identifying the relevant technologies which could assist in overcoming those challenges. This therefore evolved into the next stage of 'navigating complexities'.

7.2.1.2 Navigating Complexities

Following the activities identified in the first component, the next stage of the framework identified another process whereby actions were taken towards '*navigating the complexities*' surrounding the actualisation of the findings from the first stage were entered into. As expected, some of these involved the identification and understanding of regulatory and legislative requirements that needed to be met in order to successfully produce and commercialise these healthcare/medical products and services. This is due to the fact that the regulatory requirements prescribed new procedures that governed the operations of the firms such as those regarding good manufacturing practice, ISO standards and so on. Once again, this established the legitimacy of the organisation within the society in which they operated due to the fact that the organisation would have faced threats if any actual or potential disparity existed between their operations and the regulatory requirements.

As identified in the framework also, navigating complexities was further broken down into two major parts; *technological complexities* and *socioeconomic complexities*. Although these two categories covered a multitude of issues they were identified as major potential roadblocks or springboards which the firms needed to contend with on a regular and dynamic basis. Regular, due to the need to remain informed in a constant and consistent manner regarding the short-term needs of their clients, and dynamic, due to the mid to longer term trends driving the industry in which they were operating.

The first aspect therefore, that the organisations needed to contend with revolved around the socioeconomic complexities. With the understanding that all organisations were, or are subsets of the economy in which they operate, it is pertinent that all owner-managers, entrepreneurs, innovators and organisations as a whole, understand the social and economic environments in which they operated in. This enabled them understand the drivers and trends which they had to take into consideration towards the development of their products and services. As the focus of the project revolved around biotechnology, medical sciences and healthcare, the organisations had to understand the trends which influenced this sector. For example, in the UK, organisations needed to understand the inadequacies of healthcare funding mechanisms and how these affected the workings of

the NHS, especially regarding their procurement rules and regulations. They also had to understand the workings of private healthcare providers or medical insurance operators. This is because more often than not, it is these organisations that funded the purchase of some medical devices on behalf of their patients and the organisations needed to know if their devices were eligible for such funding. This of course posed some challenges to the business models of these organisations as it brought to the fore questions such as; who are our customers – the people paying the bills or those using the products? How do we align our value propositions to these two separate customer segments? Some other trends that needed close observation included the rising cases of long-term conditions, increase in telehealth opportunities, personalised health IT, overall call for cost reduction while asking for increased service levels, gamification within healthcare, augmented and virtual reality applications and so on. All these factors had the potential to influence these firms.

The second aspect of navigating complexities that needed consideration revolved around the technological complexities which involved the scientific and technological issues that the organisations had to contend with in the bid to develop their products and services for the customers. These customers, of course, were a major consideration especially as they were the core drivers of the socioeconomic complexities described above. For example, before the scientific or technological issues were taken into consideration, the HVM SMEs had to understand the situations these users were going through and why (for example, were they suffering from long term conditions due to old age; did the patients need constant monitoring and observation due to critical impairments and disabilities; did the patients need digitally enhanced prosthetics due to permanent damage, and so on)? It was identified and concluded by all the firms that it was the understanding of these social complexities that drove the scientific and technological solutions, as it was considered a venture in futility to engage in the creation of a solution that had no social applicability.

The challenges surrounding the scientific considerations were further increased due to the multidisciplinary or multifunctional nature of the technology consideration, acquisition and exploitation. It was identified by all of the participants, once again, that to successfully create their products, they needed the inputs from multiple science and/or technology backgrounds. Typical examples included; the creation of a digital heart monitor included a specialist heart doctor (cardiologist), a design engineer to study and understand the design and workings of a normal heart, a fluid engineer who understood the characteristics of fluid movements (to enable him/her understand the flow of blood and how the monitor would 'take readings' from an artificial device), an electronic engineer (to design the circuits), a programmer (to program and code the microcontrollers). The integration of these different

specialities needed careful consideration due to the high risks involved, should the product or processes fail. Questions such as the following were raised: how do you get a cardiologist, an engineer, a programmer, a designer amongst other professionals to work together to understand each other? How can points of integration and understanding be created between them and how much knowledge of each other's specialties should they all assimilate?

7.2.1.3 Cross Functional Intellectual Benchmarking

All the questions from the last section introduced, and created the need for the third category. For this stage, the *cross functional intellectual benchmarking*, which informed navigating complexity and its categories was developed. Because it was agreed earlier on, that; (1) no organisation, especially the HVM SMEs, has the ability to acquire all the resources they need to ensure their success, in-house, and (2) no organisation that truly innovates, does so individually or in isolation; the need to develop wider knowledge management programmes and processes, as well as any related benchmarks was necessary. Having mentioned and explored the issues surrounding multifunctional research in the last paragraph, this current category supported the organisations' development of learning programs across different functional disciplines. The cross functional intellectual benchmarking process allowed the organisations to develop markers to measure their intelligence and cognitive levels across the functions they needed within their organisation. As represented in the framework, this benchmarking process laid the foundation for organisational learning and knowledge acquisition, which was a main factor in driving activities which facilitated the dismantling of both the socioeconomic and technological complexities, and reconstructing them into different structures for value creation. In other words, the organisational ability to understand the social, economic and technological issues was based on their ability to develop key intellectual benchmarks which informed their learning needs. It was therefore possible for the cardiologist, in the example above, to create the atmosphere where he/she made attempts to understand enough of what the electronic engineer was doing while designing the circuits. This stretched or extended the cardiologist's knowledge to an extent where it was possible for them to use this knowledge to creatively conceptualise and develop other cutting-edge solutions for future benefits. It was also possible for the programmer, through intellectual benchmarks and learning processes, to develop an above average level of knowledge concerning the fluid engineer's area of specialty which is fluid dynamics towards putting this to use in other innovative ventures.

7.2.1.4 Situational Knowledge Extension

Following the interplay between the aforementioned categories of cross functional intellectual benchmarking and navigating complexities, the outcomes from these interactions is expected to be some kind of value which has the ability to provide critically needed succour to potential users. This category, which is identified as situational knowledge extension, is so called because it is expected that new knowledge which captures some momentary situations will be created for the benefit of the users. In this section, we understood the word 'situational' to mean the description of conditions which occurred at a particular moment. In a sense, especially from our engagement with the respondents, we believe that the capturing of these 'momentary' occurrences and subsequent definition and ascription of knowledge pointers supported the disruptive and unique nature of the solutions developed. The consideration and subsequent acquisition of this capability was considered critical as this was the foundation stage at which the development of products and solutions commenced.

7.3 Theory Linkages

In this section, the researcher seeks to link the above narrative concerning the emergent grounded theory framework to the wider body of knowledge. At this stage, it is emphasized that this does not take the place of a literature review and neither does it seek to be an exhaustive activity. The aim in this section is predominantly to emphasize the relationship between the emergent theory and other empirical studies. It is believed that this validates some of our findings.

7.3.1 The Moderating Factors

In the following paragraphs, the researcher first of all takes a look at advanced [manufacturing] technologies and collaborative R&D partnerships, which were considered to be the moderating factors that encompassed the grounded theory of this study. Following the evidence from the results of the data analysis (See Chapters 4 and 5), it is believed that the moderating factors were the driving force behind the organisations' operations due to the fact that they provided the potency to their value propositions. It is strongly believed that without these moderating factors, the findings (the core, and other categories) are prone to exhibiting a certain level of impotence, which will hinder the organisations abilities to reach

their full potentials. This impotence, which may be exhibited at the individual (Lovell, 2002; Aas, 2008) or organizational levels (Greeno, 2006) are considered to foster situations where the organisations lack the ability to sustain their drive to continually engage in positive processes and activities to further their objectives such as those concerned with the delivery of their value propositions – by that the researcher means the inability to follow through activities to completion such as those that drive the actions involved with product development and commercialisation, process improvement activities and other general operational activities. This assertion is according to Greeno (2006) for example, who suggests that the end point of this impotence is death or even worse – a resignation to an organizational plan that falls short of the great potential for possibilities within the organisation. Within this context therefore, an example in the form of a question from the proposed theory that may be put forward is; can we consider the attempt by an HVM SME to effectively 'navigate complexities' without the use and support of advanced technologies and/or collaborative R&D? The outcomes or results will be much weaker than when it is used in tandem with a select assemblage of advanced technologies and collaborative R&D that is strategic to the organisations aims and objectives

For this purpose, therefore, the researcher considered the moderating factors to be interacting elements which affect the process related relationships between variables, dependent and/or independent, that are in effect prone to some level of disturbance or displacement. Aptly defined by King (2013), "a moderator variable is a qualitative or quantitative variable that affects the direction and/or strength of the relationship between an independent or predictor variable and a dependent or criterion variable." In other words, and due to the nature of our exploratory research, our moderating variables are advanced manufacturing technologies or advanced technologies for example, 3D printing, nanotechnology and robotics, while strategic collaborative R&D partnerships are those that are often developed with specialist university research institutes and can involve joint research activities, knowledge transfer partnerships and contractual research activities.

Take for example, previous research studies that have included moderating factors into their research. Sun and Zhang (2006) after conducting their literature review, conclude that prior studies imply great potentials regarding the inclusion of moderating factors to enhance the explanatory power of their theories. Their research which examines existing user acceptance models suggests that the current models still have room for improvement and their limited explanatory power and inconsistent relationships call for the inclusion of additional factors. They therefore included moderators in their user acceptance models namely organisational factors, technology factors and individual factors. Similarly, Chang et

al. (2016) apply the moderating effects of time, relationship quality, and national culture in their examination of how discrete dimensions of supply chain integration (SCI) enhance firm performance. Their conclusions indicate that each dimension of SCI improves financial performance.

Going forward, we take a closer look at our moderating factors, by introducing them in the following paragraphs.

7.3.2 Advanced Manufacturing Technologies (AMT)

A combination of both local and global pressures have impelled manufacturers to adopt more flexible, agile and responsive processes within their organisations. In response to this, the adoption and implementation of AMTs is considered to not only overcome such issues but also to enhance a range of in-house capabilities which enable the organisations deliver the promise of value to clients (Jonsson, 2000). The literature on AMT has therefore received much attention amongst scholars, practitioners and policy makers. Although the evidence suggests that this literature can be split into distinctive research areas such as assessments, investments, implementation and benefits, it can be shown that demonstrable connections exist between them due to the fact that a consideration of one is often built from a good understanding the other. Included also into these distinct research areas is the relationship between AMTs, organisations (especially SMEs) and strategic concerns. This is the area into which our research falls, as our focus revolves around how AMTs moderate the relationships between the development of competitive manufacturing capabilities and its effects therein, on the competitiveness of HVM SMEs

Commencing this discussion involved first of all, the understanding of AMTs through a careful analysis of its definitions. Firstly, Chung et al (2009) in a general sense suggests that AMTs include both hard and soft technologies that are employed to enhance manufacturing competences. Corroborating this, Youssef (1992) expanded on the definition by arguing that AMTs are “a group of integrated hardware-based and software-based technologies, which if properly implemented, monitored and evaluated, will lead to improving the efficiency and effectiveness of the firm in manufacturing a product or providing a service.” In addition, McDermott and Stock (1999) argued that AMT’s have different meanings in different situations and provided a broad definition of the concept, referenced from Pennings (1987). According to them, AMT’s are “an automated production system of people, machines and tools for the planning and control of the production

process, including the procurement of raw materials, parts and components and the shipment and services of finished products”. Examples of these AMTs were given as flexible manufacturing systems, robotics, digital and computer integrated manufacturing and just in time systems (Liu 2008). These definitions provided an insight into the schema of AMTs where their abilities as facilitators of ordinary organizational capabilities, if implemented properly, were possible. These capabilities however, from the latter definition traversed the entire value chain possibly across all functionalities within the organization, from operations to engineering to marketing and strategy as well as to administrative functionalities.

These definitions of course, lead to discussions about the potential benefits of AMTs, which are also very widely reported. AMTs for example, are used to revise completely the capabilities of manufacturing, i.e. to improve manufacturing parameters and ultimately companies’ abilities to enhance their order winning criteria (Efstathiades et al., 2002). Brandyberry et al (1999) also suggest that AMTs “significantly impact the design and outcomes of core organisational processes”. Take for instance, an early study conducted by Tracey et al (1999) who proposed that investments in AMT have improved competitive capabilities and better performance than firms that do not. The results of the structural equation model testing indicated clearly, that there is a positive relationship between AMT and competitive capabilities. Chung and Swink (2009) who are a bit more explicit in their suggestions indicate that over two decades of AMT implementations has reportedly helped manufacturing firms to enhance their flexibility, quality, productivity and lead time hence, reducing manufacturing costs and improving delivery speed. Specifically, they investigated the relationship between patterns of AMT utilization and manufacturing capabilities attainment and hypothesized that “manufacturing plants that pursue higher levels of AMT utilization of design, manufacturing, and administrative technologies will possess correspondingly higher combinative capabilities than their counterparts who utilize AMT at lower levels”. The results from this study conducted with 224 U.S. manufacturing plants indicated that AMT supports the attainment of multiple capabilities simultaneously, thereby supporting the theory of performance frontiers where AMT utilization is seen as a frontier extending endeavour. Some studies, on the other hand, also identified a positive link between AMT adoption and innovation capabilities in manufacturing firms. Bourke and Roper (2016), using data for Irish manufacturing plants, made several discoveries among which were: that there is a dynamic profile of benefits for AMT adoption which demonstrates weak short-term disruption effects but significant long-term benefits for innovation and that innovation benefits are strongest where AMTs are adopted simultaneously in firms. These conclusions concerning the enabling of combinative capabilities emphasised further, our choice to include AMTs as a moderator and driver of the whole process of competitive

manufacturing capabilities development. Owing to the general constraints faced by the HVM SMEs, they needed the multiplicative abilities of AMTs to support the furtherance of their abilities across all functions of their organisations.

All these benefits are probably achieved through what Saberi et al. (2010) suggest is one of the greatest advantages associated with AMTs, which is that of integration – the possibilities to create a single system consisting of numerous parts. They suggest that by utilizing the ability of computers to electronically connect different machines and workstations together - the possibilities of forming a single integrated system to control all organizational activities; starting with the sourcing and acquisition of raw materials to ending with the final products and services as well as the organization of deliveries to the final customer - infinite gains to all stakeholders will be achieved. Indeed, the integration between functions also, such as between either, or all, of production, engineering, marketing, R&D, HR and so on were possible, not just internally within an organisation, but also externally especially between collaborative R&D partners' activities and production or engineering operations. Indeed, our research results indicated that AMTs were the links and conduits between collaborators, especially when an ongoing knowledge transfer activity was in operation (see further discussions in Cross Functional Intellectual Benchmarking and Collaborative R&D partnerships). These links were also in effect in situations where just-in-time or agile operations were the norm for example, suppliers and distributors that were located across multiple sites but involved in the production of goods or their distribution thereof.

Research has however shown that there are situations in which some AMT adopters have failed to reap the benefits promised by AMTs such as increased and long-term competitiveness. Chung (1996) in his review for example, found that in 50 – 75 percent of his sampled organisations, AMT implementations resulted in failure, i.e. the benefits promised, such as demonstrable increases in flexibility, responsiveness and quality were not realised. Lewis et al (2002) also suggest that these failures are as a result of inadequate attention being paid to implementation factors such as how an organisations strategic priorities, culture and employee training propose to support new AMT. Bai and Sarkis (2013) make a few suggestions concerning the issues that hinder the ability to reap the benefits of AMT including the lack of congruence and alignment between strategic orientation of an organization, organisational culture which includes a conducive work environment, the appropriate IT skills and knowledge needed and most of all, the top management support and leadership.

Reynolds (2017) on the other hand considers the big picture by suggesting that potential benefits of AMT adoption by industries include not only their link to the enhancement of everyday organisational capabilities and innovation, but their interminable contributions to economic development as well. A number of scholars have explored this idea in some detail. Tassef (2014) for example, has explored the need for improved growth models and policies when looking at how regions compete having adopted advanced manufacturing and their related technologies. Says he, "...a growing number of emerging economies first acquired manufacturing technology from external sources and subsequently built a capability to develop it internally, thereby becoming increasingly competitive in technology-based markets". He went ahead to suggest that Asian economies have developed, and combined, an increasing expertise in manufacturing technologies with lower labour and capital costs to grow their economies while forcing the decline of previously dominant regions. In addition, Carley et al. (2011) also argue that economic development efforts have emphasized industrial development as part of economic development strategies seeking to establish a competitive advantage in the global marketplace. They argue further that regions have shifted from a focus on industries such as those in agriculture and basic manufacturing and have made moves to invest in technology and advanced manufacturing. In recognition of these arguments, policy makers in the UK for example, have emphasized the need for advanced manufacturing technologies adoption as well as the relevant skills and capabilities to be recognized and developed for regional growth.

7.3.3 Collaborative R&D Partnerships

At the heart of the innovation and/or competitive development processes for most HVM organizations and SMEs is a modern R&D facility which of course, often houses top of the range advanced technologies used for manufacturing activities amongst other things. These facilities are mostly devoted to the exploration of different configurations of value to satisfy the rapidly growing needs of its customers through the ideation, experimentation and creation of new products, or their constituents thereof. While it can be argued that these facilities are often specialised and structured into niche domains, given the limited resources of SMEs, the cross-fertilisation of disciplines has necessitated the need to span several capabilities. Indeed, Granstrand (1998) and Herstad et al. (2014) have argued that the growing knowledge content of products and processes which are necessary to meet complex client demands as well as solve complex global challenges has demanded an increasing breadth of knowledge of different technologies and a growing level of competence in each of these areas. These 'increasing breadth of knowledge' and 'growing level of competence' factors immediately indicate the need for organisations to either

acquire in house, all the necessary resources they need to actualise their goals and objectives, or embed processes to actively and continuously seek knowledge transfer and learning opportunities from collaborators, in order to continually build their competence (See Cross Functional Intellectual Benchmarking discussion) in alignment with the current or future needs of their clients and the society at large. Due to the well discussed issues facing most SMEs, such as financial and resource constraints, the latter choice is the more likely choice and adopted solution.

These occurrences have advertently altered the structures and business models of organisations where the need to innovate to remain critical, and to do so rapidly and very frequently, is of great importance to their survival. These innovative capabilities however are said to reside in not just the organisation at hand, but in a network of organisations, forcing firms to develop a sense of external orientation (Tidd et al, 2005). According to Herstad (2014) for example, “the locus of innovation is shifting away from individual firms towards territorial economies and the distributed networks by which they are linked”. Similarly, Nambisian and Sawhney (2011) argue that in the bid to pursue organic growth strategies, companies have shifted from innovation initiatives centred around internal resources to those centred on external networks - which they refer to as the move from *firm-centric innovation to network-centric innovation*. Various other arguments establish the same fact that for organisations to remain competitive, i.e. to innovate and to succeed in the marketplace, there is a need to actively participate in networks where information and knowledge are shared for the mutual benefit of the participants (Dhanaraj and Parkhe, 2006; Sol et al., 2013; Klerkx and Aarts, 2013)

These networks are especially relevant for many organisations particularly those in the HVM start-up and scale up phases, where the weighty knowledge content of their products and services as well as the levels of complexity they need to surmount require specialist resources and expertise, as well as frequent and open access to cutting edge advanced knowledge such as academic research publications, knowledgeable and skilled staff, well-equipped laboratories and technical/technology workshops. This critical challenge is further compounded by the fact that these resources are often times spread across multiple disciplines and locations, which due to their perceived value, rarity and high technology nature, are also sometimes difficult to find, afford and access as often as needed. To better understanding these occurrences, Tether and Tajar (2008) explore the behaviour of firms in sourcing information for innovation activities from specialist knowledge providers who they identify as universities, public research institutes, private research organisations and consultants. They suggest further that until now, the most attention has been paid to

university – industry relationships for a number of reasons, not least of which is the governments concern that academic research be relevant and accessible to industry. Teece (1989) also suggests that the institutional structure of innovation in capitalist economies involves a complex network of multi - directional dynamics and linkages among and between firms and other organisations such as universities and research institutes. Similarly, Brunswicker and Vanhaverbeke (2014) also explore how SMEs engage in external knowledge sourcing, a form of inbound open innovation. Amongst their conclusions is the fact that R&D sources such as universities and research labs seem to be highly relevant sources for high-tech entrepreneurial firms.

These relationships that industry has with universities have of course, been an important research subject for many years as the roles both entities play in society, especially the universities, have changed over time. During the medieval days and even up to a few decades ago, universities looked backwards, functioning as storehouses of old knowledge; more recently, the modern university looks forward as a factory of new knowledge (Huxley, 1892, cited in Youtie and Shapira, 2008). Etzkowitz and Leydesdorff (1998) who are very active proponents for the Triple Helix Theory²², suggest that due to the evolving position of the sciences in society, “universities and firms are assuming tasks that were formerly largely the province of the other” and the boundaries between science and technology as well as university and industry are in a flux. But one may ask how these relationships between universities and industry came about and why they are seen as a crucible in which the fertilization of ideas takes place?

Apart from the fragmented relationships between universities and industry which took place in the US in the early 1900's for example, some point out that a formalized frame for these University – Industry relationships commenced in the US after the Bayh-Dole act was passed in 1980²³. With demonstrable proof, this act, which is a piece of legislation that is

²² The Triple Helix Model or theory of innovation is based on the complex interactions between universities, industry and governments where their roles are; the universities engage in basic research, industries produce commercial goods, possibly from the basic research and governments regulate the market in which the universities and industries operate (Etzkowitz; 1993; Etzkowitz and Leydesdorff (1995)

²³ The Bayh-Dole Act is a United States legislation that deals with intellectual property arising from federal government funded research especially developed by universities and publicly funded research institutes. Amongst other things, the objectives of the legislation are: (1) to encourage the participation of small business firms in federally supported R&D efforts and (2) to promote collaborative partnerships between commercial organisations and universities. The law was enacted to make a group of laws to encourage technology transfer, especially from patentable university research outputs to industry practitioners and partners and has always been extolled globally, as an exemplar representing relationships between universities and publicly funded research institutes.

widely credited with the stimulation of significant growth in university-industry technology transfer and research collaboration in the US (Mowery and Sampat, 2005) is said to have spurred an increase in the number of patents and university spin-outs, as well as an increase in university-industry partnerships (Schacht, 2012). With the apparent success this programme achieved in the US, Mireles (2007) argued that numerous developed countries, especially members of the OECD, have, or are considering adopting a similar legislation to the Bayh-Dole Act. Whether or not this adoption has so far been the case, Hughes (2011) has argued that more recently in the UK, as elsewhere in OECD economies, it has become commonplace in innovation and science policies to stress the role of universities in driving forward economic welfare. For example, HM Government's (2017) most recent Industrial Strategy document for the UK speaks of the need to promote industry-university collaborative partnership in various paragraphs and emphasizes that the industrial strategy itself, "is a partnership with businesses, workers, universities and colleges, local governments...". Similarly, UKRI²⁴ (2019) also emphasize that, "business-led innovation and commercialisation can involve developing ideas from entrepreneurs within the business, or directly taking forward and developing intellectual assets emerging from universities, such as through spin-outs or licensing, or collaboration between businesses and researchers..."

While it was not intended for the previous discussions to take the form of a submission extolling the virtues of the well-researched area of University – Industry collaborative relationships and partnerships, a brief exposition nonetheless was necessary to demonstrate this area of importance. As the focus of this part of the research is on collaborative R&D partnerships and their influence on the development of competitive manufacturing capabilities, this university – industry partnerships occupies an important role as it was very much the focus of discussions with the respondent companies who all demonstrated various collaborative R&D partnerships with not just one, but multiple university research institutes and extolled the virtues of their relationships with these different research groups. Whether or not these led to an improvement of university-industry relationships is not the purpose of this discussions. The argument is to establish that there is a global push for closer collaborative relationships between universities and industry practitioners, which the researcher believes most HVM SMEs are currently taking

²⁴ United Kingdom Research and Innovation (UKRI) is a quasi-autonomous non-governmental organisation of the United Kingdom that guides research and innovation funding, provided by the science budget of the Department for Business, Energy and Industrial Strategy (BEIS). UKRI works in partnership with universities, research organisations, businesses, charities and government to create the best possible environment for research and innovation to flourish. (See www.ukri.org)

advantage of. This is the point at which it was also established that this was another major category that sought to provide unfettered influence over the whole emergent framework.

Having therefore introduced the general concept of collaborative R&D, especially from the perspective of university-industry relationships, the researcher considered how this category impacted upon the improvement of capabilities for competitiveness from management research perspectives. For example, with the use of AMT as a common denominator, collaborative R&D was used as a means to leverage on the resources of collaborator organisations where the combinative capabilities of AMT expanded the resources of these HVM SMEs. This concept was explored a bit further due to the fact that it was one concept that all respondents readily and actively sought as well as adopted for their growth and competitiveness.

Collaborative benefits have long been explored in management literature, especially when looking at its effects on organisational capability, competence development and improvements. Patrakosol and Olson (2007) in their 9-year longitudinal study across 9 top IT firms for example, explore how inter firm collaboration benefits IT innovation. Following the analyses of their hypotheses, their findings indicated that close inter-firm collaboration advanced the IT innovation process incrementally, and by extension, the capabilities responsible for those improvements. Although these scholars provided evidences for the improvement in capabilities as a result of collaborative R&D activities, some limitations were however explored by others.

Sampson (2005) from a sample of 464 cases of R&D alliances for example, explore experience effect and collaborative returns in R&D collaborative partnerships. Their results indicate that these alliances, especially with the experience from prior collaborations, represent one-way firms gain access to new capabilities via technology adoptions. They warn however, that “more extensive experience does not appear to improve outcomes over more limited experience” and that, “...the benefits of prior alliance experience depreciate rapidly over time”. Similarly, Knudsen et al. (2010) in their exploratory case study research also identify with the prominent view of strategic alliances that suggest that inter-firm collaborative R&D activities support the firm in its acquisition of new competencies as well as the improvement of in-house skills. The findings from their research however extend this by emphasizing that any firm level acquisition of new skills and capabilities depends on individual competencies, especially if and when these individuals are the ‘gatekeepers’ in technology-intensive organisations. Likewise, Vural et al. (2013) indicate also, that the successes of teams depend on the collaborative work of individuals, who bring different

sets of knowledge to the collaboration activities. These statements therefore provide caveats to the thoughts that engaging in collaborative R&D automatically ensure an increase and improvements in organisational capabilities

Lastly and in recognition of all of the above, our engagement with the HVM firms under study pointed to the fact that they were all intent on increasing their dependence on collaborative R&D, thereby allocating adequate resources to its actualisation. Research findings pointed to Geum et al. (2013) who emphasize that organisations are increasing the resources they are allocated to collaborative R&D towards speeding up the pace of their innovation and diversification of technological capabilities. They stated that R&D collaborations are regarded as important vehicles through which firms improve their innovation and competitive capabilities.

7.3.4 Navigating Complexities

Navigating Complexities facilitate the ability of an organization to pilot itself through complex and equivocal situations while trying to locate and exploit value amidst great ambiguity, through the location of a balance point between a combination of other complex situations such as those arising from social and technological complexities

The basic premise of all businesses regardless of their size, location, sectors of operation and even financial wherewithal is as much about opportunity recognition as exploiting that opportunity to their fullest advantage (Zacharakis and Shepherd, 2005). Indeed, the oft cited mantra that compels businesses to channel their resources towards engaging in activities designed to increase their profits²⁵ for the benefits of shareholders (Friedman, 1970) is predicated on the need for businesses to find these opportunities, navigate through and overcome as many complexities, uncertainties and obstacles within their business environments as possible towards exploiting the opportunities for profit.

In order to achieve the aforementioned rewards towards sustaining their competitive advantage, it has been proposed that organizations need to renew their stock of valuable internal resources as their external environment changes (Ambrosini and Bowman, 2009).

²⁵ Friedman (1970). "I have called it a "fundamentally subversive doctrine" in a free society, and have said that in such as society, "there is one and only one social responsibility of business – to use its resources and engage in activities designed to increase its profits so long as it stays within the rules of the game, which is to say, engages in open and free competition without deception or fraud."

Similarly, Chang et al. (2011) also argue that the significant mediating role of innovation ambidexterity between internal and external environment conditions suggests that SMEs allocate their internal resources towards ensuring better decision-making processes to enable proper and effective responses to environmental changes. Other authors (for example, Lee et al., 2001; Fink et al., 2005; Wong et al., 2013) also argue along the same lines of locating the point of equilibrium where the internal resources match the external requirements.

To adequately understand and explain such occurrences within businesses, scholarly contributions through management research developed theories such as those referred to as organisational ambidexterity and dynamic capability theories, where dynamic capabilities are thought to be the foundation of enterprise-level competitive advantage in regimes of rapid technological change (Teece, 2007) and organisational ambidexterity is the ability to excel at exploration and exploitation, two vital but conflicting modes of innovation (Andriopoulos and Lewis, 2010). Regarding both these theories, Jensen et al (2009) however recognize the relationship between them by arguing, "...we recognize organizational ambidexterity as a dynamic capability by arguing that it refers to the routines and processes by which ambidextrous organizations mobilize, coordinate, and integrate dispersed contradictory efforts, and allocate, reallocate, combine, and recombine resources and assets... "

While introducing the dynamic capability approach to competitive advantage, Teece et al. (1997) argued that the term 'dynamic' referred to the capacity of an organisation to renew competencies towards achieving congruence with the changing business environment while 'capabilities' emphasized the appropriate adapting, integrating and reconfiguring of internal and external organisational skills and resources to match the requirements of the changing environment. In other words, dynamic capabilities defined as "...a set of routines guiding the evolution of a firm's resource configuration" (Zott, 2003); "the abilities to reconfigure a firm's resources and routines in the manner envisioned and deemed appropriate by its principal decision-maker" (Zahra et al. 2006); "the capacity of an organization to purposefully create, extend or modify its resource base" are central to any organization's survival. We however identified that while this dynamic nature of capabilities has been well researched, the aspect of how the resources are directed, or meander through the complex and seemingly unmoveable or unchangeable situations which occur in their paths has not been adequately discussed. This therefore, is where our focus on the proposed, substantive theory of Navigating Complexities arises. Although we believe that a

relationship exists between both dynamic capabilities and navigating complexities, there are slight differences in their compositions. *This argument is revisited in Chapter 8*

Accordingly, we focus our attention on the central theme of our substantive theory, which is Navigating Complexities. This is especially important to executives and leadership teams routinely faced with piloting the affairs of their organisations through densely interconnected forces of shifting consumer demands, regulatory requirements, political instability amongst other things beyond their immediate control. Indeed, this theme was especially important and relevant to research participants due to their relative vulnerability as SMEs, in comparison to larger organisations. Being HVM SMEs with fewer resources, especially those related to their financial, human and infrastructure capacities, their abilities to cushion, adequately balance or absorb the effects of market fluctuations which came periodically and unexpectedly did not happen without a cost.

As part of our focus in attempting to identify the relevant dynamics, we identified and examined the aspect of 'change' within our Navigating Complexities category, as various indicators pointed to this activity as key. At the strategic level for all respondents a part of their competitive success was achieved having to adapt to their internal and external environments but more so, having to adapt their internal environment to their external circumstances. This strategic level, representing the position which deals with policy formulation and the overall goal setting for long term positioning of the company in its environment (Devanna, 1981), was only partly representative of the dynamics we sought to explain within the competitive capabilities inherent in HVM SMEs. This is because these strategic measures reflected broad based policies such as corporate financial plans, competitiveness and levels of adherence to organisational goals (Gunasekaran et al, 2004). While we understand the importance of this strategic levels and believe that the success of the decisions taken at other levels was wholly dependent on the decisions taken at this strategic level (Bachlaus et al, 2009), we are quick to acknowledge that our focus was not exclusively on the strategic levels.

Rather, our interests sought to also identify and explain the tactical and operational level dynamics which deal with a myriad of priorities, processes, plans and decisions which infuse the organisation. Of course, these tactical level dynamics dealt with resource allocation and the measurement of performance against targets to be met in order to achieve results specified at the strategic level (Gunasekaran et al, 2004; Schmidt and Wilhelm, 1999). In other words, information is interpreted and utilized in decision making at the tactical level. On the other hand, operational level dynamics deal with the production of transaction data,

serving as an input to create information. Maintaining and monitoring of ethical issues, standards such as integrity, confidentiality are objectives which are supported by organisational procedures (White, 2009)

Taking a step back to our focus on 'change', being one of the dynamics identified in the process of Navigating Complexities, it was identified that this occurred at all levels previously highlighted; the strategic, tactical and operational levels. It was therefore pertinent to identify a framework which satisfied the identification of relevant dynamics within this Navigating Complexity category. Referring to our findings in Chapter 5, where we identified 4 major categories in the theme, we sought to key out the dynamics involved in each category.

7.3.4.1 Balancing Complexities

Management scholars have sought to understand the concept of balancing a number of given tasks within organisations, without compromising the efficacy of either of those individual tasks. For example, in trying to explain a dilemma that all managers face regarding the organisational tensions between process, the way matters are formally organised, and practice, the way things actually get done, Brown and Duguid (2000) introduce the *balancing act* idea. In a similar vein, Turner and Rindova (2012) examine how organizations who participate in routines view and balance pressures for consistency in the face of ongoing change. This also, introduces the concept of balancing acts. Defined by The Free Dictionary (2019) in various ways as: "as a situation in which one must accomplish a number of tasks at the same time" without compromising on any of the given tasks, "...you have to decide what to do when different people want different things or when you have to be aware of different situations which could be affected by what you do", or a process in which somebody tries to please two or more people in groups who want different things", these ideas represented succinctly, the concept behind 'balancing complexities'.

Following the above narrative, we present balancing complexities as a sub-category, and one of the dynamics of navigating complexities. This category seeks to hone the ability to identify common grounds between two or more competing or opposing variables, in the bid to develop and provide value to differing stakeholder demands – even in the midst of uncertainties. This common ground transcends different levels of operation, whether strategic, tactical or operational as there are situations at each level where decisions have to be made to favour all stakeholders. At the strategic level for example, when considering

the identification of balanced solutions between the organisation and its wider environment certain complexities have to be considered such as how the political, economic, social, technological and Legal factors will affect the organization. At the operational level, when trying to identify a balanced solution between the technical complexities as well as the social complexities, the need to rely on adequate data collection and its methods, is necessary for all stakeholders. For the purpose of this theory, balancing complexities was a major subcategory, especially when trying to balance technical variables against socioeconomic variables towards creating a product that met the needs of as many stakeholders as possible.

7.3.4.2 Smart/informed prospecting

As alluded to throughout this thesis, the complexities around social and technological change create numerous uncertainties for organisations. These occurrences force HVM firms to find pathways through these uncertainties, while collecting, analysing, learning and absorbing information on the go. The challenges, or activities involved with this process necessitate the quick assessment of what information is useful, keeping this information, while archiving or discarding that which is not. Amidst these uncertainties, and as part of the path-finding activities through incertitude, these organisations have to actively conceptualise, design and develop valuable solutions that meet certain needs. Parts of these processes are akin to the 'wildcatting'²⁶ activities of American oil and gas companies where Froh (1979) describes wildcatting as "a synonym for imagination as well as daring". These characterizations therefore require certain capabilities, some of which may be based on subjective judgements including intuitive and gut emotions based on certain thought patterns. These issues surrounding intuitiveness as well as gut emotions have of course, been explored by management research (see for example, Sadler – Smith and Shefy, 2004; Kastensson and Johansson, 2011; Dane et al., 2012; Scheiner et al., 2015)

Management literature has however described a similar and very close concept which is referred to as 'venturing'. Defined as a time consuming and costly process whereby the creation of new businesses is achieved through the exploitation of opportunities in given markets (Zahra and Hayton, 2008), Garud and Van De Ven (1992) argue that "...venturing process, like any other entrepreneurial activity, is characterised by uncertainty and

²⁶ "Wildcatting is an oil and gas term used to describe exploratory drilling activities in an unproven field. Such entrepreneurial risk has afforded some with great wealth; they dared to go where no one else would..." (Jones, 1988) – *implied covenant to restore surface-judicial wildcatting yields valuable rights for surface owners*

ambiguity...”. Regarding our thesis, by far the most relevant definition was proposed by Hindle (2010) who defined spontaneous venturing as a process in which new information, sometimes revealed by unplanned occurrences, prompts a near simultaneous progression from opportunity evaluation, to commitment, to action, thereby birthing a previously unconsidered creation of new value for defined stakeholders. While these ‘venturing’ definitions bore a certain similarity with our category and described it in parts, our proposition was marginally different. For the purposes of ‘smart/informed prospecting’, the uncertainties were greatly reduced through the compulsory inclusion of advanced technologies and collaborative R&D partnerships. This therefore was an important aspect of the Negotiating Complexities category as it was revealed by the data analysis from the participants that this was/is part of the dynamics surrounding the development of competitive capabilities development.

7.3.4.3 Sensing

The purpose of this category is to demonstrate the internal capabilities within the organisation that enable it to periodically and/or continually, as the case may be, send out feelers from within the organisation into the immediate external environment for the purpose of detecting events and/or changes which can influence the ability of the organisation to navigate and find a way in uncertain territories. These capabilities, identified as sensing capabilities, are not new in management and business research. Identified as a subset of the dynamic capability theory, Teece (2007) and Teece et al. (2016) suggest that sensing capabilities refer to the ability to sense and identify opportunities and threats in the environment through the application of scanning, creation, learning and interpretive activities. For instance, medical technology solutions depend on the cooperation and collaboration between healthcare providers, R&D institutes, specialised technological firms and of course, the patients. Due to the sensitive nature of the sector and its products, regulatory concerns have to be taken into consideration necessitating the need for a good knowledge of the regulatory requirements. Hence, to develop medical innovations, firms and individuals need sensing capabilities at the environmental level (social, regulatory, economic), technological level and sectoral (medical, healthcare industry). As this sensing capability is not static, the need to continually anticipate evolutionary changes towards keeping the individuals and organisation ahead of their competition is necessary. Very importantly, it should be noted that although this category seemingly refers to the sensing of occurrences and events outside the organization, the need for sensing within the

organisation is also necessary to enable the proper development of equilibrium between both internal and external conditions.

7.3.4.4 Organisational Resonance

Derived from both 15th century French, *resonance*, from Latin *resonantia*, 'echo', and *resonare*, 'to sound again', resonance is defined in physics as "a relatively large selective response of an object or system that vibrates in step or phase with an externally applied oscillatory or pushing force..." (Hollnagel and Goteman, 2004). Seagal (2014) on the other hand, defines it as "relations of dependence between separate factors, morphing into energized complexities of mutual imbrication and inter – involvement, in which heretofore unconnected or loosely associated elements fold, bend, blend, emulsify...".

These definitions therefore imply a convergence of sorts, between two, or sometimes more, named entities and separate bodies; for example, an organisation and its external environment. If we therefore consider these two named entities as separate complex systems, they are by definition composed of a number of subsystems each, which in turn constitute multiple functions within their whole ecosystem. In such a situation, we identify with Nadler and Tushman's (1989) definition of organisational resonance which considers the resonance to be within the boundaries of the organisation and therefore between different internal functions. They explain organisational resonance as the process of ensuring that all changes within the organisation are related to, and consistent with, some of the historical core values of the organisation. In like manner, Fournier et al (2008) while discussing from a Marketing point of view, explain the concept as, "...the goodness-of-fit between the brand's claimed meanings and the internal structures and processes of the firm...".

While these examples do not completely explain the context in which our situation is expressed, the fundamentals are similar in the sense that there is an alignment, a melding, a certain pursuit for equilibrium between two entities; this time, an internal bounded system (the organisation) creating its equilibrium by resonating with its internal subsystems, following which it seeks to blend in with an external force (its environment). We therefore argue that this sub category supports the navigation of complexities such that when imbalances are experienced between the organization and its environment, this points to a 'roadblock' that needs circumventing.

Following our discussions concerning the core capability of navigating complexities, we propose the following:

Proposition 1. Over time, Navigating Complexities expands in its importance, scope and meaning and becomes embedded in a firm's core routines which inform and influence organisational strategies.

Proposition 2. Entrenched 'navigating complexities' related capabilities along with their underlying priorities and assumptions serve as organisation-level competence drivers to guide a firm's resources towards enhancing firm competitiveness.

Proposition 3. Organisations that identify Navigating Complexities as core firm capabilities and seek to actively engage with its dynamism show positive performance within a shorter time than organisations that do not possess such core ideologies

Thus, our emphasis here is that Negotiating Complexities influence a firm's ultimate direction and hence, (1) its resource and competency configurations and (2) its managerial actions and initiatives, both of which ultimately enhance the firm's competitiveness.

7.3.5 Situational Knowledge Stretching

Situational knowledge stretching is the ability to harness latent, unexplored attributes of individual or combined scientific and technology elements through intellectual exploration, pattern recognition and mind stretching towards developing solutions for specific situational occurrences, thereby taking advantage of opportunities as they arise.

Traditional views of the firm have concentrated on the notion that the firm exists, and has a binding fiduciary duty, to create value for the company owners and its shareholders whose needs are thought to come first. More recent work has however demonstrated that this 'value' is thought to originate from the ability of the firm to harness and exploit whatever knowledge it is able to acquire from multiple sources for its benefit (for example, see Moller and Svahn, 2006; Johannessen and Olsen, 2010; Lerro et al., 2014). This has been described as the knowledge-based view of the firm (KBVF), a theory whose central premise proposes that knowledge is an asset apportioned to maximize value for the firm (Grant, 1996; Eisenhardt and Santos, 2002). This KBVF occupies an important place in the proposed grounded theory of Navigating Complexities, where knowledge acquired from a

process of balancing, mapping and sorting the combinatorial process of both technology and socioeconomic complexities navigation is key to the dynamics involved in developing competitive advantage.

The findings have also pointed to a concept, situational knowledge, which is a topic that has been identified in literature but not explored in much detail. Various studies however, explain that this concept is thought to be about situations as they typically appear in a particular domain. In this case, knowledge of problem situations which enable the solver to sift relevant features out of the problem statement (Solaz-Portoles and Lopez, 2008) towards achieving a particular outcome. Ahmed et al (2005) define it as the knowledge of understanding the context in which knowledge is applied, i.e. where, how and when, while Chung and Reynolds (2000) describe Situational knowledge as “a set of exemplar cases that are useful for the interpretation of specific individual experience”. They explain that this knowledge is contained within a cultural system. In our case, and based on our particular initiative, we define situational knowledge as that which is specific to, and bounded by particular occasions or occurrences, often embedded in one, or a combination of social, technological and cultural norms such as language, culture, traditions, technological breakthroughs. For example, these occasions or occurrences involve the development of interventions relating to complex medical conditions, sometimes for particular demographics, or particular individuals. This has led to findings such as those which inform that situational knowledge is often valid only in a given time frame, for example, during a session with a customer (Gordon et al. 2002), which point to the fact that situational knowledge and skills are sometimes developed and used without defining them in advance (Lester, 1995). Indeed, it can also be argued, within the context of our findings, that situational knowledge when applied in medical and healthcare sciences is a driver of personalised medicine. This concept of personalised medicine is an emerging approach to patient care in which a patient’s characteristics, including their genetic profile, serve as the basis for the right treatment for that particular patient, at the right time (Jackson and Chester, 2015)

Having recognized the aspect of situational knowledge, the second part of our category has to do with the stretching of the knowledge that has been, or is being, acquired. This process of knowledge stretching is about developing and encouraging the conditions where a combination of various factors such as creativity and intellectual prowess extend the potentials for the creation of value for HVM organisations using current, and sometimes incomplete knowledge. This process of knowledge stretching, which is often achieved through scientific and/or objective illative processes, encourages the use of observation,

objective background knowledge and other established premises to determine a conclusion that makes viable sense. In a similar manner to the chemical processes in which elements such as Hydrogen and Oxygen are combined using laboratory processes to produce water, the respondents spoke of engineering a combination of science and technology components (having understood the individual characteristics of each of the constituent elements) brought together through integrative means, to propose a new concept that has not previously been seen. This organisational process therefore explains the ways in which HVM enterprises, and the people that work in them, are encouraged to exercise their creative abilities in combination with the objective knowledge they are able to acquire from an understanding and combination of both social needs analysis and technical solution development.

The above discussions of course, evoke the concept of logic and its constituent behaviours in our bid to further demonstrate the concept of knowledge stretching. After all, logical reasoning is defined as the ability to use complex and abstract cognitive skills to solve problems which in turn facilitate more mature decisions (Garrigan et al., 2018) or “the formal manipulation of symbols representing a collection of believed propositions to produce representations of new ones...these symbols are used to represent the knowledge and also to infer it through some known rules” (Hashemian and Mavaddat, 2007). According to Von Plato (2014), “Logical reasoning is applied at all levels from everyday life to advanced sciences...a remarkable level of complexity is achieved...even if the principles behind it remain intuitive”. The emergent category, Situational Knowledge Stretching therefore occurs when information coming in from different locations is captured, tied together through transformational processes and introduced as outputs which mean something entirely new and different from the initial base elements in a given moment in time. Once again Hashemian and Mavaddat’s (2007) definition of logic is considered deeply, as it provides good similarities to the definition of ‘knowledge stretching’. This is due to the fact that the ‘believed propositions’ spoken about have probably only been proven through scientific simulations and logical expressions and not through constant use in practice.

In the following paragraphs, the sub-categories are identified and related to some of the literature within the body of knowledge

7.3.5.1 Knowledge Sorting and Coding

Following the detailed interactions with the case study organisations, the sorting and coding of acquired knowledge was considered to be a critical part of an organisations competitive edge over other organizations operating in the same market. A hypothetical example of two organisations that had been given the same task to accomplish was therefore considered. With the benefit of some experience, it is believed that both organisations will produce different outputs, even when allocated with the same information, similar resources, objectives and timelines. This will be due to the combination of both the tacit and explicit knowledge measures within the company which we understand will be due to outcomes of internal cognitive attainment levels of the individuals who make up the totality of the organisation. With reference to the current discussion, it should be noted that we are referring to the sorting and coding of explicit knowledge, which according to Smith (2001) is, “technical or academic data or information that is described in formal language, like manuals, mathematical expressions, copyright....this systematic knowledge is readily communicated and shared through print, electronic methods and....is technical and requires a level of academic knowledge or understanding gained through formal education, or structured study”

Take for instance, a situation where an entrepreneur/firm acquires some insights into what a customer wants or needs. The entrepreneur, alone or in collaboration with other specialists, begins to create a mental picture of this users' needs and commences the process of identifying the pieces of knowledge that can help in the actualisation of a customized solution. To assist the customer make a decision concerning the suitability of the product or solution, the entrepreneur sorts knowledge based on the product characteristics, functions and aesthetic designs. The entrepreneur collects this data in written form and possibly stores the information in a digital receptacle for onward sharing with other collaborators. This data may be in the form of written words, codes, diagrams and figures but the critical point is that these will have to be understood by the others accessing the information.

According to Chen and Occena (1999), who propose a knowledge sorting process for product design systems, knowledge sorting is defined as a way to organise the knowledge that has been acquired from domain specialists and various other sources. Indeed, even though the researcher does not emphasize the knowledge acquisition activities which are those that come before the sorting stage, the acquisition of the right knowledge itself presents a challenge to organisations. He et al. (2013) therefore emphasize that knowledge

sorting is needed after any acquisition of knowledge. Their arguments emphasize that when tremendous knowledge extracted from experts and documents has been undertaken, the information is usually large scale and ambiguous and therefore needs sorting before being used. Based on these definitions and descriptions, it is clear to see how this category plays an important role in the competitiveness of HVM firms, who mostly measure their successes on their abilities to transform knowledge into tangible products and services.

Following this sorting process, the task of coding the knowledge is often very necessary and is a process of changing knowledge into accessible and applicable formats for ease of storage, dissemination and re-use. This is according to Mohapatra et al., (2016) who argue that knowledge codification is the process of systematically organising and representing knowledge before it is accessed and used by authorized personnel. This definition contains one of the main reasons for codification, which is to enable the ease of storage, access, or transfer, of the information between authorized entities, people or organisations. Tzortzaki and Mihiotis (2014) allude to this by stating that the goal of knowledge codification is to enable the sharing of the right information with the right people at the right time. What is not mentioned, but implicit and equally important points to the fact that coding also facilitates security due to the fact that unless the right 'passwords' are applied, the explicit meanings of the stored information will not be accessed. This is sometimes a feature of intellectual property strategies, which are another means of developing competitive strategies for HVM SMEs

Furthermore, if we agree with, and accept the concept and tenets of knowledge-based systems, knowledge-based organisation and by extension, knowledge-based economies, which all rely on computer systems that utilize knowledge, data and information from different sources to support human learning as well as solve complex problems using complex algorithms, understanding that codified knowledge makes up an important building block in these systems is paramount.

7.3.5.2 Evidential Knowledge Mapping

Closely related to the knowledge sorting process is an aspect of knowledge management, which is identified as evidential knowledge mapping. Although knowledge mapping has been studied extensively in management research, it remains a core constituent of our core category without which the centre or core of the grounded theory framework cannot hold.

With the possibilities of experiencing information overload which increasingly occurs across organisations to choke innovation activities, the need to develop knowledge maps based on evidential information and proof of usefulness is necessary for directional progress. Knowledge mapping, which is sometimes identified as knowledge visualization is therefore, a multi-faceted approach for creating structure out of an overabundance of potentially useful information (Hellstrom and Husted, 2004); the process of associating items of information or knowledge, preferably visually, in such a way that the mapping generates additional knowledge (Eppler, 2004); and “a technique used to represent knowledge in the form of network maps”. Speel et al. (1999) provides a much more detailed definition thus, “knowledge mapping is defined as the process, methods and tools for analysing knowledge areas in order to discover features of meaning and to visualize them in a comprehensive, transparent form such that the business-relevant features are clearly highlighted”. These definitions therefore generate the following characteristics of knowledge mapping; (1) it is a process, that is (2) multidimensional, and is therefore (3) preferably represented visually, towards (4) creating an understandable and easily accessible structure.

As it is therefore with geographical maps, the idea behind our evidential knowledge mapping and is to encourage and support the creation a visual representation of relationships between particular points of interest as well as a directional representation of the different paths to a preferred destination. This is where the ‘evidential’ aspect of the mapping comes into place as it is believed, from our interaction with respondents, that ‘unproven knowledge’, akin to blue sky thinking, does not have much value for the mapping phase of product development. While it must be emphasized however that blue-sky thinking does have a place in our grounded theory, regarding the expression of creative capabilities, it is not a core aspect of this category of evidential knowledge mapping. In this category, evidence of a certain type of tangible value, is needed before the knowledge can be included, or mapped. Knowledge is particularly important and valuable in fields such as science and engineering where knowledge is proliferated at a fast pace (Dang et al., 2011) thereby generating large caches of obsolete material. Considerably time-consuming and expensive (Lachner and Pirnay-Dummer, 2010) knowledge mapping is said to be one of the critical components needed to support the navigation of complexities in a dynamic environment

7.3.5.3 Creativity

Although the researcher believes that the concept of creativity does not need any introduction or convoluted explanation, he will provide a brief exposition due to the fact that it is an important sub category of most of the core categories and indeed, the substantive grounded theory. Creativity was often mentioned during the case study interaction as it was claimed by the respondents that it plays a role in the various phases of complexity navigation, intellectual benchmarking and all other aspects leading up to the competitiveness of firms.

The concept of creativity has long been a subject of research activities, especially by psychologists and HR professionals, who have sought to develop theories that can be used to increase these abilities to acquire the relevant skills. Rogers (1954) for example, sought to develop a theory concerning this subject taking into consideration the nature of the creative act, the conditions under which it occurred and the manner in which it may be fostered. Altshuller and Shapiro (1956) also led an investigation into creativity claiming that it is the psyche that improves the instruments of labour and is the basis of technical progress. If the concept is to be viewed from an objective, scientific lens therefore, it must be defined in a way that permits objective observation and measurement (Torrance, 1965). Defined as the ability to combine ideas, things, techniques, or approaches in a new way, Romey (1970) emphasizes that creativity is a complex process that can be divided into four main stages; (1) a period of mental labour and deep engagement in a problem, (2) an incubation period, (3) a period of illumination, and, (4) a period of elaboration and refinement of an idea. Similarly, Prucha et al. (1994) cited in Trnova (2014) define creativity as, "mental ability based on cognitive and motivational processes where an important role is played by inspiration, imagination, and intuition. It develops itself by finding solutions that are not only correct, but also new, unusual and unexpected." Once again, we come across concepts such as cognition, imagination and intuition, which were all core aspects of other sections earlier discussed, thereby bringing this to a full circle.

Having defined creativity, it is worth exploring its relationship to competitive capabilities to enable some further understanding of how it fits in with our emergent theory as well as how it will contribute to the competitive manufacturing capabilities of HVM SMEs. Asadegan et al. (2008) in an exploratory experiment of 74 design engineers from ten firms for example, sought to understand whether design creativity was a static or dynamic capability. Although the concept of competitive capabilities was not explicitly mentioned in their research, we consider dynamic capabilities to be of the competitive capability kind.

Proposition 4: The stronger the organisations abilities to balance a multitude of complexities alongside situational knowledge stretching capabilities, the easier it is to lay the foundation to disrupt the market place with a portfolio of unique products and services

7.3.6 Cross Functional Intellectual Benchmarking

Cross Functional Intellectual Benchmarking is defined as an organisations ability to develop increasing levels of cognitive markers and measurements, in collaboration with other organizations, preferable external, that are perceived to possess higher standards of the needed expertise in relation to them, which provide progressive levels of attainment across a number of functional disciplines relevant to that organisation's endeavours. High level key drivers of this core category include effective and efficient knowledge transfer processes, learning abilities, advanced collaboration capabilities and well entrenched absorptive capabilities amongst other things.

Beyond regarding academic qualifications solely as a capability benchmark which qualifies individuals to perform a particular job or task that is dependent on specialist advanced knowledge, organisations frequently view professional accomplishments as well as relevant work experience as indicators for specific competence and capabilities in chosen areas of professed expertise. More importantly, organisations seek to perfect the abilities which enable them to build upon, and attain the desired state where individual employees, as well as the organization as a whole, are able to continue the learning and development process towards enabling the organization evolve alongside, or even ahead of, their chosen markets. This indeed, is one of the indicators of an organisation's competitiveness

As mentioned earlier, HVM start-ups and SMEs develop, and engage in collaborative R&D as one of the means through which they learn as well as acquire the skills, capabilities and resources towards establishing some competitive business and manufacturing advantage. The process by which this is done is often through knowledge transfer activities delivered through learning mechanisms. These mechanisms which are "institutionalized structural and procedural arrangements allowing organizations to systematically collect, analyse, store, disseminate and use information that is relevant to the performance of the organization" (Popper and Lipshitz, 1998), are often the factors which set organizations apart. Very important in the observance and successes of these learning mechanisms is

the ability of the organisations to absorb and utilize whatever knowledge they are able to glean from the environment about them. This concept called absorptive capacity is defined as the ability of firms to recognize the value of new, external information, assimilate and apply it to commercial ends for increased value delivery, profits and competitiveness (Cohen and Levinthal, 1990). In our field of enquiry, this external information includes the most recent scientific and technological developments in both specific and general fields as well as the wider socioeconomic trends which drive innovative ventures.

Before the issues of knowledge transfer and absorptive capacity are considered however, the study findings highlighted lower level issues which needed to be considered critically. For example, the case studies revealed that these HVM organisations routinely developed benchmarks to enable them develop points of reference by which they measured themselves and developed strategies towards attaining a desired level of knowledge and/or expertise. Benchmarking in this context is therefore one way of identifying and understanding the practices needed to reach new goals (Voss et al., 1997), the essence of which is to support “the process of identifying the highest standards...and then making the improvements necessary to reach those standards (Bhutta and Huq, 1999). Having been studied extensively in literature, the use of benchmarking is strongly linked to both improved operational performance and business performance (Voss et al., 1997). Other scholars have also established that benchmarking is a tool that leads to competitive advantage (see Elmuti and Kathawala, 1997; Anderson, 1999; Attiany, 2014)

Taking for example learning benchmarks which are defined as “progress indicators for gauging students’ achievement of each exit standard...they form the basis for measuring student achievement over a specified period of time...” (Westbury, 2016). A practical example was demonstrated by Doll et al. (2003) who proposed a web-enabled process for benchmarking IT outcomes and diagnosing problems with the user’s learning within an organisation. According to them;

“while implementation learning is important, today’s rapidly changing business environment and IT’s powerful and integrative applications require users to continually learn new skills. The term post-implementation learning is used to describe this continuing learning after the application is in operation. This post-implementation learning often represents “firm-specific” knowledge that must be developed internally. Without this continuing IT learning, there will

always be a gap between how technology is actually used and the realization of its full potential.”

They continue their arguments by stating that;

“By the end of the millennium, firms had made heavy investments in people, process, and technology, yet there was a perception of a growing gap between how IT was actually used and its full or potential use. It has become increasingly apparent that the critical issue was not what technology users have, but rather, how users learn to use that technology effectively in their work. Effective management of this gap requires IT learning benchmarking”

As it is with the organization above, which is developed with respect to the IT function of an organisation, it is proposed that similar processes be formulated for HVM organisations in functions such as other critical science and technology disciplines relevant for that organisations products and processes. I make bold to state that the benchmarking activities which make up part of our substantive theory, are representative of the gaps that are spotted, as demonstrated by the ‘as-is’ vs ‘where we want to be’ models.

In the same vein as the above core categories, it is proposed that another form of benchmarking referred to as Cross Functional Intellectual Benchmarking (CFIB) which is defined as an organisations ability to develop increasing levels of cognitive markers and measurements, in collaboration with other organizations, preferable external, that are perceived to possess higher standards, which provide progressive levels of attainment across a number of functional disciplines relevant to an organisations endeavours. In other words, CFIB on a general level is (1) the process of identifying the relevant competence and cognitive maturity levels that are required to deliver particular tasks, responsibilities and activities, sometimes across multiple scientific and/or technology disciplines, (2) identifying external organisations that possess these intellectual abilities, (3) approaching, establishing collaborative partnerships and developing knowledge transfer mechanisms to effect the acquisition of the new knowledge and (4) developing action plans to reach similar levels of cognitive maturity, (5) embedding and absorbing the new knowledge within the organisation and (5) the process reverts back to (1) following more navigation complexity activities which identify other areas of skills deficits.

Breaking this concept down, it is recognized that the core aspect of this category relates to the process of intellectual benchmarking. Therefore, the 'intellectual' part of it is explored in some detail because one may ask the question, what do you mean by 'intellectual'? We of course turn to the body of scholarship which defines intellectual as "something that is given to activities or pursuits that require exercise of the intellect (i.e. ability to learn and reason; capacity for knowledge and understanding) and something that is associated with or requiring the use of the mind rather than emotions" (Chan, 2017). By exercise of the intellect, the importance of cognitive activities which refer to the process by which the organism exercises operant control and can modulate or govern sources of variation in what he or she does or thinks (Fischer, 1980) is considered. By this definition it is implied that the organism exercises control over certain circumstances and is able to actively utilize resources at their disposal, say information, to guide their thoughts or actions as well as make rational and informed decisions. Possibly, another definition by Wilson et al. (2017) provides a more succinct understanding. According to them, cognitive activities are those in which seeking or processing information is central to taking action in whatever activity is being participated in. Following this definition, I pause for a moment to consider its implication. Considering the fact that cognitive activities are related to the processing of information following which decisions are made, it must be asked where this information comes from. Once again, I submit that the information is acquired from the core category of navigating complexities, whether across the individual technological or socioeconomic contexts or a combination of both, especially when engaged in the critical process 'balancing' differences.

These scholarly outputs discussed above indicate therefore the possible levels of intellectual or cognitive attainment which we propose are necessary to accomplish the strategic and competitive goals of HVM enterprises, especially when we consider examples of these cognitive and intellectual activities to be "problem solving, sense-making, learning, decision making and analytical reasoning" (Parsons and Sedig, 2014). Given the broad and diverse set of activities carried out by entrepreneurs, their success requires a conceptual framework linking experience, expertise and performance that does not require precise task definitions...the domain of entrepreneurship is inherently multidimensional and consists of many different kinds of tasks at different levels of aggregation (Reuber and Fischer, 1994). These requirements therefore presented opportunities, often interlaced with complexities, that needed critical solutions, especially within the sample population.

While the organizations that were engaged with did not have any formalised ways to set up and measure their chosen processes to establish cross functional, or even, intellectual

benchmarking measures, it was evident from the onset of this research endeavour that this was one of the most critical aspects of their operations. Even with the importance this concept occupied in their operations, I was unable to identify any such evidential information from the extant literature concerning the necessary activities and steps taken by HVM SMEs, or other organisations, to improve upon their intellectual benchmarking activities in a dynamic fashion. Haphazard activities and processes which included both formal and informal continuing professional development (CPD) activities were however very common among these organisations who developed 'learning' programmes, in fragmented patterns, from their relationships with universities and other institutions.

Once again, it was recognised that intellectual capability is a necessary, but insufficient condition on its own, for occupational and competitive success. More than this capability, which we consider can be static or insular on many levels, it is recognized that intellectual benchmarking on the other hand provided the opportunities to recognize one's shortcomings and showed them what to learn, when to learn, and how to learn them. This template is basically a tool for improvement, which is achieved through a means of a continuous and dynamic comparison with other entities or organisations recognised as having the best practices within the designated area. Many who had passed through the universities, for example, viewed them as the custodians of all knowledge, both ancient and futuristic, and therefore consider these institutions as essential to shaping communities through the encouragement of critical thinking and personal development as well as the design and implementation of public policy. They therefore sought to use the relevant research institutes as critical points of reference for their scientific enterprises.

Being that intellectual benchmarking in an organisation should not be carried out in a haphazard manner or in isolation but should be integrated into the organizational framework as part of the overall business objectives of the organisation, the following subcategories were identified from the data analyses:

7.3.6.1 Advanced/Specialist Education

Human Capital is a subject that has been studied extensively, especially by economists. Defined by scholars as the collection of skills that a labour force possesses (Golding, 2016), the force behind the human intellect and innovative capacity of the firm (Johnson, 1999), and better still, "the collective knowledge, skills, abilities and characteristics (that is, all of the capabilities combined) of an organisation's employees and managers that create a

capacity (potential that can be realized) for competitive advantage” (Lengnick-Hall and Lengnick-Hall, 2003; cited in Adam and Urquhart, 2007) this concept has occupied a distinguishable and pivotal position in the determination of the wealth of nations. Indeed, Golding (2016) made reference to this concept going back to the period of Adam Smith. According to her, Smith (1776) noted: “The acquisition of...talents during...education, study, or apprenticeship, costs a real expense, which is capital in [a] person. Those talents [are] part of his fortune [and] likewise that of society “.

However, it was not until the 1950's and 60's that academic scholars began to explore and understand the makeup, characteristics and subsequent impact of this concept. According to Kiker (1966), whose work delved into the economic and historical roots of the Human Capital concept, several motives exist for treating human beings as capital and valuing them in quantitative terms such as demonstrating the economic effects of education, determining the economic effects of education and the significance of the economic life of an individual to his family and country, amongst other things. More recent studies have however identified the positive relationship between human capital and success. Unger et al's (2011) conclusions in their meta analytical study based on 70 independent samples emphasize this relationship and also argue that this human capital increases owners' capabilities of exploiting business opportunities as well as the abilities to acquire resources such as financial and physical capital.

The significance of these are played out in current political and economic situations. More recent studies are however linking this concept to the entrepreneurial pursuits of the modern-day innovator, making reference to the importance of educational pursuits, whether specialist or advanced, in the eventual success of start-ups and innovative firms. Colombo and Grilli (2010) for example, suggest that

“Individuals who have greater educational attainments, greater work experience, especially in the same sector as the new firm (i.e. industry-specific human capital), and greater entrepreneur-specific human capital developed either through a managerial position in another firm or in prior self-employment episodes, are likely to have better entrepreneurial judgment and more specialized knowledge than other individuals. So, they are in a better position to seize neglected business opportunities and take effective strategic decisions crucial for the success of the new firm”

Similarly, Marvel (2013) in their sample of 166 founders of new technology ventures found two classes of entrepreneurs; those entrepreneurs who searched to find venture opportunities and those whose business ideas came to them without having the desire to start the business. The former tended to have bachelor's and master' degrees as their highest levels of formal education while the latter had statistically more years of experience and deeper levels of formal education, such as doctorate degrees. The implications of this finding were significant to this research because in other words, Marvel (2016) was emphasizing that those with doctorate degrees and more years of experience were able to identify cutting edge opportunities without consciously seeking them. In other words, would the results or outcomes be different if those with doctorate degrees actively sought to find venture opportunities? This was a question that was ruminated on but not pursued any further.

Other scholars such as Gimmon and Levie (2010) raised certain hypotheses and following their analysis, found out from their studies that academic status, the acquisition of a PhD or title of professor, had a highly significant and positive effect on the odds of attracting investment as well as the fact that general technological expertise significantly affected venture survival. Similar results from other scholars such as Lee et al. (2005); Manigart et al. (2007) emphasized the advantages of technical and specialist educational attainments in the success and competitiveness of SMEs

Very important, from the excerpt, is the fact that greater educational attainments do not negate the need for skilled and advanced experience within the entrepreneurial sectors. Having both is certainly considered the utmost importance for competitiveness. According to Subramaniam et al. (2016), "...individuals with terminal (doctorate) degrees are skilled in conceptual thinking and conduct their research in highly specialized areas. The value that doctorate degree holders bring to knowledge work stems from their focused specialization".

Regarding advanced and/or specialist education therefore, it was identified from our discussions and analyses that a large number HVM entrepreneurs had acquired, or were in the process of acquiring advanced degrees, for example, PhD's, research MSc's and MPhils. Some had also been involved in Post Doctorate or research positions which within the academic sectors, were seen as advanced, scientific apprenticeships. It was therefore from the specificities and specialist understandings of particular fields of endeavour that 'situational knowledge extensions' (another core capability) and new products and processes were developed.

The findings also identified the ease with which doctorate and other advanced degree holders were able to navigate the seeming complexities of the academic domains towards locating other specialist collaborators for the multidisciplinary partnerships (see Vignette in Chapter 5).

7.3.6.2 Mentorship and Coaching

Oftentimes, the activities that follow the identification of intellectual benchmarking outcomes in HVM SMEs, revolve around the development of action plans to either close the knowledge gaps that have been identified or acquire the new knowledge and capabilities needed for the actualisation of the organisational strategies. These considerations are of course, added to the other challenges faced on a daily basis by these organisations which include inadequate financing, poor marketing as well as resource and skills deficiencies amongst other things. It is therefore obvious, even to indurate observers, that these organisations need some advanced support to ensure their long-term success. In line with this, Gray and Mabey (2005) have stated that the structure of these small businesses and the context in which they operate has led to their preference for informal support rather than formal avenues. Statistics indicate that 82% of managers in large organizations undertake formal development while only 37% of managers in firms with less than 10 employees do the same (Storey, 2004). This of course might be due to the time constraints faced by SME managers and employees which limits the extent to their abilities to engage in formal, full on management development activity (Leitch, 2007), as opposed to the flexibility, focused and informal nature of coaching and mentorship activities. Peel (2004) supports the findings which emphasize this choice by SMEs and includes that rather than engage in external training or support activities, SMEs favour using individuals and mentors and coaches, especially those with whom they have an existing relationship. Despite these needs, and the importance of SMEs to the economy, there is relatively very little research on small firm mentoring (Peel, 2004; Terjesen and Sullivan, 2011). In line with this research however, the literature concerning the effects of mentoring and coaching on capability development and competitiveness was explored. To develop these arguments, I first of all defined the terms from the extant management literature, especially in line with the particular context of the research, which is the focus on SMEs. These definitions are necessary due to the fact that both are often confused for each other. D'Abate et al. (2003) cited in McKeivitt and Marshal (2015) for example, argue that mentoring shares 'concept space' with other developmental relationships such as coaching.

Coaching is seen as a short-term business relationship which is put in place to improve current performance through the acquisition of new skills (McKevitt and Marshall, 2015). Gray et al. (2011) on the other hand suggest that executive coaching is an experimental, individualised and leadership development process that builds capabilities to achieve short and long-term organisational goals. Regarding these definitions critically, it can be identified that the goal of coaching is to improve job performance by facilitating a demonstrable increase in the employee's capabilities which according to Peel (2004) helps these employees manage their own performance. While the links between coaching and capabilities development seem self-explanatory from the definitions and immediately establish the links between them, we are yet to identify the empirical links, if any, between the two concepts. Ideally, we would expect this to be so but we first of all seek the empirical evidence to support this.

We therefore consider some more management research outputs such as Vidal-Salazar et al. (2012), who specifically explore the relationships between coaching and business competitiveness. Using a Wilcoxon-Mann-Whitney test on a sample size of 40 SMEs, their results indicate that coaching substantially increases improvements in these organisations which in turn increase the organisations' competitive capabilities. Similarly, Pousa and Mathieu (2015) seek to understand whether competitive advantage can be achieved through the successes of management coaching. Using results obtained from a sample of 122 Financial Advisors, the findings indicated that the coaching increased employee self-efficacy which promoted employee self-regulation, increased the organisation's resilience which had an eventual positive influence on increasing the organisations competitive advantage. Other studies (Ciutiene and Petrauskas, 2012; Dobrea and Maiorescu, 2015) also demonstrate the links between coaching and its effects on, or contributions to business performance and competitive advantage.

7.3.6.3 Cross Functional Co-ordination

As global competition intensifies, more and more firms are pushed to improve their performance by innovating as well as adopting new processes as well as product development and improvement strategies. To achieve these goals, issues such as the integration, coordination and cooperation between functional areas, whether internal to an organisation or externally between organisations, are considered very important. These are situations in which multidisciplinary and/or cross functional R&D activities are developed and executed towards developing solutions that are able to meet the needs of the societies

in which these organisations operate. This is according to Carr et al. (2008) who agree that cooperation between functional areas facilitate the completion of tasks that benefit the entire organisation as opposed to furthering the interest of the individual functions. Cross functional issues are therefore an important and critical topic in management literature and research.

Within the context of the earlier findings, I first of all define coordination as the skilful and effective interaction of multiple, sometimes complex, elements towards working together effectively for the achievement of a single goal. Carr et al. (2008) provide a similar definition of coordination as “the act of harmonizing the various activities to be performed within a firm to achieve a desired level of effectiveness and efficiency”. Having defined and understood what coordination is, we next look to build the complete meaning of the term, cross functional coordination. We define it as the process through which exchanges, dialogues and interactions happen between functions to speed up the achievement of a single goal. Within the context, once again, of our current discussion where we are looking at this concept as relating to intellectual benchmarking, we consider cross functional coordination to be an important consideration in ensuring that the intellectual benchmarking for the different functions is successful.

With the incorporation of advanced technologies, some of the activities involving cross functional coordination are now supported and sometimes executed by information and communication technologies. Manufacturing related ICT improves the storage and flow of information across functions and supports the knowledge management processes, for example, the operations of e-libraries and e-learning platforms which help in the actualisation of the benchmarking processes.

Proposition 5: organisations that embed advancing levels of cross functional intellectual benchmarking processes into their core capabilities are more likely to develop disruptive products which enhance their overall competitiveness

7.3.7 Proprietary Process & Technology Development

Although we do not consider this to be a part of the core framework which is centred around navigating complexities, we aim to provide a little background to this category considering its importance on the wider framework. As a means to gain competitive advantage in the highly competitive global business environment, organisations continually strive to acquire

and/or develop advanced technologies which facilitate the development and commercialisation of unique products and services. To accelerate these occurrences, many HVM SMEs develop product and technology platforms which provide a strong leverage for the efficient creation of their derivative products (Meyer and Lehnerd, 1997). As it is with some of the RBV tenets, these organisations seek to develop these technologies such that they abide by the VRIN framework (Barney, 1991), which ensures that the resources serve as a basis for sustainable competitive advantage. According to Barney (1991) resources must be valuable, rare, inimitable and nonsubstitutable which of course, means that these resources are sometimes proprietary in nature. These proprietary technologies, which increase the valuation of companies, are considered as decisive factors to achieve market success (Grimaldi et al, 2015) hence the drive to acquire specific capabilities which lead to the development and exploitation of these proprietary technologies.

PPTD is therefore characterized by the acquisition, manipulation and exploitation of technological, and even non-technological, information acquired from the outcomes of the situational knowledge development category. It involves the combination of outputs, often advanced and multidisciplinary technologies and processes, strategically integrated via systems integration methods to create organisation specific value. These are often tangible products which include algorithms, basic designs, tools which serve as platforms upon which innovative products and services are launched for commercial benefits. To buttress this fact, Ferdows et al. (2016) suggest that a firms plant network can be delayered into a set of subnetworks based on a) complexity and proprietary design of the products they produce and b) complexity and proprietary design of the processes they use to produce them.

7.3.7.1 Advanced Technology [Management] Platforms

Many organisations understand that one of the keys to success involves the development of a continuous stream of valueable products that target specific markets with growth potentials. This therefore compels these organisations to find ways in which multiple new products can be developed, thereby building up product families which share common base technologies but have different outward features. This is the basis for the development of product platforms or platform technologies, which Meyer and Lehnerd (1991) define as, “a set of subsystems and interfaces that form a common structure from which a stream of derivative products can be efficiently developed and produced”. Robertson and Ulrich (1998) on the other hand define the platform as the collection of assets that are shared by a set of products, where these assets can be divided into 4 categories; components,

processes, knowledge and people or relationships; while Chen et al (2017) define a platform technology as a baseline technical architecture, often a combination of both software and hardware, that allows other applications, processes and/or technologies to be developed on it.

Take for example, Weinberger (2015) who commented on Apple's platform, "Apple's goal is to create the best platform experience in the world, so each new apple product you buy improves the experience on all the other Apple products you already own...". Also referring to Apple, an excerpt from Lohr's (2011) article in the New York Times entitled 'The Power of the Platform at Apple', he provided examples of successful organisations that leveraged the platform strategies in their business models;

"Successful technology platforms sustain and reinforce growth. And this self-reinforcing cycle is known as a network effect. It helps the platform owner and raises a barrier to competitors... Still, the technology business – with its interconnected hardware, software and networks – tends to be where platform strategies are most prevalent and the payoff greatest. In the corporate market, IBM is pursuing a platform strategy... Oracle has built a rival computing platform surrounding its database software... Google's search service, combined with its in-house advertising marketplace, is the leading internet platform strategy. In personal computers, Microsoft has been the platform-strategy master...its Windows operating system running Microsoft's Office productivity application is probably the most lucrative product platform in history"

Within Lohr's (2011) article, he cited two professors, Michael Cusumano²⁷, and Marco Iansiti²⁸, who stated respectively, that "Apple has hit that magical combination of gradually shifting from a product to a platform strategy" and "the iPhone was such a great product that lots of people wanted to write applications for it... This was a case of the hit leading to

²⁷ Professor Michael A. Cusumano at Sloan School of Management M.I.T, specializes in strategy, product development and entrepreneurship and is the author of 13 books including *Staying Power: Six Enduring Principles for Managing Strategy and Innovation in an Uncertain World* and *Platform Leadership: How Intel, Microsoft, and Cisco Drive Industry Innovation*

²⁸ Professor Marco Iansiti, at Harvard Business School specializes in technology, operations strategy and the management of innovation. He has authored a number of books including: *One Strategy: Organization, Planning and Decision making*, *The Keystone Advantage: What the New Dynamics of Business Ecosystems Mean for Strategy, Innovation and Sustainability*

the platform, and not necessarily voluntary for Apple". Lohr's (2011) comments once again, point to the adoption of platform business models by modern digital organisations such as Apple. In the case of the above citations, Apple's adoption of this business model was not planned but was as a result of the success of the iPhone. This shift in the model emphasized the 'smart prospecting' aspect of navigating complexities.

These selected quotations above indicate that organisations must therefore determine the precise structure of the product or technology platforms suitable for their business (Meyer and Lehnerd, 1991). Indeed, these have presented a new type of business model which organizations are keen to acquire because essential to all these platform businesses is the ability to acquire, store and manipulate data for their benefit. It is worth stating, that in knowledge driven economies, data and access to a sizeable portion of it is the fuel that drives most firms, as it provides their advantage over competitors.

These discussions also indicate the proprietary nature of most of these platform technologies due to the fact that they are the sole property of the organisation that developed them. This is aligned with Prasad's (1986) argument stating that proprietary technologies are best treated as assets of the firm due to the fact that the firms in question allocate a certain amount of their financial resources over a period of time to R&D activity which enables these technologies come into existence. Furthermore, others argue that these proprietary technologies are both tangible and intangible knowledge-based resources over which the firm has control, having developed them in-house (Khavul et al., 2010). According to Schroeder and Flynn (2001), proprietary technology is often the only aspect of manufacturing technology that is attributed to high performance manufacturing. This is due to the fact that organisations frequently leverage the technologies to establish longer lead time over potential market entrants thereby earning high rents over a period of time (Shepherd and Shanley, 1998). These proprietary technologies are therefore protected by law, through intellectual property rights and are used solely by that organisation for product development and proliferation (Jin et al., 2013), which overall impact upon the competitiveness of the organisations.

In summary, Featherstone and O'Sullivan (2017) provide a brief overview of proprietary technologies thus;

"A proprietary technology is a technology that has reached a point of specificity in configuration and application where intellectual property rights (e.g, technical or design patents, industrial design

rights) have been recognised, registered or acquired... Generic technologies (or application platform technologies) are technologies that have become platforms which can be built upon and configured, possibly with other technologies, to form a number of sequential generations of proprietary application technologies... Generic technologies and proprietary technologies are 'principal technologies' – technical knowledge that is advanced and combined to create commercial technologies deployed in markets”

Based on evidential data from our interaction with our case study respondents therefore, we conclude somewhat that HVM firms competitiveness is based on their ability to develop and subsequently exploit any proprietary platform technologies in their possession. After all, according to (Harianto and Pennings, 1994) The scope of new technological projects in HVM firms is contingent upon proprietary technology and access to that of others.

Proposition 6: Market competitiveness is strongly dependent on the development and exploitation of proprietary technologies as well as the organisations ability to develop situational knowledge stretching outputs from navigated complexities

7.4 Chapter Summary

This chapter has presented the theoretical framework of Navigating Complexities, which is the culmination of all research activities for this study and the result of complex social interactions and multiple layers of compounded processes. Detailed explanations have been proposed for each of the components of the framework, thereby providing answers to the research questions. The chapter also provides evidence from the body of literature, for each of the components discussed, thereby highlighting some previous references and relationships to the body of knowledge. In addition to the above, 6 high-level propositions which are intended to be further refined, explored and elaborated by the OM and strategy research community are presented. These propositions are all related to the substantive theory hence, are all closely interwoven.

Chapter 8: Conclusions and Recommendations

8.1 Introduction

The purpose of this chapter is to conclude the entire study by reiterating the grounded theory outcome, linking it with the initial literature review conducted in Chapter 2 as well as the more focused review in Chapter 6, following which the discussions surrounding the implications for practice and research will be stated. The relationship between the Dynamic Capabilities and Navigating Complexities theories will also be touched upon, giving examples of other theories also. The research limitations will be identified and some ideas and directions for future research based on not just our experience, but also the research outcomes will be proposed.

8.2 Grounded Theory Conclusions

The core aim of grounded theory is to generate a theory specific to a particular issue, which is grounded in the data collected from those involved with the issue or situations surrounding it (Strauss and Corbin, 1990). The grounded theory developed in this current study proposes a Navigating Complexities framework (See Figure 8.1) that explicates the most important issues that HVM innovators, entrepreneurs and owner/managers who are responsible for managing the affairs of SMEs located in Wales, have to contend with. More importantly, the framework that the study presents for consideration explains the processes involved in identifying and managing the development of competitive manufacturing capabilities. This framework draws on literature from general business and management including dynamic capabilities, knowledge management and some aspects of decision making. Other subject areas from which ideas are drawn include social science topics such as economics, complexities management and communication.

The grounded theory framework suggests that with the myriad of complexities inherent within the socio-economic fabric of different levels of society, the processes by which organisations develop their competitive manufacturing capabilities which in turn support the delivery of their products and services as well as their value propositions to their customers, must take into consideration the need to overcome or navigate through multiple complex situations, sometimes simultaneously. The grounded theory suggests therefore, that HVM

SMEs need to adopt and embed navigating complexities capabilities into their portfolio of core competitive and organisational capabilities, as this impacts upon their end-to-end operations whether they are inward facing within the organisation or outwardly facing towards the external environments. It should be noted however, that this theory conceptualises one pattern of combined behaviours and as such, acknowledges that the organisations may be engaged in other patterns which may be investigated further.

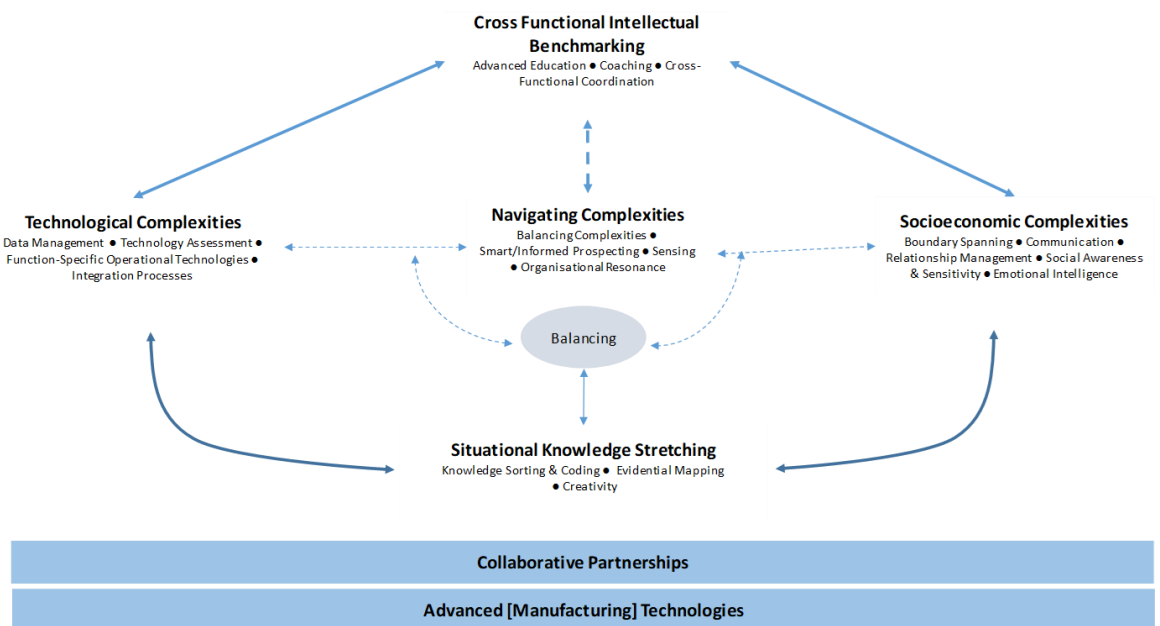


Figure 8.1: Emergent theory of Navigating Complexities

This proposed core capability, for the purpose of this study, was further split up into technological and socioeconomic complexities due to the fact that HVM SMEs, often characterised by their dependence on advanced technologies and its use in all facets of their operations, were mostly set up to meet or overcome socioeconomic needs. In the case of this research, these HVM medical/healthcare SMEs were established to develop and manufacture solutions to meet medical/healthcare challenges, while exploiting the most advanced technologies available for this purpose.

The findings also suggest that the proposed core capability of navigating complexities is grossly inadequate without a second proposed core capability identified as cross functional intellectual benchmarking. Indeed, it is this capability that provides the impetus to

continually acquire the knowledge and resources necessary, wherever and whatever they may be, to develop the modularised building blocks which are subsequently morphed into complete solutions. The adjectival inclusion, 'wherever and whatever they may be' represents the cross functional aspect of the capability, as the knowledge required for most advanced technology new products are multidisciplinary in nature. That said, intellectual benchmarking in itself was identified as a powerful capability for organisations to develop as the need to continually measure their intellectual and cognitive capabilities against chosen external standards was the first step toward implementing and executing learning and knowledge transfer activities. Again, based on findings, the processes surrounding cross functional intellectual benchmarking were often established and subsequently executed in collaboration with multiple university research institutes as these entities were able to provide the advanced knowledge, resources and general capabilities needed by the organisations seeking to develop innovative products and services towards enhancing their competitiveness. The universities provided the 'meeting point' where one organisation could source for support across different disciplines, and do so with coordinated expertise from university technology transfer offices – all at affordable rates when compared to privately sourced support.

Finally, the last capability which the research presented had to do with situational knowledge stretching. Ideally, in the knowledge-based economies of the 21st century, the ability to harness and manage knowledge makes the difference between an organisation's ability to succeed, rather than fail. This, for all organisations is an order qualifier, the capability that enables organisations remain operational. The order winner however, is that capability that takes the organisation a step further to begin to 'create' new knowledge as well as solutions which according to the emergent theory, is the culmination of all of the other category outputs put together; where knowledge from a situational event is captured and possibly developed, not necessarily through conventional knowledge, but through inference – the stretching of knowledge. This is the moment when the collaborative efforts between the organisation and the external partners, having worked to navigate through both technical and socioeconomic complexities, identify that product or solution that has commercial value. This new knowledge becomes the potential currency of the organisation delivered through intellectual property rights which can be monetized for the further benefit of the organisation and its staff.

Building Blocks	Composition	Explanation
Cross Functional Intellectual benchmarking	Advanced/specialist education • Coaching • Cross functional Coordination	To support the knowledge management agenda of the organisation across multiple disciplines and functions, simultaneously • Improve the acquisition of advanced knowledge and capabilities for new product development
Navigating Complexities <i>Respondent considered this to be their core concern regarding competitive capabilities and felt that all other categories affirmed this one</i>	Balancing complexities • Smart/informed prospecting • Sensing • Organisational resonance	To methodically navigate complex situations, especially those of the technological and socioeconomic kind • Gather value from different sources towards providing balance and/or proportionally designed and sustainable solutions for customers
Technological Complexities <i>Subset of Navigating Complexities</i>	Data management • Technology assessment • Function specific operational technologies expertise • Integration processes	Having a high level, general understanding of multiple technologies but desirable specialism in one or more • Ability to conceptualise and integrate multiple technologies to create compounded solutions that are difficult to imitate
Socioeconomic Complexities <i>Subset of Navigating Complexities</i>	Boundary spanning • Communication • Social awareness & sensitivity • Emotional intelligence	Understand the socioeconomic, macro and micro trends driving human behaviours • Identify relevant details and 'connect the dots'
Situational Knowledge Stretching	Knowledge sorting & coding • Evidential mapping • Creativity	To make logical inferences concerning the creative use of elements for proposed innovative solutions • Develop solutions and their building blocks based on certain needs, situational occurrences and positional challenges
Proprietary Process Technology Development <i>Although identified in the initial research, it was not considered part of the core framework following the framework evaluation and assessment</i>	Specialist knowledge • Technology & Systems Integration • Advanced technology platforms	To develop unique, organisation specific platforms upon which products can be assembled, maintained and launched

Table 8.1: Summary of core categories, explanations and building blocks

8.3 Integrating the grounded theory into the literature

The initial literature review in Chapter 2 as well as the more focused effort in Chapter 6 present different interpretations of the current research endeavour. While the review in Chapter 2 provides a general background to the research with respect to understanding the general manufacturing capabilities literature as well as the philosophical underpinnings behind the choices of methodologies chosen for the different research activities, Chapter 6 provides a more concise view of the aspects of manufacturing capabilities that were important to HVM SMEs, which when based on the emergent theory of this research, focus on competitive and dynamic capabilities. In other words, while Chapter 2 provided the overview of what manufacturing capabilities are made up of, Chapter 6 highlighted the uniqueness of the individual manufacturers' operations and what makes each one competitive and different from the others by looking at theories such as the Resource Based View (RBV) and how these resources need to be valuable, rare, imitable and non-substitutable (VRIN). This, according to Hayes and Pisano (1994), is what the new manufacturing strategy entails; the creation of operating capabilities a company needs for the future;

“In a dynamic setting, however, solutions are viewed as part of a longer-term path of improvement. Individual practices are adopted not just to solve an immediate problem but also to build new skills that open up new opportunities. From this perspective, manufacturing strategy is not just about aligning operations to current competitive priorities but also about selecting and creating the operating capabilities a company will need in the future”

Peng et al (2008) also highlight the importance of individual (organisational) routines in the creation and development of competitive manufacturing capabilities. According to them, “capabilities do not reside in individual routines but emerge from the synergistic interplay among multiple interrelated routines”. In other words, they imply that capabilities are built through the identification, development and integration of bundles of routines.

In our research findings, certain routines and dynamics were identified, which when combined made up the core categories described throughout the thesis. These routines were captured in the low-level categories identified for each of the 4 core categories (see Chapter 5; Tables, 5.3, 5.5, 5.7 and 5.9). The research findings indicate that these may

constitute the routines that Peng et al. (2008) speak about, when they mention that, “drawing on the resource-based view (RBV), we argue that routines are a critical source of operations capabilities and subsequently investigate operations capabilities by means of their underlying routines”.

Issues which may remain however, are with the understanding of what the dynamic capabilities theory represents and what are the key relationships and/or differences between existing theories and the proposed Navigating Complexities theory. This arises because while the concept of Dynamic Capabilities is defined and expatiated upon in Section 6.4, no specific relationships or differences were provided.

Question	Reason	Description
What	What is the claim?	<i>Enunciates the critical factors or entities that must be considered an important part of the phenomena being explored</i>
How	What is the claim?	<i>What are the relationships among these entities?</i> <i>“...this involves using ‘arrows’ to connect the ‘boxes’. Such a step adds order to the conceptualization by explicitly delineating patterns. In addition, it typically introduces causality”</i>
Why	What are the reasons for the claim? What is our evidence for the claim?	<i>“What are the underlying psychological, economic, or social dynamics that justify the selection of factors and the proposed causal relationships? This rationale constitutes the theory’s assumptions – the theoretical glue that welds the model together”</i>
Who-Where-When	Under what context are we making this claim? What are the qualifiers for the claim?	Proves theory with empirical data and sets limits on how that theory is, or can be used. Under what conditions will the theory operate.... or not?

Table 8.2: Tabular representation of Whetten's (1989) framework

Dynamic Capabilities represents the ‘what’, while Navigating Complexities identifies the ‘how’ as indicated in Table 8.2. Dynamic Capabilities is defined as “a set of specific and identifiable processes such as product development, strategic decision making, and alliancing” (Eisenhardt and Martin, 2000); “a firm’s ability to integrate, build and reconfigure internal and external competencies, to address rapidly changing environments” (Teece et al., 1997) and “the capacity of an organization to purposefully create, extend and modify its

resource base” (Helfat et al., 2007), where the resource base includes the tangible, intangible and human assets (Helfat and Peteraf, 2009). The critical aspects from the definitions are: Eisenhardt and Martin (2000) in their definition, refer to ‘specific and identifiable processes’, Teece et al. (1997) refer to ‘internal and external competencies’, while Helfat et al. (2007) point to a ‘resource base’. As argued earlier, these represent the ‘what’ of the dynamic capability definition and construct.

Navigating Complexities on the other hand identify the ‘how’ indicating, from Eisenhardt and Martin (2000); Teece et al. (1997) and Helfat et al (2007), the exact capabilities and resources that need to be acted upon to enable the construct of Dynamic Capabilities. In this case, the ‘specific and identifiable processes’, the ‘internal and external competencies’ as well as the ‘resource base’ are represented by the following building blocks (processes) of the Navigating Complexities theory; *Intellectual Benchmarking*, *Navigating Socioeconomic and Technological complexities*, *Balancing these complexities*, *Situational Knowledge Extension* as well as their individual underlying routines. It is with clarity therefore, that we confidently argue that Navigating Complexities *is* a dynamic capability as once again, Anand et al. (2009) argue that “the ability to make changes to routine operating processes through organisational learning is a dynamic capability”.

In light of these arguments, scholars have identified other examples of dynamic capabilities within management research such as ambidexterity (Lee and Rha, 2016; O’Reilly and Tushman, 2008; Zollo and Winter, 2002), design creativity/management (Azadegan et al., 2008; Fernandez-Mesa et al. 2013), absorptive capacity (Patterson and Ambrosini, 2015; Daspit et al, 2019). Going back to the definition once again, we understand dynamic capabilities to be “repeatable routines and competencies that are associated with effective short run competition in mature markets and technologies and in the long-term through adaptation to new markets/technologies” (O’Reilly and Tushman, 2008). In the case of ambidexterity for example, various researchers (Tushman and O’Reilly, 1996; Kauppila, 2010; Stettner and Lavie, 2014) suggest that firms need to be able to ‘explore and exploit’ simultaneously to be ambidextrous. Birkenshaw and Gibson (2004) suggest that firms need to master both ‘adaptability and alignment’ while Bodwell and Chermack (2010) on the other hand adopt Teece’s ‘tripartite taxonomy of sensing, seizing and reconfiguring’ opportunities to remain ambidextrous. In comparison with Navigating Complexities, we identify similar lower capabilities and/or routines that align with exploration and exploitation, adaptability and alignment, as well as sensing, seizing and reconfiguring. For example, in comparison to exploration and exploitation, Navigating Complexities deals with ‘exploration’ by navigating through both technological and socioeconomic complexities to identify the

relevant opportunities available to the firm for 'exploitation' purposes. This exploitation arises from both these complexities (technological and socioeconomic) and their balancing thereof, especially regarding the new knowledge that has been created for the actualisation of a new product, service or process. Similar arguments arise for ambidexterity's 'adaptability and alignment' bottomline in that the theory of Navigating Complexities similarity to these two concepts rests in its being able to navigate while balancing priorities towards catering to the exact needs of the stakeholders. By far the most straightforward similarity and comparison is from Bodwell and Chermack (2010) who mention 'sensing, seizing and reconfiguring' as prerequisites for ambidexterity. Sensing and seizing were identified as lower level capabilities in the Navigating Complexities category while reconfiguring was a part of the situational knowledge extension category where knowledge was sorted, coded, mapped and creatively extended, or better still, 'reconfigured'.

Similarly, Absorptive Capacity also demonstrates some similarities with Navigating Complexities, especially regarding their base routines which constitute their individual constructs. Defined as 'the ability to recognize the value of new external knowledge, assimilate it, and apply it to commercial ends (Cohen and Levinthal 1990), Zahra and George's (2002) representation of Absorptive Capacity for example argues that organisations need to 'acquire and assimilate', as well as 'transform and exploit' external sources of knowledge and experience to remain competitive. A closer consideration of the Navigating Complexities theory identifies these routines within its various categories as the need to acquire and assimilate knowledge which navigating, as well as transform and exploit while creating new knowledge is critical for success

What all these 'dynamic capabilities' represent is the fact that whether we refer to ambidexterity, absorptive capacity or even Navigating Complexities, organisations need to consciously imbibe the capacity to recognise various trends and then effectively implement the relevant changes within their operations. In most cases, this is done through elements of knowledge exploitation, where the capacity to identify relevant information, absorb it and exploit is critical.

8.4 The substantive theory and its theoretical contribution

The role of the university has evolved over time, from a primary emphasis on freedom and independence of scholarly inquiry and 'knowledge for its own sake' to being a source of knowledge that is requisite for economic growth and a strong economic performance

(Audretsch, 2012). Higher education institutions, especially those of the research-intensive kind, have therefore been assigned the crucial role to play in forging new forms of economic productivity through the generation of new knowledge and understanding. Some other researchers point to the importance of theory in management thus: “theory is the currency of our scholarly realm” (Corley and Gioia, 2011),

According to Boer et al. (2015), doctoral studies are a starting point in this journey where a great emphasis is placed on the researcher making a theoretical contribution to theory in the field, and this continues throughout the researchers’ career in the social sciences. Evans et al. (2005) explain further;

“A doctoral candidate is expected to demonstrate that they have conducted an appropriate piece of research on a topic about which their scholarship has made a ‘significant original contribution’ to our knowledge. In this sense, a doctoral candidate typically has a lot more invested in their doctorate than a university staff member has invested a research project. The risk for the doctoral candidate is not just that their research may not produce worthwhile findings—something that is a risk with any research—but that, if they do produce worthwhile findings, they will be ‘gazumped’ by another researcher producing the same or similar results and publishing them before their thesis is examined. There is also the risk that their findings may not be seen as significant and original by their examiners. In many respects, some might think that the risks of ‘failure’ are too great”

To determine what constitutes a theoretical or significant original contribution to management research therefore, various scholars have proposed different building blocks or ‘checklists’ which provide benchmarks with which the ‘strengths’ of theoretical contributions can be measured. According to Bergh (2003), frameworks which remove some of the guesswork in considering the strengths of a contribution are in existence. For the purpose of this PhD’s theory submission, we will consider some of these frameworks before we use one of them to assess our theory of navigating complexities.

Whetten (1989) for example, proposed a simple way to identify the necessary ingredients of a theoretical contribution. According to him, a complete theory must contain four essential elements; What, How, Why, Who-Where-When (See Table 8.2).

Bergh (2003) on the other hand, propose that researchers evaluate their contributions relative to three tests:

- **Whether the contribution is valuable.** Does it add an insight that is important and relevant for other researchers and/or practitioners? Will it change the development of explanations or how researchers think about a subject?
- **Whether the contribution is imitable.** Is the contribution specific to the theory that it is trying to extend or revise?
- **Whether the contribution is rare.** Is the contribution surprising and unexpected? Is it more of a common-sense derivation or does it present a novel and unique insight?

After these tests have been administered to each individual contribution towards understanding their contributions to the body of knowledge, Bergh (2003) still argues that researchers identify, explain and argue for their contributions to be seen as valuable, original and specific to the theories they proposed to advance. In other words, he stresses that 'ticking the boxes' will not ensure that your contributions are readily received with open arms - a well-articulated argument stating your points logically may do just that.

Although other frameworks and arguments exist (See Van de Ven, 1989; Reay and Whetten, 2011; Corley and Gioia, 2011) we take a look at one more before assessing our substantial theory. This submission, in the first instance looking at the importance of theories, examines Wacker's (1998) guidelines as to what makes a good theory: it provides (1) a framework for analysis, (2) an efficient method for field development, (3) clear explanations for the pragmatic world. Following this, Wacker, through his definition of a theory also points out that a theory is made up of; (1) definitions of variables, (2) boundaries where the theory applies, (3) the relationships between variables, and (4) specific predictions. Lastly, Wacker also proposes some further guidelines which he calls 'the virtues of good theory'. He identified these as; Uniqueness, conservatism, generalizability, fecundity, internal consistency, empirical riskiness and abstraction

Having considered these different guidelines, the theoretical contribution of 'navigating complexities' is critically assessed according to Whetten's (1989) four-step guidelines. Although Wacker's (1989) guidelines were proposed for theories within an Operations

Management domain, there are close similarities between their guidelines and those of Whetten (1989) and so we believe that using one as an assessment tool invariably provides a shoe-in to the other.

Whetten's (1989) first building block is the 'what' – which compels us to table our claims by asking, "which factors (variables, constructs, concepts) logically should be considered as part of the explanation of the social or individual phenomena of interest"? Zhou et al. (2017), having understood Whetten's (1989) guidelines, suggest that we 'choose the factors affecting the phenomena'. Regarding 'navigating complexities', the factors affecting the phenomena include those just outside its boundaries, and connected by arrows; including; Cross functional intellectual benchmarking, situational knowledge extension, technological complexities, socioeconomic complexities and the balancing of both therein (These are explained further in Chapters 5 and 7). That said, when we consider the 'parsimonious' aspect of Whetten's (1989) assessment criteria, we delete factors which add little value to our understanding of the theory, including proprietary process technology development and Innovation and product development capabilities (See complete framework in Figure 7.2). As these are argued to be the outcomes of negotiating complexities their addition to the theory does not add any greater understanding. Further arguments which may be extended regarding the 'what' question include the fact that as this theory is an emergent one, arising from the GT process, its credibility is likely to be strengthened. It is worth calling to mind that in the classic GT studies, the categories leading to the theories are not pre-defined but emerge from within the data as an evolutionary research process, reflecting the concerns of the research participants.

The second building block used to assess theoretical contributions is the 'how' – having identified the critical entities or set of factors, what are the relationships between them? Whetten (1989) suggests "using arrows to connect the boxes", where "such a step adds order to the conceptualization", thereby introducing causality. In other words, this stage makes suggestions concerning the linkages between activities towards generating outcomes for our phenomena under observation. The diagrammatic representation therefore, of our 'how' represented by navigating complexities and the other factors is demonstrated in Chapter 7 (See Figures 7.2 and 7.3) showing the relationships between the set of factors identified by the 'what' question above. This is in line with Whetten's (1989) suggestion that, "the more complex the set of relationships under consideration, the more useful it is to graphically depict them". Once again, in accordance with the GT tenets, these relationships are emergent and not prescribed by the researcher.

The third building block of theoretical contribution once again, according to Whetten (1989), is 'why'. The question to answer is, "what are the underlying psychological, economic, or social dynamics that justify the selection of factors and the proposed causal relationships?" This again, is demonstrated by the arguments tabled in Chapter 7, where navigating complexities as well as the set of factors related to it are intermeshed in social, psychological and economic dynamics. If we accept Durlauf and Young's (2004) definition of social dynamics as "the processes by which individuals are directly influenced by the choices and characteristics of others, creating a feedback loop from the past choices of some people to the current social context and future choices of others" as well as The Business Dictionary (2019) definition of economic dynamics as, "changes in an economic system over time, particularly those reflected in the behaviour of markets, businesses and the general economy", it is easy to see and juxtapose our theory with both definitions. For one, the success of the theory is dependent on collaborative R&D, learning and intellectual progress processes, which amongst other things that constitute the theory can be classified as influencers of psychological, economic and social dynamics.

The last building block is the 'who, where, when' and by these, Whetten (1989) compels the researcher to identify the conditions or circumstances under which the concepts and relationships will work. Once again, the arguments of Section 7.2.1.1 provide the context under which we make the claim that this emergent theory will work. The organisations themselves need, first of all, to be in search of improvements to their current states. The desire to want to compete and upgrade their competitive capabilities needs to be imbibed within all levels of their operations.

8.5 Methodological contribution

As highlighted earlier in the thesis (see Chapters 1 and 2), various scholars have suggested the need for alternative approaches to modern research activities, whether through problematization as a methodology for assumption-challenging studies (Alvesson and Sandberg, 2011) or the use of previously unused, or rarely used methodologies. In response to this, a few Operations Management researchers, for example, McAdam et al (2008), Binder and Edwards (2010), have heeded the call and have taken it upon themselves to develop theories for operations managers using the Grounded Theory methodology. Likewise, in response to this call, this research study has used the Grounded Theory methodology in this exploratory study to try to understand competitive manufacturing capabilities from the point of view of High Value Manufacturing SMEs.

8.6 Evaluating the Grounded Theory

Having developed the grounded theory methodology, Glaser and Strauss (1967), and later on reaffirmed by Glaser (1992), proposed the concepts *fit*, *work*, *relevance* and *modifiability* as criteria for judging the quality of their theory.

By 'fit', they meant that the emergence of the categories strictly from the data was essential and that these categories must not have been forced or selected from any preconceived understandings of other theories and phenomena. To ensure that this 'fit' was observed, Giske et al. (2007) emphasized the need to constantly validate the categories by fitting and re-fitting them into data.

In the case of this research, the research 'fit' was sought through the dissemination of the emergent results and discussions with different stakeholders. Regarding the dissemination, publications based on the emergent categories were presented at public fora, including academic conferences and fairs at both international and local levels. The feedback received was favourable, with participants commenting on the usefulness and relevance of the categories, following some advice provided by some of the more experienced participants. In addition to the above, the emergent theory in its complete stage, was shared and discussed with practitioners and professionals working in the same sector as the research endeavour. Although the research was carried out in Cardiff and these practitioner discussions held in Central London, the practitioners commented on the succinctness of the theory as well as fit with their ongoing challenges. For example, one of the companies 'tested' the theory with mentioned that they were using the theory as a checklist for developing their business. As a 2-year-old startup being run by a former biosciences post-doctorate researcher from a university research institute, she recognised the need for continuous intellectual development, the need to 'balance' priorities (socioeconomic and technological complexities) as well as the need to develop capabilities around situational knowledge stretching. She was particularly interested in the lower level categories which made up the themes and mentioned that;

"...the simplicity of this tool is welcome...it is so easy to use as a checklist to help us identify what we may be missing in our company...and the things we need to develop. I guess we can use it

time and time again, even as the company grows. Some of the words though, might be a bit...a bit...misunderstood and you may need to explain them to some people as you explained them to me..."

The second criterion, 'work' refers to the ability of the emergent theory as well as the different categories to explain, interpret and predict what is going on in the area under study. Once again, these ideas, emerging codes and categories were presented to both academic and practitioner audiences who validated them, sometimes with comments and suggestions for change and/or improvements. Earlier discussions also with the research supervisors helped the process of validation. Based on professional experience, the supervisors also offered their suggestions for coding and category improvements

'Relevance', the third criteria meant that the theory and its categories should be relevant to the core concerns of the participants and practitioners. The same arguments above hold for this category. In the very often ambiguous environments in which these HVM SMEs operate, the need to identify models and frameworks that will support the advancement of their operations is necessary. In this context, routines and dynamics such as intellectual benchmarking, navigating complexities and knowledge extensions identified the relevant activities that needed to take place. In a similar way, to the 'fit' evaluation above, two other company owners were engaged in a detailed discussion around the relevance of the categories which make up the theory. Once again, the feedback received was favourable. For example, Company 1 mentioned

"...I recognise some of what you have supported us with...the introduction to the universities...I suppose that this is where the intellectual benchmarking will happen...we can continue measuring ourselves...our organisation's knowledge capacity against that of our our collaborators. Actually, one of our biggest challenges is the balancing part of Navigating Complexities...we always ensure that our product development process is a co-innovative one. We develop our products with our clients...this is where out balance comes from. Overall, I think your work is relevant for us...is it a flexible one and can we use only what we want... I would like to explore the cross functional intellectual benchmarking and situational knowledge extention parts a bit more....?"

Following this discussion, Company 2, who was in the same room and involved in the discussion mentioned that:

“...both frameworks are relevant to our businesses.... our preference actually, is for the end-to-end framework which contains the...your [shortened] theory...plus more. The end to end framework contains everything we are concerned about...we continually strive to develop and sustain our competitive capabilities which amongst other things, we do through benchmarking, balancing our use of social complexities to inform our technological innovations, developing our abilities to utilise information and knowledge....and developing company specific processes and technologies...as you know, we are rich in patents...I would consider these to be our proprietary assets...”

The last criteria, ‘modifiability’, simply means that the emergent theory might still be prone to changes should new data be introduced. This criterion is therefore hinged on the ease with which additional insights can be considered within the emergent theory to facilitate changes within that theory. This is a core feature of grounded theory studies

8.7 Implications of study

Although the main focus of this research endeavour was to develop a substantive theory, the theory that has been developed exhibited practical applicability, not only in the firms that were sampled, but in others who had at one time or the other, had cause to engage with the researcher outside the boundaries of the project. This section highlights therefore, the implications that navigating complexities has on practitioners, academics and policy makers, due to their individual stakes in it.

8.7.1 Implications for Practitioners

The transition from being a self-reliant, internal facing organisation to one that constantly looks outwards for support, and owes a substantial portion of their successes to collaborative efforts and successes from their external engagement is not something that organizations find easy to accomplish. This however, is an activity that has to be built into

their operations if they hope to take advantage of the knowledge that university research institutes, as well as certain external partners and collaborators, have to offer.

One of the characteristics of adopting navigating complexities as a core category within HVM SMEs is that it enhances the abilities of the organisations to react spontaneously to changes within the socioeconomic fabric of society, while at the same time developing new competencies in resonance with the ability to identify, understand and react to these changes. In addition to those new competencies that have been developed, it is indeed possible also, for the organisation to soon after develop their enhanced situational knowledge awareness skills which directly inform the conceptualisation of novel organisational outputs such as products and/or services. That said, such an environment incubates the desires for continuous improvement through the embedding of intellectual benchmarking practices, in addition to others such as the smart prospecting, sensing, balancing complexities and others

While some member of the organisation may adjust easily to the new environment, which has as its core, a need to as much as possible, remain outward looking for directions, others may struggle and possibly decide not to continue. It is however up to the managers to ensure that those in the relevant departments engage actively with external partners.

In addition, the results from the case studies identified a number of actions that need to be observed within the HVM SME's to ensure they maximize the opportunities provided by this emergent theory. Firstly, the owners and senior managers should have a clear understanding of the aims and objectives of their organizations as well as their immediate projects as well as ensure that they identify the exact knowledge streams necessary to achieve these goals. This ensures that they understand what kind of expertise they need from their collaborative R&D partners.

Secondly, the owners and senior managers of these SMEs need to consider critically, the criteria they use for the selection of academic partners. Rather than a narrow focus on institutions that possess the particular expertise needed by the organisation, such as immunology or oncology, the SME should focus on institutions that have well rounded and multidisciplinary research groups such as those that have the immunology or oncology groups, but also certain engineering as well as other medical sciences. Additionally, the SMEs should ascertain whether these institutions have active outward facing research groups as it is one thing to possess particular expertise and it is another to have it frequently tried and tested practically. This puts some pressure on the organisations to do more ground

research as well as effective networking before committing to any substantial engagement and partnerships.

8.7.2 Implications for Research and Academia

Aspects of the emergent theory of navigating complexities that impact on academia are those regarding the issues around intellectual benchmarking, especially in areas relating to science and technology knowledge and practice. This category, intellectual benchmarking directly impacts on academia as they are the benchmark that these organisations look up to for intellectual guidance and knowledge. It therefore puts upon them further responsibilities to not only engage themselves in tasks pertaining to teaching and fundamental research, but to also ensure that their ability to interface with, and support practitioners is up to date. This therefore throws some extra responsibilities upon them. That said, this project affirms the need for increased levels of university-industry relationships which challenged the universities further, to adopt new business models for their industry. No longer should university models only consider teaching and research as their sole responsibilities, but a measure of external engagement and business support should feature on their priorities. Although policy makers are already pushing this into the mainstream of university responsibilities, through their 'impact'²⁹ agenda, some institutions still abide by the old business models.

Consequently, this study has contributed to the theoretical extension, and the body of knowledge of one of the ways in which competitive manufacturing capabilities are developed and further enhanced. With findings from the case study firms, the theory provides some further indication of the different components that make up each individual category and the activities that must be performed continuously to achieve the desired outcomes. This theory therefore presents a framework that academic researchers, strategic consultants can use towards analysing the propensity of companies to achieve competitive advantage. Set as a 'foundation' theory, it is possible that it can be built on (modifiability) to further extend the theory into other dimensions.

²⁹ Impact is "the demonstrable contribution that excellent research makes to society and the economy". Available at <https://www.ukri.org/innovation/excellence-with-impact/> [Accessed 28th August 2019]

8.8 Limitations of Study

According to Creswell (2007) study limitations are the characteristics of research design and methodology that have influenced or made an impact on the outcomes of any research endeavour. Recognising and discussing these potential limitations, following which they are presented in an unbiased way represents a crucial part of the scientific progression (Puhan et al., 2012). It is believed that a forthright discussion of these limitations puts the research into further perspective for the stakeholders invested in it and offers, directly or indirectly, steps which may be taken into consideration during the next phases of the research. That said, there are limitations to this study that need to be acknowledged and discussed in some detail.

Firstly, the purpose of this study was to develop theory based on the general features of a particular phenomenon. Although the theory developed is verifiable through its grounding in the data collected from the participants as well as its validation by word of mouth, it was not tested in any way. The theory therefore remains a suggestion, which could be validated through further studies.

Secondly, unlike quantitative research where it appears that there is an unequivocal agreement that the goal is typically to generalize findings and inferences from a representative statistical sample from the population from which it was drawn (Onwuegbuzie and Leech, 2010), our methodological approach presents some limitations which some argue are endemic to qualitative research studies. Owing to the fact that the data was collected from a relatively small pool of respondents, located within a single geographic location, when compared to the wider number of similar enterprises within the HVM ecosystem, the findings herein may not be generalizable to the broader SME population. Although this research effort attempted to widen the respondent base through the initial sampling activity, the total number of companies engaged remain negligible, from the perspective of the quantitative domain. This inability to offer any generalisability of findings is also further limited by the emphasis on purposive sampling which is key to the chosen methodology – the constant comparison dogma prescribes that each subsequent respondent was questioned based on the findings from the latter interview and its analysis. Denzin and Lincoln (1995), Payne and Williams (2005) and Myers (2000) amongst other researchers argue that the primary concern of qualitative research is not to produce generalizable findings. Glaser and Strauss (1967) also state that findings from the substantive theory are limited to the substantive areas for which the data was collected.

Thirdly, the perception of the GTM is that it is a complicated methodology for PhD and early career researchers to understand and utilize for research undertakings, especially when bounded by time limits combined with the availability of research participants. Further pressure is put on these researchers to develop novel theoretical frameworks through the collection and analysis of large amounts of data, as the success of their research projects are dependent on this. The achievement of this task may involve long periods of doubt regarding the quality of data collected and how these may cause the emergence of this new theory being sought. As mentioned in the Chapter 3 also, long and frequent periods of reflexive thinking and testing are also required for success. This approach therefore demands a high level of theoretical predisposition on the part of the researcher which also involves the highest levels of subjectivity and creativity. That said, the success of the project was limited by the researcher himself due to the demonstrated subjective decisions and levels of creativity on the part of the researcher, especially with the amount of time necessary for the research. The coding activities and selection of variables, combination of categories towards densification, choice of nomenclature, were all very subjective and possibly biased. It is therefore acknowledged that the depth and comprehension of multiple theoretical codes and combinations were limited.

8.9 Recommendations and Future Directions

Given the diversity of issues which have arisen from the current study, the potential for further research to follow up some of the findings from this one is great. The possible areas for extending this study are now discussed

First, this study has developed a substantive theory of navigating complexities and has empirically established some key components in a framework. Due to the fact that the focus of this study was on HVM organisations, specifically those operating within the medical sciences discipline, generalisation across all other SMEs is not possible. It is therefore recommended that a similar study, such as this one, be carried out on other high growth, high value SMEs, such as those within the Fintech (including InsurTech), Agritech and others that have the potentials to disrupt their sectors of operation.

Secondly, although the validity of the theory was ensured using the grounded theory tenets of constant comparison, the emergent theory has not been tested as this is not a part of the

Propositions	Future Research
<p><u>Proposition 1:</u> Over time, Navigating Complexities expands in its importance, scope and meaning and becomes embedded in a firm's core routines which inform and influence organisational strategies.</p> <p><u>Proposition 2:</u> Entrenched 'navigating complexities' related capabilities along with their underlying priorities and assumptions serve as organisation-level competence drivers to guide a firm's resources towards enhancing firm competitiveness.</p> <p><u>Proposition 3:</u> Organisations that identify Navigating Complexities as core firm capabilities and seek to actively engage with its dynamism show positive performance within a shorter time than organisations that do not possess such core ideologies</p>	<p>Proposition 1 for example, could be developed into a longitudinal research study to further understand how the embedding of navigating complexities will affect the strategies and indeed, the competitiveness of the organisation over time</p> <p>Both Propostions 2 and 3 can be explored further using objective methods of enquiry such as statistical methods and/or modelling techniques. The end goal is to understand how different variables cause, or lead to, firm competitiveness and positive performance</p>
<p><u>Proposition 4:</u> The stronger the organisations abilities to balance a multitude of complexities alongside situational knowledge stretching capabilities, the easier it is to lay the foundation to disrupt the market place with a portfolio of unique products and services</p>	<p>Propositions 4, 5 and 6 can also be explored using objective methods of enquiry, as they seek to understand the relationships and dependencies between different variables. These relationships could be correlational or causal and can be studied using statistical methodologies.</p>
<p><u>Proposition 5:</u> Organisations that embed advancing levels of cross functional intellectual benchmarking processes into their core capabilities are more likely to develop disruptive products which enhance their overall competitiveness</p>	
<p><u>Proposition 6:</u> Market competitiveness is strongly dependent on the development and exploitation of proprietary technologies as well as the organisations ability to develop situational knowledge stretching outputs from negotiated complexities</p>	

Table 8.3: Table of research propositions

grounded theory approach. Future work therefore is required to test the process using other forms of research strategies. The future research activity may focus on validating this model in firms other than the ones used to develop the theory. As identified in the first point therefore, an ideal situation, may be to first of all, test this framework on the identified sectors (Fintech, Agritech and others) to ascertain if this theory fits, following which an extension to the theory can be made if necessary.

Thirdly, given that Cross Functional Intellectual Benchmarking emerged as a major theme in the current study and appeared to be the critical driving force of the core category, navigating complexities, some further research into the nature of this category and the factors which underpin it is recommended. Indeed, while it can be argued that some of the underpinning factors have already been identified, it is possible that a different research approach may create avenues for others to emerge.

Finally, having advanced a number of research propositions (See Table 8.3) related to each of the building blocks of the substantive theory, it is suggested that these propositions serve as prompts for future research activities in this area of study. As this research endeavour was inductive in nature, it is expected that some of the following future research studies will adopt deductive methods to test this theory using theory-driven hypotheses.

8.10 Chapter Conclusions

As the concluding chapter to this thesis and Grounded Theory research, the conclusions were summarized regarding the findings, which is the emergent theory and framework of Navigating Complexities. Following this, the framework's integration into the current body of knowledge is attempted where major theories such as the Resource Based View and Dynamic Capability theories were presented in relation to Navigating Complexities. Thereafter, the substantive theory and its theoretical contribution to the body of knowledge was discussed. Whetten's (1989) framework of 'what', 'how', 'why' and 'who-where-when' were used to examine the extent of the theory's contribution.

As an important part of the research also, three major limitations were discussed:

- The 'incomplete' nature of the Navigating Complexities theory. Grounded Theory studies develop substantive theories grounded in data and are not concerned with testing or validating them. These are left for future research activities

- The findings are not generalizable due to the fact that the data was collected from a relatively small pool of respondents in a single geographical location
- A high level of theoretical predisposition on the part of the researcher was observed. This involved very high levels of subjectivity and creativity. That said the success of the research was limited by the researcher's ability to assess, group, describe and give certain descriptive labels to the categories.

Finally, recommendations and future directions are proposed. First of all, the substantive, emergent theory can be validated through well planned and orchestrated research activities. These could be done either through quantitative or qualitative methods. It is also proposed that the earlier highlighted research propositions can also be explored using different methods such as a longitudinal studies and/or experimental methods.

References

- Aas, K.F., Gundhus, H.O., Lomell, H.M., (2008) *Technologies of inSecurity: the surveillance of everyday life*: Routledge.
- Abbey, J., Davies, G., Mainwaring, L. (2008) Vorsprung durch Technium: Towards a system of Innovation in South-west Wales. *Regional Studies*, 42(2), 281-293.
- Adam, M., Urquhart, C., (2007) IT capacity building in developing countries: A model for the Moldavian tourism sector. *Information Technology for Development*, 13(4), 315-335
- Adu-Oppong, B., Gasparrini, A.J., Dantas, G. (2017) Genomic and functional techniques to mine the microbiome for novel antimicrobials and antimicrobial resistance genes. *Annals of the New York Academy of Sciences*, 1388(1), 42.
- Ahmed, S., Hacker, P., Wallace, K., (2005) *The role of knowledge and experience in engineering design*.206-207 (exec. Summ.), full paper no. DS235_493. 245.
- Akgün, A.E., Keskin, H., Byrne, J. (2012) Antecedents and contingent effects of organizational adaptive capability on firm product innovativeness. *Journal of Product Innovation Management*, 29, 171-189.
- Alexander, A., Walker, H., Naim, M. (2014) Decision theory in sustainable supply chain management: a literature review. *Supply Chain Management: An International Journal*, 19(5/6), 504-522.
- AlGeddawy, T., ElMaraghy, H. (2011) A model for co-evolution in manufacturing based on biological analogy. *International Journal of Production Research*, 49(15), 4415-4435.
- Altshuller, G., Shapiro, P., (1956) *On the psychology of inventive creativity*.
- Alvesson, M. (2003) Beyond neopositivists, romantics, and localists: A reflexive approach to interviews in organizational research. *Academy of management review*, 28(1), 13-33.
- Alvesson, M. (2013) Do we have something to say? From re-search to rei-search and back again. *Organization*, 20(1), 79-90.
- Alvesson, M., Hardy, C., Harley, B. (2008) Reflecting on reflexivity: Reflexive textual practices in organization and management theory. *Journal of management studies*, 45(3), 480-501.
- Alvesson, M., Sandberg, J. (2011) Generating research questions through problematization. *Academy of management review*, 36(2), 247-271.
- Alvesson, M., Sandberg, J. (2013) Has management studies lost its way? Ideas for more imaginative and innovative research. *Journal of Management Studies*, 50(1), 128-152.
- Alvesson, M., Sandberg, J. (2014) Habitat and habitus: Boxed-in versus box-breaking research. *Organization studies*, 35(7), 967-987.
- Alvesson, M., Skoldberg, K., (2000) *Reflexive methodologies: Interpretation and research*.

- Al-Zu'bi, Z.b.M., Tsinopoulos, C. (2012) Suppliers versus lead users: Examining their relative impact on product variety. *Journal of Product Innovation Management*, 29(4), 667-680.
- Ammann, R. (2004) On resonance. *Sandplay therapy: Treatment of psychopathologies*, 241-267.
- Anand, G., Ward, P.T., Tatikonda, M.V. and Schilling, D.A., 2009. Dynamic capabilities through continuous improvement infrastructure. *Journal of operations management*, 27(6), pp.444-461.
- Andersen, B. (1999) Industrial benchmarking for competitive advantage. *Human Systems Management*, 18(3, 4), 287-296.
- Anderson, P. (1999) Perspective: Complexity theory and organization science. *Organization science*, 10(3), 216-232.
- Andriopoulos, C., Lewis, M.W. (2010) Managing innovation paradoxes: Ambidexterity lessons from leading product design companies. *Long range planning*, 43(1), 104-122.
- Arend, R.J., Bromiley, P., (2009) *Assessing the dynamic capabilities view: spare change, everyone?*
- Atkinson, R.D., Stewart, L.A., Andes, S., Ezell, S. (2012) Worse than the great depression: What experts are missing about American manufacturing decline. *Washington, DC: Information Technology and Innovation Foundation*, 327-339.
- Attiany, M.S. (2014) Competitive advantage through benchmarking: field study of industrial companies listed in Amman stock exchange. *Journal of business studies quarterly*, 5(4), 41.
- Audretsch, D.B. (2014) From the entrepreneurial university to the university for the entrepreneurial society. *The Journal of Technology Transfer*, 39(3), 313-321.
- Avella, L., Vázquez-Bustelo, D. (2010) The multidimensional nature of production competence and additional evidence of its impact on business performance. *International Journal of Operations & Production Management*, 30(6), 548-583.
- Azadegan, A., Bush, D. and Dooley, K.J., 2008. Design creativity: static or dynamic capability?. *International Journal of Operations & Production Management*.
- Bachlaus, M., Tiwari, M., Chan, F. (2009) Multi-objective resource assignment problem in a product-driven supply chain using a Taguchi-based DNA algorithm. *International Journal of Production Research*, 47(9), 2345-2371.
- Baert, P., (2005) *Philosophy of the social sciences: Towards pragmatism: Polity*.
- Bai, C., Sarkis, J. (2013) A grey-based DEMATEL model for evaluating business process management critical success factors. *International journal of production economics*, 146(1), 281-292.
- Barney, J.B. (2012) Purchasing, supply chain management and sustained competitive advantage: The relevance of resource-based theory. *Journal of supply chain management*, 48(2), 3-6.

- Barrales-Molina, V., Montes, F.J.L., Gutierrez-Gutierrez, L.J. (2015) Dynamic capabilities, human resources and operating routines: A new product development approach. *Industrial Management & Data Systems*, 115(8), 1388-1411.
- Barratt, M., Choi, T.Y., Li, M. (2011) Qualitative case studies in operations management: Trends, research outcomes, and future research implications. *Journal of Operations Management*, 29(4), 329-342.
- Bates, S.R., Jenkins, L. (2007) Teaching and learning ontology and epistemology in political science. *Politics*, 27(1), 55-63.
- Beattie IV, V., Collins, B., McInnes, B. (1997) Deep and surface learning: a simple or simplistic dichotomy? *Accounting Education*, 6(1), 1-12.
- Beesley, L. (2004) Multi-level complexity in the management of knowledge networks. *Journal of Knowledge Management*, 8(3), 71-100.
- Benedettini, O., Clegg, B., Kafouros, M. and Neely, A. (2010), *The Ten Myths of Manufacturing: What Does the Future Hold for UK Manufacturing?* AIM Executive Briefing, London.
- Bergh, D.D., (2003) *Thinking strategically about contribution*.
- (2015) *The British growth crisis*: Springer.
- Berry, C. (2016) UK manufacturing decline since the crisis in historical perspective.
- Bhaskar, R. (1975) Forms of realism.
- Bhutta, K.S., Huq, F. (1999) Benchmarking—best practices: an integrated approach. *Benchmarking: An International Journal*, 6(3), 254-268.
- Biggs, J.B. (1978) Individual and group differences in study processes. *British Journal of Educational Psychology*, 48(3), 266-279.
- Binder, M., Edwards, J.S. (2010) Using grounded theory method for theory building in operations management research: a study on inter-firm relationship governance. *International Journal of Operations & Production Management*, 30(3), 232-259.
- Binder, M., Edwards, J.S. (2010) Using grounded theory method for theory building in operations management research: a study on inter-firm relationship governance. *International Journal of Operations & Production Management*, 30(3), 232-259.
- Bingham, C.B., Eisenhardt, K.M. (2008) Position, leverage and opportunity: a typology of strategic logics linking resources with competitive advantage. *Managerial and Decision Economics*, 29(2-3), 241-256.
- Birkinshaw, J. and Gibson, C.B., 2004. Building an ambidextrous organisation. *Advanced Institute of Management Research Paper*, (003).
- Birks, M., Mills, J., (2015) *Grounded theory: A practical guide*: Sage.
- Bode, C., Wagner, S.M. (2015) Structural drivers of upstream supply chain complexity and the frequency of supply chain disruptions. *Journal of Operations Management*, 36, 215-228.

- Bodwell, W. and Chermack, T.J., 2010. Organizational ambidexterity: Integrating deliberate and emergent strategy with scenario planning. *Technological Forecasting and Social Change*, 77(2), pp.193-202.
- Booth, C. (1998) The problems and possibilities of reflexivity in strategy. *Electronic Journal of Radical Organization Theory*, 4(1).
- Botchkarev, A., Finnigan, P. (2015) Complexity in the context of information systems project management. *Organisational Project Management*, 2(1), 15-34.
- Bourke, J., Roper, S. (2016) AMT adoption and innovation: An investigation of dynamic and complementary effects. *Technovation*, 55, 42-55.
- Bourlakis, M., Maglaras, G., Aktas, E., Gallear, D., Fotopoulos, C. (2014) Firm size and sustainable performance in food supply chains: Insights from Greek SMEs. *International Journal of Production Economics*, 152, 112-130.
- Boyer, K.K., Lewis, M.W. (2002) Competitive priorities: investigating the need for trade-offs in operations strategy. *Production and Operations Management*, 11(1), 9-20.
- Boyer, K.K., Swink, M.L. (2008) Empirical elephants—why multiple methods are essential to quality research in operations and supply chain management. *Journal of Operations Management*, 26(3), 338-344.
- Bozarth, C.C., Berry, W.L. (1997) Measuring the congruence between market requirements and manufacturing: a methodology and illustration. *Decision Sciences*, 28(1), 121-150.
- Bozarth, C.C., Warsing, D.P., Flynn, B.B., Flynn, E.J. (2009) The impact of supply chain complexity on manufacturing plant performance. *Journal of Operations Management*, 27(1), 78-93.
- Brady, H.E., Collier, D. (2004) Rethinking Social Inquiry: Diverse Tools. *Shared Standards*, 330.
- Brandyberry, A., Rai, A., White, G.P. (1999) Intermediate performance impacts of advanced manufacturing technology systems: An empirical investigation. *Decision Sciences*, 30(4), 993-1020.
- Brewer, G.D., (1973) *Analysis of complex systems: an experiment and its implications for policymaking*.
- Brown, J.S., Duguid, P. (2000) Balancing act: How to capture knowledge without killing it. *Harvard business review*, 78(3), 73-80.
- Bruneel, J., Ratinho, T., Clarysse, B., Groen, A. (2012) The Evolution of Business Incubators: Comparing demand and supply of business incubation services across different incubator generations. *Technovation*, 32(2), 110-121.
- Brunswick, S., Vanhaverbeke, W. (2015) Open innovation in small and medium-sized enterprises (SMEs): External knowledge sourcing strategies and internal organizational facilitators. *Journal of Small Business Management*, 53(4), 1241-1263.

- Bryant, A., Charmaz, K., (2007) *The Sage handbook of grounded theory*. Sage.
- Bryman, A. (2001) 2012. *Social research methods*.
- Bryman, A., Bell, E. (2007) *Business Research Methods*: OUP Oxford.
- Bryman, A., Bresnen, M., Beardsworth, A., Keil, T. (1988) Qualitative research and the study of leadership. *Human relations*, 41(1), 13-29.
- Buffa, E.S. (1980) Research in operations management. *Journal of Operations Management*, 1(1), 1-7.
- Caldwell, B. (1980) Positivist philosophy of science and the methodology of economics. *Journal of Economic Issues*, 14(1), 53-76.
- Camuffo, A., Gerli, F. (2007) Competent production supervisors. *Industrial Relations: A Journal of Economy and Society*, 46(4), 728-737.
- Carbonell, P., Rodriguez, A.I. (2006) Designing teams for speedy product development: The moderating effect of technological complexity. *Journal of Business Research*, 59(2), 225-232.
- Carley, S., Lawrence, S., Brown, A., Nourafshan, A., Benami, E. (2011) Energy-based economic development. *Renewable and Sustainable Energy Reviews*, 15(1), 282-295.
- Carr, A., Muthusamy, S.K. (2008) The cross-functional coordination between operations, marketing, purchasing and engineering and the impact on performance. *Marketing, Purchasing and Engineering and the Impact on Performance*.
- Chakravarthy, B.S. (1982) Adaptation: A promising metaphor for strategic management. *Academy of management review*, 7(1), 35-44.
- Chalmers, D.M., Balan-Vnuk, E. (2013) Innovating not-for-profit social ventures: Exploring the microfoundations of internal and external absorptive capacity routines. *International small business journal*, 31(7), 785-810.
- Chan, E.K. (2017) A Tutorial on Scale Development: The Experiential Value Scale. *Global journal of management and business research*.
- Chang, Y.-Y., Hughes, M., Hotho, S. (2011) Internal and external antecedents of SMEs' innovation ambidexterity outcomes. *Management Decision*, 49(10), 1658-1676.
- Charmaz, K., (2006) *Constructing grounded theory: A practical guide through qualitative analysis*: sage.
- Charmaz, K. (2008) Constructionism and the grounded theory method. *Handbook of constructionist research*, 1, 397-412.
- Charmaz, K. (2008) Grounded theory as an emergent method. *Handbook of emergent methods*, 155, 172.
- Chase, R.B. (1980) A classification and evaluation of research in operations management. *Journal of Operations Management*, 1(1), 9-14.

- Chen, C.H., Occenă, L.G. (1999) A knowledge sorting process for a product design expert system. *Expert Systems*, 16(3), 170-182.
- Chen, P.-T., Kuo, S.-C. (2017) Innovation resistance and strategic implications of enterprise social media websites in Taiwan through knowledge sharing perspective. *Technological Forecasting and Social Change*, 118, 55-69.
- Chen, T., Qian, L., Narayanan, V. (2017) Battle on the wrong field? Entrant type, dominant designs, and technology exit. *Strategic management journal*, 38(13), 2579-2598.
- Chen, W., Hirschheim, R. (2004) A paradigmatic and methodological examination of information systems research from 1991 to 2001. *Information systems journal*, 14(3), 197-235.
- Chesbrough, H.W., (2006) *Open innovation: The new imperative for creating and profiting from technology*. Harvard Business Press.
- Chia, R. (1996) The problem of reflexivity in organizational research: Towards a postmodern science of organization. *Organization*, 3(1), 31-59.
- Christiansen, Ó. (2011) The literature review in classic grounded theory studies: A methodological note. *The Grounded Theory Review*, 10(3), 21-25.
- Chung, C.A. (1996) Human issues influencing the successful implementation of advanced manufacturing technology. *Journal of Engineering and Technology Management*, 13(3-4), 283-299.
- Chung, C.-J., Reynolds, R.G. (2000) Knowledge-based self-adaptation in evolutionary search. *International Journal of Pattern Recognition and Artificial Intelligence*, 14(01), 19-33.
- Chung, W., Swink, M. (2009) Patterns of advanced manufacturing technology utilization and manufacturing capabilities. *Production and Operations Management*, 18(5), 533-545.
- Cilliers, P. (2000) Knowledge, complexity, and understanding. *Emergence, A Journal of Complexity Issues in Organizations and Management*, 2(4), 7-13.
- Čiutienė, R., Petrauskas, P. (2012) Management by objectives using coaching. *Economics and Management*, 17(4), 1559-1563.
- Coffey, A., Atkinson, P., (1996) *Making sense of qualitative data: complementary research strategies*: Sage Publications, Inc.
- Cohen, W.M. and Levinthal, D.A., 1990. Absorptive capacity: A new perspective on learning and innovation. *Administrative science quarterly*, pp.128-152.
- Colombo, M.G., Grilli, L. (2010) On growth drivers of high-tech start-ups: Exploring the role of founders' human capital and venture capital. *Journal of business venturing*, 25(6), 610-626.
- Cooke, P. (2001) From technopoles to regional innovation systems: the evolution of localised technology development policy. *Canadian journal of regional science*, 24(1), 21-40.

- Cooke, P. (2004) The regional innovation system in Wales. *Regional Innovation Systems. The Role of Governances in a Globalized World*, 245-263.
- Corbett, L., Campbell-Hunt, C. (2002) Grappling with a gusher! Manufacturing's response to business success in small and medium enterprises. *Journal of Operations Management*, 20(5), 495-517.
- Corbett, L., Claridge, G. (2002) Key manufacturing capability elements and business performance. *International Journal of Production Research*, 40(1), 109-131.
- Corley, K.G., Gioia, D.A. (2011) Building theory about theory building: what constitutes a theoretical contribution? *Academy of management review*, 36(1), 12-32.
- Coughlan, P., Coughlan, D. (2002) Action research for operations management. *International Journal of Operations & Production Management*, 22(2), 220-240.
- Courtney, J., Merali, Y., Paradise, D., Wynn, E. (2008) On the study of complexity in information systems. *International Journal of Information Technologies and Systems Approach (IJITSA)*, 1(1), 37-48.
- Craighead, C.W., Meredith, J. (2008) Operations management research: evolution and alternative future paths. *International Journal of Operations & Production Management*, 28(8), 710-726.
- Cresswell, J., Clark, V.P. (2007) *Designing and Conducting Mixed Methods Research*. Thousand Oaks CA: Sage.
- Crotty, M., (1998) *The foundations of social research: Meaning and perspective in the research process*: Sage.
- Cunliffe, A.L. (2002) Reflexive dialogical practice in management learning. *Management learning*, 33(1), 35-61.
- Cunliffe, A.L. (2003) Reflexive inquiry in organizational research: Questions and possibilities. *Human relations*, 56(8), 983-1003.
- Cunliffe, A.L. (2004) On becoming a critically reflexive practitioner. *Journal of management education*, 28(4), 407-426.
- Cunliffe, A.L. (2009) The philosopher leader: On relationalism, ethics and reflexivity—A critical perspective to teaching leadership. *Management learning*, 40(1), 87-101.
- Cunliffe, A.L., Linstead, S., Locke, K., Orr, K., Bennett, M. (2009) Reflexivity in the co-production of academic-practitioner research. *Qualitative Research in Organizations and Management: An International Journal*.
- Cutcliffe, J.R. (2000) Methodological issues in grounded theory. *Journal of advanced nursing*, 31(6), 1476-1484.
- Dabhilkar, M., Bengtsson, L. (2008) Invest or divest? On the relative improvement potential in outsourcing manufacturing. *Production Planning and Control*, 19(3), 212-228.
- Daft, R.L., Lewin, A.Y. (1990) Can organization studies begin to break out of the normal science straitjacket? An editorial essay. *Organization Science*, 1(1), 1-9.

- Dallos, R., Stedmon, J. (2009) Flying over the swampy lowlands: Reflective and reflexive practice. *Reflective practice in psychotherapy and counselling*, 1-22.
- Damanpour, F. (1996) Organizational complexity and innovation: developing and testing multiple contingency models. *Management science*, 42(5), 693-716.
- Dane, E., Rockmann, K.W., Pratt, M.G. (2012) When should I trust my gut? Linking domain expertise to intuitive decision-making effectiveness. *Organizational Behavior and Human Decision Processes*, 119(2), 187-194.
- Dang, Y., Zhang, Y., Hu, P.J.-H., Brown, S.A., Chen, H. (2011) Knowledge mapping for rapidly evolving domains: a design science approach. *Decision Support Systems*, 50(2), 415-427.
- Daspit, J.J., Long, R.G. and Pearson, A.W., 2019. How familiness affects innovation outcomes via absorptive capacity: A dynamic capability perspective of the family firm. *Journal of Family Business Strategy*, 10(2), pp.133-143.
- David, R.J., Han, S.K. (2004) A systematic assessment of the empirical support for transaction cost economics. *Strategic management journal*, 25(1), 39-58.
- Davies, G., Abbey, J. (2007) Technium pan-Wales: impact assessment. *Institute for Policy and Economic Development Technical report. El Paso, TX: University of Texas.*
- De Liddo, A., Sándor, Á., Shum, S.B. (2012) Contested collective intelligence: Rationale, technologies, and a human-machine annotation study. *Computer Supported Cooperative Work (CSCW)*, 21(4-5), 417-448.
- Dearing, A. (2000) Sustainable innovation: Drivers and barriers. *Innovation and the Environment. OECD: Paris*, 103-125.
- Delamont, S. (2005) Four great gates: Dilemmas, directions and distractions in educational research. *Research Papers in Education*, 20(1), 85-100.
- Denscombe, M. (2003) The Good Research Guide: For Small Scale Social Science Research Projects. *Social Sciences research methodology handbook.*
- Denzin, N.K., Lincoln, Y.S. (2008) Introduction: Critical methodologies and indigenous inquiry. *Handbook of critical and indigenous methodologies*, 1-20.
- Devanna, M.A., Fombrun, C., Tichy, N. (1981) Human resources management: A strategic perspective. *Organizational Dynamics*, 9(3), 51-67.
- Dhanaraj, C., Parkhe, A. (2006) Orchestrating innovation networks. *Academy of management review*, 31(3), 659-669.
- DiCicco-Bloom, B., Crabtree, B.F. (2006) The qualitative research interview. *Medical education*, 40(4), 314-321.
- Dick, B., Stringer, E., Huxham, C., (2009) *Theory in action research.*
- Dilley, P., (2004) *Interviews and the philosophy of qualitative research.*
- Dobrea, M., Maiorescu, I. (2015) Entrepreneurial outcomes and organisational performance through business coaching. *Amfiteatru Economic Journal*, 17(38), 247-260.

- Dobson, P.J. (2001) The philosophy of critical realism—an opportunity for information systems research. *Information systems frontiers*, 3(2), 199-210.
- Doh, J.P. (2005) Offshore outsourcing: Implications for international business and strategic management theory and practice. *Journal of Management Studies*, 42(3), 695-704.
- Doll, W.J., Deng, X., Scazzero, J.A. (2003) A process for post-implementation IT benchmarking. *Information & Management*, 41(2), 199-212.
- Dolores Vidal-Salazar, M., Ferrón-Vílchez, V., Cordon-Pozo, E. (2012) Coaching: an effective practice for business competitiveness. *Competitiveness Review: An International Business Journal*, 22(5), 423-433.
- Drnevich, P.L., Kriauciunas, A.P. (2011) Clarifying the conditions and limits of the contributions of ordinary and dynamic capabilities to relative firm performance. *Strategic management journal*, 32(3), 254-279.
- Dunne, C. (2011) The place of the literature review in grounded theory research. *International journal of social research methodology*, 14(2), 111-124.
- Duriau, V.J., Reger, R.K., Pfarrer, M.D. (2007) A content analysis of the content analysis literature in organization studies: Research themes, data sources, and methodological refinements. *Organizational research methods*, 10(1), 5-34.
- Durlauf, S.N., Young, H.P., (2004) *Social dynamics*: Mit Press.
- Dutta, S., Narasimhan, O., Rajiv, S. (2005) Conceptualizing and measuring capabilities: Methodology and empirical application. *Strategic Management Journal*, 26(3), 277-285.
- Eakman, A. (2007) Occupation and social complexity. *Journal of Occupational Science*, 14(2), 82-91.
- Easterby-Smith, M., Thorpe, R., Jackson, P.R., (2015) *Management and business research*: Sage.
- Easton, G. (2010) Critical realism in case study research. *Industrial marketing management*, 39(1), 118-128.
- Eden, C., Huxham, C. (1996) Action research for management research. *British Journal of management*, 7(1), 75-86.
(1995) *The evolution of complexity*: Kluwer, Dordrecht.
- Edwards, T., Delbridge, R., Munday, M., (2001) *Linking Innovative Potential to SME Performance: An Assessment of Enterprises in Industrial South Wales. Paper for 41st European Regional Science Association Meeting, Zagreb, Croatia, August 2001.*
- Efstathiades, A., Tassou, S., Antoniou, A. (2002) Strategic planning, transfer and implementation of Advanced Manufacturing Technologies (AMT). Development of an integrated process plan. *Technovation*, 22(4), 201-212.
- Egbunike, O., Biggs, C. (2014) Towards Revitalizing Welsh Manufacturing: The Role of Welsh Universities. *Sustainable Design and Manufacturing 2014 Part 1*, 243.

- Egbunike, O., Naim, M.M., Purvis, L., (2015) *The Process of Identifying Manufacturing Related Capabilities in Advanced Technology Firms for Enhanced Competitive Advantage*.
- Egbunike, O., Purvis, L., Naim, M.M. (2018) A systematic review of research into the management of manufacturing capabilities. *Production Planning & Control*, 29(16), 1349-1366.
- Eisenbeiß, S.A., Brodbeck, F. (2014) Ethical and unethical leadership: A cross-cultural and cross-sectoral analysis. *Journal of Business Ethics*, 122(2), 343-359.
- Eisenhardt, K.M., Martin, J.A. (2000) Dynamic capabilities: what are they? *Strategic management journal*, 21(10-11), 1105-1121.
- Eisenhardt, K.M., Santos, F.M. (2002) Knowledge-based view: A new theory of strategy. *Handbook of strategy and management*, 1(1), 139-164.
- Elmuti, D., Kathawala, Y. (1997) An overview of benchmarking process: a tool for continuous improvement and competitive advantage. *Benchmarking for Quality Management & Technology*, 4(4), 229-243.
- Enkel, E., Groemminger, A., Heil, S. (2018) Managing technological distance in internal and external collaborations: absorptive capacity routines and social integration for innovation. *The Journal of Technology Transfer*, 43(5), 1257-1290.
- Entwistle, N. (1997) Introduction: Phenomenography in higher education. *Higher Education Research & Development*, 16(2), 127-134.
(2004) *Handbook on Knowledge Management 1*: Springer.
- Escribano, A., Fosfuri, A., Tribó, J.A. (2009) Managing external knowledge flows: The moderating role of absorptive capacity. *Research Policy*, 38(1), 96-105.
- Eshima, Y., Anderson, B.S. (2017) Firm growth, adaptive capability, and entrepreneurial orientation. *Strategic management journal*, 38(3), 770-779.
- Esmailian, B., Behdad, S., Wang, B. (2016) The evolution and future of manufacturing: A review. *Journal of Manufacturing Systems*, 39, 79-100.
- European Commission (2016) *User guide to the SME Definition*. Luxembourg: Publications Office of the European Union. Available at: https://ec.europa.eu/regional_policy/sources/conferences/state-aid/sme/smedefinitionguide_en.pdf [Accessed 28th May 2020]
- Evans, P., Holz, R., Roberts, A. (2008) Empirical Investigation of Foreign Direct Investment in Wales. *Report sponsored by Welsh Assembly Government Research Unit*.
- Evans, T., Lawson, A., McWilliam, E., Taylor, P. (2005) Understanding the management of doctoral studies in Australia as risk management. *Studies in research: evaluation, impact and training*, 1(1), 1-11.
- Eyers, D.R., Potter, A.T., Gosling, J., Naim, M.M. (2018) The flexibility of industrial additive manufacturing systems. *International Journal of Operations & Production Management*, 38(12), 2313-2343.

- Fabrizio, K.R. (2009) Absorptive capacity and the search for innovation. *Research Policy*, 38(2), 255-267.
- Fawcett, S.E., Calantone, R., Smith, S.R. (1996) An investigation of the impact of flexibility on global reach and firm performance. *Journal of Business Logistics*, 17(2), 167.
- Feagin, J.R., Orum, A.M., Sjoberg, G., (1991) *A case for the case study*: UNC Press Books.
- Featherston, C.R., O'Sullivan, E. (2017) Enabling technologies, lifecycle transitions, and industrial systems in technology foresight: Insights from advanced materials FTA. *Technological forecasting and social change*, 115, 261-277.
- Fendt, J., Sachs, W. (2008) Grounded theory method in management research: Users' perspectives. *Organizational Research Methods*, 11(3), 430-455.
- Ferdows, K., Vereecke, A., De Meyer, A. (2016) Delaying the global production network into congruent subnetworks. *Journal of Operations Management*, 41, 63-74.
- Fernández-Mesa, A., Alegre-Vidal, J., Chiva-Gómez, R., Gutiérrez-Gracia, A. (2013) Design management capability and product innovation in SMEs. *Management Decision*, 51(3), 547-565.
- Fielding, N., Thomas, H. (2008) Qualitative interviewing.
- Fink, A., Marr, B., Siebe, A., Kuhle, J.-P. (2005) The future scorecard: combining external and internal scenarios to create strategic foresight. *Management Decision*, 43(3), 360-381.
- Fischer, K.W. (1980) A theory of cognitive development: The control and construction of hierarchies of skills. *Psychological review*, 87(6), 477.
- Flynn, B.B., Sakakibara, S., Schroeder, R.G., Bates, K.A., Flynn, E.J. (1990) Empirical research methods in operations management. *Journal of Operations Management*, 9(2), 250-284.
- Forza, C. (2002) Survey research in operations management: a process-based perspective. *International Journal of Operations & Production Management*, 22(2), 152-194.
- Fournier, S., Solomon, M., Englis, B.G. (2008) When brands resonate. *Handbook of brand and experience management*, 35-57.
- Frankfort-Nachmias, C., Nachmias, D., (2007) *Study guide for research methods in the social sciences*: Macmillan.
- Friedman, Y., Carmeli, A., Tishler, A. (2016) How CEOs and TMTs build adaptive capacity in small entrepreneurial firms. *Journal of Management Studies*, 53(6), 996-1018.
- Froh, R. (1979) The Folklore and Facts Behind the Luling Discovery Well. *East Texas Historical Journal*, 17(2), 8.
- Fryer, D., (1926) *Foundations of Mental Activity*.
- Fynes, B., Coughlan, P., Boer, H., Holweg, M., Kilduff, M., Pagell, M., Schmenner, R.,

- Voss, C. (2015) Making a meaningful contribution to theory. *International Journal of Operations & Production Management*.
- Galbreath, J., Galvin, P., (2004) *WHICH RESOURCES MATTER? A FINE-GRAINED TEST OF THE RESOURCE-BASED VIEW OF THE FIRM*. 2004(1):L1-L6.
- Garcia, R., Calantone, R. (2002) A critical look at technological innovation typology and innovativeness terminology: a literature review. *Journal of Product Innovation Management: An International Publication of the Product Development & Management Association*, 19(2), 110-132.
- Garrigan, B., Adlam, A.L., Langdon, P.E. (2018) Moral decision-making and moral development: Toward an integrative framework. *Developmental review*, 49, 80-100.
- Garrison, D.R., Cleveland-Innes, M. (2005) Facilitating cognitive presence in online learning: Interaction is not enough. *The American journal of distance education*, 19(3), 133-148.
- Garud, R. (1994) Cooperative and competitive behaviors during the process of creative destruction. *Research Policy*, 23(4), 385-394.
- Garud, R., Van De Ven, A.H. (1992) An empirical evaluation of the internal corporate venturing process. *Strategic management journal*, 13(S1), 93-109.
- Garvin, D.A., 2000. Learning in Action: A Guide to Putting the Learning Organization to Work. Harvard Business School Press. Boston, Massachusetts.
- Gavronski, I., Klassen, R.D., Vachon, S., do Nascimento, L.F.M. (2011) A resource-based view of green supply management. *Transportation Research Part E: Logistics and Transportation Review*, 47(6), 872-885.
- Gergen, K.J., (1991) *The saturated self: Dilemmas of identity in contemporary life*: Basic books.
- Geum, Y., Lee, S., Yoon, B., Park, Y. (2013) Identifying and evaluating strategic partners for collaborative R&D: Index-based approach using patents and publications. *Technovation*, 33(6-7), 211-224.
- Ghauri, P.N., Grønhaug, K., (2005) *Research methods in business studies: A practical guide*: Pearson Education.
- Gilmore, M., Smith, D. (1996) Set-up reduction in pharmaceutical manufacturing: an action research study. *International Journal of Operations & Production Management*, 16(3), 4-17.
- Gimmon, E., Levie, J. (2010) Founder's human capital, external investment, and the survival of new high-technology ventures. *Research Policy*, 39(9), 1214-1226.
- Gioia, D.A., Pitre, E. (1990) Multiparadigm perspectives on theory building. *Academy of management review*, 15(4), 584-602.
- Glaser, B., Strauss, A. (1967) Grounded theory: The discovery of grounded theory. *Sociology the journal of the British sociological association*, 12(1), 27-49.

- Glaser, B.G. (1965) The constant comparative method of qualitative analysis. *Social problems*, 12(4), 436-445.
- Glaser, B.G., (1992) *Basics of grounded theory analysis: Emergence vs forcing*: Sociology press.
- Glaser, B.G., (1998) *Doing grounded theory: Issues and discussions*: Sociology Press.
- Glaser, B.G., (2001) *The grounded theory perspective: Conceptualization contrasted with description*: Sociology Press.
- Glaser, B.G., Holton, J., (2004) *Remodeling grounded theory*. 5(2).
- Glaser, B.G., Strauss, A.L. (1964) Awareness contexts and social interaction. *American sociological review*, 669-679.
- Glaser, B.G., Strauss, A.L. (1964) The social loss of dying patients. *The American Journal of Nursing*, 119-121.
- Glaser, B.G., Strauss, A.L. (1965) Discovery of substantive theory: A basic strategy underlying qualitative research. *American Behavioral Scientist*, 8(6), 5-12.
- Glaser, B.G., Strauss, A.L. (1966) The purpose and credibility of qualitative research. *Nursing research*, 15(1), 56-61.
- Gmelin, H., Seuring, S. (2014) Achieving sustainable new product development by integrating product life-cycle management capabilities. *International Journal of Production Economics*, 154, 166-177.
- Goel, V., (1995) *Sketches of thought*. Mlt Press.
- Goldin, C. (2016) Human capital. *Handbook of cliometrics*, 55-86.
- Gordon, M., Jakubczyc, J., Galant, V., Paprzycki, M., (2002) *Knowledge Management in an E-commerce System*.
- Gosling, J., Towill, D.R., Naim, M.M., Dainty, A.R. (2015) Principles for the design and operation of engineer-to-order supply chains in the construction sector. *Production Planning & Control*, 26(3), 203-218.
- Goulding, C., (2002) *Grounded theory: A practical guide for management, business and market researchers*: Sage.
- Graban, M., (2018) *Lean hospitals: improving quality, patient safety, and employee engagement*. Productivity Press.
- Granstrand, O. (1998) Towards a theory of the technology-based firm. *Research policy*, 27(5), 465-489.
- Gray, C., Mabey, C. (2005) Management development: key differences between small and large businesses in Europe. *International small business journal*, 23(5), 467-485.
- Gray, D.E., Ekinci, Y., Goregaokar, H. (2011) Coaching SME managers: business development or personal therapy? A mixed methods study. *The International Journal of Human Resource Management*, 22(04), 863-882.

Great Britain. Department for Business, E., Strategy, I. (2017) Industrial Strategy: building a Britain fit for the future.

Greeno, N.J., (2006) *Corporate learning strategies*: American Society for Training and Development.

Grimaldi, M., Cricelli, L., Di Giovanni, M., Rogo, F. (2015) The patent portfolio value analysis: A new framework to leverage patent information for strategic technology planning. *Technological forecasting and social change*, 94, 286-302.

Grix, J. (2002) Introducing students to the generic terminology of social research. *Politics*, 22(3), 175-186.

Grossmann, I. (2017) Wisdom in context. *Perspectives on Psychological Science*, 12(2), 233-257.

Gubrium, J.F., Holstein, J.A., (1997) *The new language of qualitative method*: Oxford University Press on Demand.

Gulati, R. (1998) Alliances and networks. *Strategic management journal*, 19(4), 293-317.

Gummesson, E., (2000) *Qualitative methods in management research*: Sage.

Gunasekaran, A., Patel, C., McGaughey, R.E. (2004) A framework for supply chain performance measurement. *International journal of production economics*, 87(3), 333-347.

Gutierrez-Gutierrez, L.J., Barrales-Molina, V., Kaynak, H. (2018) The role of human resource-related quality management practices in new product development: A dynamic capability perspective. *International Journal of Operations & Production Management*, 38(1), 43-66.

Hall, R. (1993) A framework linking intangible resources and capabilities to sustainable competitive advantage. *Strategic management journal*, 14(8), 607-618.

Hammersley, M., Atkinson, P. (1995) *Ethnography: Practices and principles*. New York: Routledge. Retrieved December, 2, 2008.

Hammersley, M., Atkinson, P., (2007) *Ethnography: Principles in practice*: Routledge.

Hariato, F., Pennings, J.M. (1994) Technological convergence and scope of organizational innovation. *Research Policy*, 23(3), 293-304.

Harvey, C., Kelly, A., Morris, H., Rowlinson, M. (2010) Academic journal quality guide. London: The Association of Business Schools.

Hashemian, S.V., Mavaddat, F., (2007) *Automatic composition of stateless components: a logical reasoning approach*. 175-190.

(2014) *The Oxford handbook of the archaeology and anthropology of hunter-gatherers*,

Hayes, R.H. (1985) Strategic planning-forward in reverse. *Harv. Bus. Rev.*; (United States), 63(6).

Hayes, R.H., Pisano, G.P. (1994) Beyond world-class: the new manufacturing strategy. *Harvard business review*, 72(1), 77-86.

- Healy, M., Perry, C. (2000) Comprehensive criteria to judge validity and reliability of qualitative research within the realism paradigm. *Qualitative market research: An international journal*, 3(3), 118-126.
- Heath, H., Cowley, S. (2004) Developing a grounded theory approach: a comparison of Glaser and Strauss. *International journal of nursing studies*, 41(2), 141-150.
- Heineke, J., Davis, M.M. (2007) The emergence of service operations management as an academic discipline. *Journal of Operations Management*, 25(2), 364-374.
- Helfat, C.F., Finkelstein, S., Mitchell, W., Peteraf, S., Singh, H. and Teece, D., D. and WINTER, SG (2007). *Dynamic capabilities: Understanding strategic change in organizations*.
- Helfat, C.E. and Peteraf, M.A., 2009. Understanding dynamic capabilities: progress along a developmental path.
- Helfat, C.E., Finkelstein, S., Mitchell, W., Peteraf, M., Singh, H., Teece, D., Winter, S.G., (2009) *Dynamic capabilities: Understanding strategic change in organizations*: John Wiley & Sons.
- Helfat, C.E., Winter, S.G. (2011) Untangling dynamic and operational capabilities: Strategy for the (N) ever-changing world. *Strategic management journal*, 32(11), 1243-1250.
- Hellström, T., Husted, K. (2004) Mapping knowledge and intellectual capital in academic environments: A focus group study. *Journal of Intellectual capital*, 5(1), 165-180.
- Herstad, S.J., Aslesen, H.W., Ebersberger, B. (2014) On industrial knowledge bases, commercial opportunities and global innovation network linkages. *Research Policy*, 43(3), 495-504.
- Hibbert, P. (2013) Approaching reflexivity through reflection: Issues for critical management education. *Journal of Management Education*, 37(6), 803-827.
- (2000) *Wales in the 21st Century*. Springer.
- Hindle, K. (2010) Skillful dreaming: testing a general model of entrepreneurial process with a specific narrative of venture creation. *An Issue about The Republic of Tea*, 97.
- Hoda, R., Noble, J., Marshall, S., (2011) *Grounded theory for geeks*.
- Hoda, R., Noble, J., Marshall, S. (2012) Developing a grounded theory to explain the practices of self-organizing Agile teams. *Empirical Software Engineering*, 17(6), 609-639.
- Hoffman, J., Hoelscher, M., Sorenson, R. (2006) Achieving sustained competitive advantage: A family capital theory. *Family business review*, 19(2), 135-145.
- Hollnagel, E., Goteman, O. (2004) The functional resonance accident model. *Proceedings of cognitive system engineering in process plant*, 2004, 155-161.
- Holton, J. (2007) Rehumanising knowledge work through fluctuating support networks: a grounded theory. *Grounded Theory Review*, 6(2), 23-46.

- Holton, J.A. (2007) The coding process and its challenges. *The Sage handbook of grounded theory*, (III), 265-289.
- Hsu, B.-M., Shu, M.-H. (2008) Fuzzy inference to assess manufacturing process capability with imprecise data. *European Journal of Operational Research*, 186(2), 652-670.
- Huaccho Huatuco, L., Martinez, V., Burgess, T.F. and Shaw, N.E., 2019. High value manufacturing (HVM) in the UK: case studies and focus group insights. *Production Planning & Control*, 30(1), pp.60-75.
- Huang, X., Kristal, M.M., Schroeder, R.G. (2008) Linking learning and effective process implementation to mass customization capability. *Journal of Operations Management*, 26(6), 714-729.
- Hughes, A. (2011) Open innovation, the Haldane principle and the new production of knowledge: science policy and university–industry links in the UK after the financial crisis. *Prometheus*, 29(4), 411-442.
- Humphrys, G. (1976) Industrial Change: Lessons from South Wales. *Geography*, 246-254.
- Huq, F., Pawar, K.S. and Subramanian, N., 2020. Disturbances to the supply chains of high-value manufacturing firms: comparison of the perceptions of product managers and supply chain managers. *International Journal of Production Research*, pp.1-19.
- Insead, L.C., Chatain, O. (2008) Competitors' resource-oriented strategies: Acting on competitors' resources through interventions in factor markets and political markets. *Academy of management review*, 33(1), 97-121.
- Jackson, S.E., Chester, J.D. (2015) Personalised cancer medicine. *International journal of cancer*, 137(2), 262-266.
- James, K., Vinnicombe, S. (2002) Acknowledging the individual in the researcher. *Essential skills for management research*, Sage, London, 84-98.
- James, W. (1907) Lecture II: What pragmatism means.
- Jansen, J.J., Tempelaar, M.P., Van den Bosch, F.A., Volberda, H.W. (2009) Structural differentiation and ambidexterity: The mediating role of integration mechanisms. *Organization science*, 20(4), 797-811.
- Janssens, M., Steyaert, C. (2009) HRM and performance: A plea for reflexivity in HRM studies. *Journal of management studies*, 46(1), 143-155.
- Jennifer, M. (2002) Qualitative researching. *University of Manchester, UK: Sage Publishings*.
- Jensen, A., Aven, T. (2018) A new definition of complexity in a risk analysis setting. *Reliability Engineering & System Safety*, 171, 169-173.
- Jin, Y., Vonderembse, M., Ragu-Nathan, T. (2013) Proprietary technologies: building a manufacturer's flexibility and competitive advantage. *International Journal of Production Research*, 51(19), 5711-5727.

- Johannessen, J.-A., Olsen, B. (2010) The future of value creation and innovations: Aspects of a theory of value creation and innovation in a global knowledge economy. *International Journal of Information Management*, 30(6), 502-511.
- Johnson, P., Duberley, J. (2003) Reflexivity in management research. *Journal of management studies*, 40(5), 1279-1303.
- Johnson, W.H. (1999) An integrative taxonomy of intellectual capital: measuring the stock and flow of intellectual capital components in the firm. *International journal of technology management*, 18(5), 562-575.
(2000) *Wales in the 21st Century*. Springer.
- Jones, M., Alony, I. (2011) Guiding the use of grounded theory in doctoral studies—An example from the Australian film industry.
- Jones, P., Beynon-Davies, P., Muir, E. (2003) Ebusiness barriers to growth within the SME sector. *Journal of Systems and Information Technology*, 7(1/2), 1-25.
- Jonsson, P. (2000) An empirical taxonomy of advanced manufacturing technology. *International Journal of Operations & Production Management*, 20(12), 1446-1474.
- Jüttner, U., Peck, H., Christopher, M. (2003) Supply chain risk management: outlining an agenda for future research. *International Journal of Logistics: Research and Applications*, 6(4), 197-210.
- Karna, A., Richter, A., Riesenkampff, E. (2016) Revisiting the role of the environment in the capabilities–financial performance relationship: A meta-analysis. *Strategic management journal*, 37(6), 1154-1173.
- Kastensson, Å., Johansson, C. (2011) Decision-making in gates: based on formal basis or gut feeling? *International Journal of Technology Intelligence and Planning (IJTIP)*, 7(2), 140-152.
- Kauppila, O.P., 2010. Creating ambidexterity by integrating and balancing structurally separate interorganizational partnerships. *Strategic organization*, 8(4), pp.283-312.
- Kelley, D.J., Rice, M.P. (2002) Leveraging the value of proprietary technologies. *Journal of Small Business Management*, 40(1), 1-16.
- Kemmis, S., McTaggart, R., (2005) *Participatory action research: Communicative action and the public sphere*: Sage Publications Ltd.
- Kenny, M., Fourie, R. (2014) Tracing the history of grounded theory methodology: From formation to fragmentation. *The Qualitative Report*, 19(52), 1-9.
- Khavul, S., Peterson, M., Mullens, D., Rasheed, A.A. (2010) Going global with innovations from emerging economies: investment in customer support capabilities pays off. *Journal of International Marketing*, 18(4), 22-42.
- Kim, N.C., Kusimba, C.M. (2008) Pathways to social complexity and state formation in the southern Zambesian region. *African Archaeological Review*, 25(3-4), 131-152.
- King, P.S. (2013) Moderators/Moderating Factors. *Encyclopedia of Behavioral Medicine*, 1256-1258.

- Klerkx, L., Aarts, N. (2013) The interaction of multiple champions in orchestrating innovation networks: Conflicts and complementarities. *Technovation*, 33(6-7), 193-210.
- Knudsen, L.G., Nielsen, B.B. (2010) Collaborative capability in R&D alliances: exploring the link between organisational-and individual-level factors. *International Journal of Knowledge Management Studies*, 4(2), 152-175.
- Koc, T., Bozdog, E. (2009) The impact of AMT practices on firm performance in manufacturing SMEs. *Robotics and Computer-Integrated Manufacturing*, 25(2), 303-313.
- Kraatz, M.S., Zajac, E.J. (2001) How organizational resources affect strategic change and performance in turbulent environments: Theory and evidence. *Organization science*, 12(5), 632-657.
- Kuhn, T.S. (1962) The structure of scientific revolutions. *Chicago and London*.
- Kuhn, T.S. (1970) The structure of scientific revolutions. Second edition. *International Encyclopedia of Unified Science*, 2(2), 210.
- Kumar, M., Rodrigues, V.S. (2018) Synergetic effect of lean and green on innovation: A resource-based perspective. *International Journal of Production Economics*. (2010) *Learning and instruction in the digital age*: Springer.
- Laureano Paiva, E., Roth, A.V., Evaldo Fensterseifer, J. (2002) Focusing information in manufacturing: a knowledge management perspective. *Industrial Management & Data Systems*, 102(7), 381-389.
- Lee, C., Lee, K., Pennings, J.M. (2001) Internal capabilities, external networks, and performance: a study on technology-based ventures. *Strategic management journal*, 22(6-7), 615-640.
- Lee, H., Kelley, D., Lee, J., Lee, S. (2012) SME survival: The impact of internationalization, technology resources, and alliances. *Journal of small business management*, 50(1), 1-19.
- Lee, S.M. and Rha, J.S., 2016. Ambidextrous supply chain as a dynamic capability: building a resilient supply chain. *Management Decision*.
- Lee, S.-H., Wong, P.-K., Chong, C.-L. (2005) Human and social capital explanations for R&D outcomes. *IEEE Transactions on Engineering Management*, 52(1), 59-68.
- Leitch, C. (2007) An action research approach to entrepreneurship. *Handbook of qualitative research methods in entrepreneurship*, 144, 169.
- Leonard, D., McAdam, R. (2001) Grounded theory methodology and practitioner reflexivity in TQM research. *International Journal of Quality & Reliability Management*, 18(2), 180-194.
- Lerro, A., Linzalone, R., Schiuma, G., Kianto, A., Ritala, P., Spender, J.-C., Vanhala, M. (2014) The interaction of intellectual capital assets and knowledge management practices in organizational value creation. *Journal of Intellectual capital*.
- Lessard, D., Sakhrani, V., Miller, R. (2014) House of Project Complexity—understanding complexity in large infrastructure projects. *Engineering Project Organization Journal*, 4(4), 170-192.

- Lester, S. (1995) Beyond knowledge and competence: Towards a framework for professional education. *Capability*, 1(3), 44-52.
- Lewin, A.Y., Massini, S., Peeters, C. (2011) Microfoundations of internal and external absorptive capacity routines. *Organization science*, 22(1), 81-98.
- Lewin, K. (1946) Action research and minority problems. *Journal of social issues*, 2(4), 34-46.
- Liao, Y., Liao, K., Tu, Q., Vonderembse, M. (2011) A mechanism for external competence transfer to improve manufacturing system capabilities and market performance. *International Journal of Production Economics*, 132(1), 68-78.
- Liao, J., Kickul, J.R., Ma, H. (2009) Organizational dynamic capability and innovation: An empirical examination of internet firms. *Journal of Small Business Management*, 47 (3), 263-286
- Linden, G., Hart, J., Lenway, S.A., Murtha 1, T.P. (1998) Flying geese as moving targets: Are Korea and Taiwan catching up with Japan in advanced displays? *Industry and Innovation*, 5(1), 11-34.
- Linderman, K., Chandrasekaran, A. (2010) The scholarly exchange of knowledge in operations management. *Journal of Operations Management*, 28(4), 357-366.
- Lissack, M.R. (1999) Complexity: the science, its vocabulary, and its relation to organizations. *Emergence*, 1(1), 110-126.
- Liu, S.-T. (2008) A fuzzy DEA/AR approach to the selection of flexible manufacturing systems. *Computers & Industrial Engineering*, 54(1), 66-76.
- Livesey, F., 2006. *Defining high value manufacturing*. CBI.
- Lloyd-Reason, L., Ibeh, K., Deprey, B. (2009) Top barriers and drivers to SME internationalisation.
- Locke, K.D., (2000) *Grounded theory in management research*: Sage.
- Locke, K.D., (2000) *Grounded theory in management research*: Sage.
- Lockett, A., Wiklund, J., Davidsson, P., Girma, S. (2011) Organic and acquisitive growth: Re-examining, testing and extending Penrose's growth theory. *Journal of Management Studies*, 48(1), 48-74.
- Lohr, S. (2011) The power of the platform at Apple. *New York Times*.
- Lovell, A. (2002) Moral agency as victim of the vulnerability of autonomy. *Business Ethics: A European Review*, 11(1), 62-76.
- MacBryde, J., Paton, S. and Mendibil, K., 2010. From manufacturing to high value manufacturing: exploring this transition. *Journal of General Management*, 36(2), pp.65-79
- MacBryde, J., Paton, S. and Clegg, B., 2013. Understanding high-value manufacturing in Scottish SMEs. *International Journal of Operations & Production Management*, 33(11-12), pp.1579-1598.

- MacCarthy, B.L., Lewis, M., Voss, C., Narasimhan, R. (2013) The same old methodologies? Perspectives on OM research in the post-lean age. *International Journal of Operations & Production Management*, 33(7), 934-956.
- Macher, J.T., Mowery, D.C. (2009) Measuring dynamic capabilities: practices and performance in semiconductor manufacturing. *British Journal of Management*, 20, S41-S62.
- Mack, L., (2010) *The philosophical underpinnings of educational research*.
- Mackenzie, N., Knipe, S. (2006) Research dilemmas: Paradigms, methods and methodology. *Issues in educational research*, 16(2), 193-205.
- Madsen, E. (2010). A dynamic capability framework – Generic types of dynamic capabilities and their relationship to entrepreneurship. In Wall, S., Zimmerman, C., Klingebiel, R and Lange, D. (eds) *Strategic Reconfigurations: Building Dynamic Capabilities in Rapid-Innovation Based Industries*. Cheltenham: Edward Elgar.
- Mangan, J., Lalwani, C., Gardner, B. (2004) Combining quantitative and qualitative methodologies in logistics research. *International journal of physical distribution & logistics management*, 34(7), 565-578.
- Manigart, S., Collewaert, V., Wright, M., Pruthi, S., Lockett, A., Bruining, H., Hommel, U., Landstrom, H. (2007) Human capital and the internationalisation of venture capital firms. *International Entrepreneurship and Management Journal*, 3(1), 109-125.
- Mannino, D.M., Buist, A.S. (2007) Global burden of COPD: risk factors, prevalence, and future trends. *The Lancet*, 370(9589), 765-773.
- Manson, S.M. (2001) Simplifying complexity: a review of complexity theory. *Geoforum*, 32(3), 405-414.
- Martin, P.Y., Turner, B.A. (1986) Grounded theory and organizational research. *The journal of applied behavioral science*, 22(2), 141-157.
- Martinez, V., Neely, A., Ren, G., Smart, A., (2008) *High Value Manufacturing: Delivering on the Promise*: Advanced Institute of Management Research (AIM).
- Marvel, M.R. (2013) Human capital and search-based discovery: A study of high-tech entrepreneurship. *Entrepreneurship theory and practice*, 37(2), 403-419.
- Matthews, R.L., Marzec, P.E. (2012) Social capital, a theory for operations management: a systematic review of the evidence. *International Journal of Production Research*, 50(24), 7081-7099.
- Mayring, P. (2004) Qualitative content analysis. *A companion to qualitative research*, 1, 159-176.
- Mazzocchi, F. (2008) Complexity in biology: Exceeding the limits of reductionism and determinism using complexity theory. *EMBO reports*, 9(1), 10-14.
- McCutcheon, D.M., Meredith, J.R. (1993) Conducting case study research in operations management. *Journal of Operations Management*, 11(3), 239-256.

- McDermott, C.M., Stock, G.N. (1999) Organizational culture and advanced manufacturing technology implementation. *Journal of Operations Management*, 17(5), 521-533.
- McElroy, M.W. (2000) Integrating complexity theory, knowledge management and organizational learning. *Journal of Knowledge Management*, 4(3), 195-203.
- McGhee, G., Marland, G.R., Atkinson, J. (2007) Grounded theory research: literature reviewing and reflexivity. *Journal of advanced nursing*, 60(3), 334-342.
- McKevitt, D., Marshall, D. (2015) The legitimacy of entrepreneurial mentoring. *International Journal of Entrepreneurial Behavior & Research*, 21(2), 263-280.
- Meredith, J. (1993) Theory building through conceptual methods. *International Journal of Operations & Production Management*, 13(5), 3-11.
- Meredith, J. (1998) Building operations management theory through case and field research. *Journal of Operations Management*, 16(4), 441-454.
- Meredith, J.R., Raturi, A., Amoako-Gyampah, K., Kaplan, B. (1989) Alternative research paradigms in operations. *Journal of Operations Management*, 8(4), 297-326.
- Meyer, M.H., Lehnerd, A.P., (1997) *The power of product platforms*: Simon and Schuster.
- Miles, M.B., Huberman, M. (1984) a.(1994). Qualitative data analysis: An expanded sourcebook. *Evaluation and Program Planning*, 19, 106-107.
- Miles, R.E., Snow, C.C. (1995) The new network firm: A spherical structure built on a human investment philosophy. *Organizational Dynamics*, 23(4), 5-18.
- Minchinton, W.E., (2013) *Industrial South Wales 1750-1914: Essays in Welsh Economic History*: Routledge.
- Mital, A., Pennathur, A., Huston, R., Thompson, D., Pittman, M., Markle, G., Kaber, D., Crumpton, L., Bishu, R.R., Rajurkar, K.P. (1999) The need for worker training in advanced manufacturing technology (AMT) environments: A white paper. *International Journal of Industrial Ergonomics*, 24(2), 173-184.
- (2016) *Designing Knowledge Management-Enabled Business Strategies*: Springer.
- Mol, A. (2002) Complexities: social studies of knowledge practices.
- Mole, K.F., Bramley, G. (2006) Making policy choices in nonfinancial business support: an international comparison. *Environment and Planning C: Government and Policy*, 24(6), 885-908.
- Möller, K., Svahn, S. (2006) Role of knowledge in value creation in business nets. *Journal of Management Studies*, 43(5), 985-1007.
- Morgan, D.L. (2007) Paradigms lost and pragmatism regained: Methodological implications of combining qualitative and quantitative methods. *Journal of mixed methods research*, 1(1), 48-76.
- Morgan, G., (1983) *Beyond method: Strategies for social research*: Sage.

- Morgan, G., Smircich, L. (1980) The case for qualitative research. *Academy of management review*, 5(4), 491-500.
- Morris, J. (1987) Industrial restructuring, foreign direct investment, and uneven development: the case of Wales. *Environment and Planning A*, 19(2), 205-224.
- Morris, J. (1995) McJobbing a region: industrial restructuring and the widening socioeconomic divide in Wales. *The British Economy in Transition: From the Old to the New*, 59.
- Morrison, K. (2008) Educational philosophy and the challenge of complexity theory. *Educational Philosophy and Theory*, 40(1), 19-34.
- Mowery, D.C., Sampat, B.N. (2004) The Bayh-Dole Act of 1980 and university–industry technology transfer: a model for other OECD governments? *The Journal of Technology Transfer*, 30(1-2), 115-127.
- Mulrow, C.D. (1994) Systematic reviews: rationale for systematic reviews. *Bmj*, 309(6954), 597-599.
- Myers, M. (2000) Qualitative research and the generalizability question: Standing firm with Proteus. *The Qualitative Report*, 4(3), 9.
- Nadin, S., Cassell, C. (2006) The use of a research diary as a tool for reflexive practice: Some reflections from management research. *Qualitative Research in Accounting & Management*, 3(3), 208-217.
- Nadler, D.A., Tushman, M.L. (1989) Organizational frame bending: Principles for managing reorientation. *Academy of Management Perspectives*, 3(3), 194-204.
- Nair, A., Malhotra, M.K., Ahire, S.L. (2011) Toward a theory of managing context in Six Sigma process-improvement projects: An action research investigation. *Journal of operations management*, 29(5), 529-548.
- Nambisan, S., Sawhney, M. (2011) Orchestration processes in network-centric innovation: Evidence from the field. *Academy of Management Perspectives*, 25(3), 40-57.
- Narasimhan, R. (2014) Theory development in operations management: Extending the frontiers of a mature discipline via qualitative research. *Decision Sciences*, 45(2), 209-227.
- Narasimhan, R., Schoenherr, T. (2013) Revisiting the progression of competitive capabilities: results from a repeated cross-sectional investigation. *International Journal of Production Research*, 51(22), 6631-6650.
- Neill, S., Rose, G.M. (2007) Achieving adaptive ends through equivocality: A study of organizational antecedents and consequences. *Journal of Business Research*, 60(4), 305-313.
- Nelson, R., Winter, S. (1982) *Evolutionary Economics*. Cambridge, Mass., Belknap Harvard.
- Neupert, K.E., Baughn, C.C., Thanh Lam Dao, T. (2006) SME exporting challenges in transitional and developed economies. *Journal of Small Business and Enterprise Development*, 13(4), 535-545.

- Ng, K., Hase, S. (2008) Grounded Suggestions for Doing a Grounded Theory Business Research. *Electronic Journal of Business Research Methods*, 6(2).
- Noke, H., Hughes, M. (2010) Climbing the value chain: Strategies to create a new product development capability in mature SMEs. *International Journal of Operations & Production Management*, 30(2), 132-154.
- O'Reilly, K., Paper, D., Marx, S. (2012) Demystifying grounded theory for business research. *Organizational Research Methods*, 15(2), 247-262.
- O'Reilly III, C.A. and Tushman, M.L., 2008. Ambidexterity as a dynamic capability: Resolving the innovator's dilemma. *Research in organizational behavior*, 28, pp.185-206.
- Oktemgil, M., Greenley, G. (1997) Consequences of high and low adaptive capability in UK companies. *European Journal of Marketing*, 31(7), 445-466.
- Onal Vural, M., Dahlander, L., George, G. (2013) Collaborative benefits and coordination costs: Learning and capability development in science. *Strategic Entrepreneurship Journal*, 7(2), 122-137.
- Onwuegbuzie, A.J., Leech, N.L. (2010) Generalization practices in qualitative research: a mixed methods case study. *Quality & Quantity*, 44(5), 881-892.
- Orlikowski, W.J., Baroudi, J.J. (1991) Studying information technology in organizations: Research approaches and assumptions. *Information systems research*, 2(1), 1-28.
- Osuszek, L., Stanek, S., Twardowski, Z. (2016) Leverage big data analytics for dynamic informed decisions with advanced case management. *Journal of Decision systems*, 25(sup1), 436-449.
- Parhi, M. (2013) Innovation in the Welsh Automotive Industry: Challenges and Strategies. *Contemporary Wales*, 26(1), 24-44.
- Park, S.H., Chen, R., Gallagher, S. (2002) Firm resources as moderators of the relationship between market growth and strategic alliances in semiconductor start-ups. *Academy of management Journal*, 45(3), 527-545.
- Parse, R.R., (2001) *Qualitative inquiry: The path of sciencing*: Jones & Bartlett Learning. (2014) *Handbook of human centric visualization*: Springer.
- Patel, P.C., Terjesen, S., Li, D. (2012) Enhancing effects of manufacturing flexibility through operational absorptive capacity and operational ambidexterity. *Journal of Operations Management*, 30(3), 201-220.
- Patrakosol, B., Olson, D.L. (2007) How interfirm collaboration benefits IT innovation. *Information & Management*, 44(1), 53-62.
- Patterson, W. and Ambrosini, V., 2015. Configuring absorptive capacity as a key process for research intensive firms. *Technovation*, 36, pp.77-89.
- Paul, J.L., Marfo, K. (2001) Preparation of educational researchers in philosophical foundations of inquiry. *Review of Educational Research*, 71(4), 525-547.

- Payne, G., Williams, M. (2005) Generalization in qualitative research. *Sociology*, 39(2), 295-314.
- Peel, D. (2004) Coaching and mentoring in small to medium sized enterprises in the UK: Factors that affect success and a possible solution. *International Journal of Evidence Based Coaching and Mentoring*, 2(1), 46-56.
- Peeters, C., Massini, S., Lewin, A.Y. (2014) Sources of variation in the efficiency of adopting management innovation: the role of absorptive capacity routines, managerial attention and organizational legitimacy. *Organization studies*, 35(9), 1343-1371.
- Peng, D.X., Schroeder, R.G., Shah, R. (2008) Linking routines to operations capabilities: A new perspective. *Journal of Operations Management*, 26(6), 730-748.
- Pennings, J.M., Buitendam, A. (1987) New technology and organizational innovation: The development and diffusion of micro-electronics.
- Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Broström, A., D'Este, P., Fini, R., Geuna, A., Grimaldi, R., Hughes, A. (2013) Academic engagement and commercialisation: A review of the literature on university–industry relations. *Research Policy*, 42(2), 423-442.
- Perkmann, M., Walsh, K. (2009) The two faces of collaboration: impacts of university–industry relations on public research. *Industrial and Corporate Change*, 18(6), 1033-1065.
- Perona, M., Miragliotta, G. (2004) Complexity management and supply chain performance assessment. A field study and a conceptual framework. *International Journal of Production Economics*, 90(1), 103-115.
- Phaal, R., Farrukh, C., Probert, D. (2001) Technology management process assessment: a case study. *International journal of operations & production management*, 21(8), 1116-1132.
- Pickernell, D., Jones, P., Thompson, P., Packham, G. (2016) Determinants of SME exporting: insights and implications. *The International Journal of Entrepreneurship and Innovation*, 17(1), 31-42.
- Pilkington, A., Meredith, J. (2009) The evolution of the intellectual structure of operations management—1980–2006: A citation/co-citation analysis. *Journal of Operations Management*, 27(3), 185-202.
- Piorkowski, B.A., Gao, J.X., Evans, R.D. and Martin, N., 2013. A dynamic knowledge management framework for the high value manufacturing industry. *International Journal of Production Research*, 51(7), pp.2176-2185.
- Podsakoff, P.M., MacKenzie, S.B., Bachrach, D.G., Podsakoff, N.P. (2005) The influence of management journals in the 1980s and 1990s. *Strategic Management Journal*, 26(5), 473-488.
- Popper, M., Lipshitz, R. (1998) Organizational learning mechanisms: A structural and cultural approach to organizational learning. *The Journal of Applied Behavioral Science*, 34(2), 161-179.

Pousa, C., Mathieu, A. (2015) Is managerial coaching a source of competitive advantage? Promoting employee self-regulation through coaching. *Coaching: An International Journal of Theory, Research and Practice*, 8(1), 20-35.

(1997) *Strategische Unternehmensplanung/Strategische Unternehmensführung*: Springer.

Prasad, S.B. (1986) Technology transfer: The approach of a Dutch multinational. *Technovation*, 4(1), 3-15.

Priem, R.L., Butler, J.E. (2001) Is the resource-based "view" a useful perspective for strategic management research? *Academy of management review*, 26(1), 22-40.

Puhan, M.A., Akl, E.A., Bryant, D., Xie, F., Apolone, G., ter Riet, G. (2012) Discussing study limitations in reports of biomedical studies-the need for more transparency. *Health and quality of life outcomes*, 10(1), 23.

Randall, K.R., Resick, C.J., DeChurch, L.A. (2011) Building team adaptive capacity: The roles of sensegiving and team composition. *Journal of Applied Psychology*, 96(3), 525.

Reay, T., Whetten, D.A., (2011) *What constitutes a theoretical contribution in family business?*

Reed, R., DeFillippi, R.J. (1990) Causal ambiguity, barriers to imitation, and sustainable competitive advantage. *Academy of management review*, 15(1), 88-102.

Reuber, A.R., Fischer, E.M. (1994) Entrepreneurs' experience, expertise, and the performance of technology-based firms. *IEEE Transactions on Engineering Management*, 41(4), 365-374.

Reynolds, E.B. (2017) Innovation and Production: Advanced Manufacturing Technologies, Trends and Implications for US Cities and Regions. *Built Environment*, 43(1), 25-43.

Rezaei, J., Ortt, R., Trott, P. (2015) How SMEs can benefit from supply chain partnerships. *International Journal of Production Research*, 53(5), 1527-1543.

Rheinberger, H.-J. (1997) Experimental complexity in biology: Some epistemological and historical remarks. *Philosophy of Science*, 64, S245-S254.

Ridgway, K., Clegg, C.W., Williams, D., Hourd, P., Robinson, M., Bolton, L., Cichomska, K., Baldwin, J. (2013) The factory of the future. *Government Office for Science, Evidence Paper*, 29.

Riessman, C.K., (2008) *Narrative methods for the human sciences*: Sage.

Robertson, D., Ulrich, K. (1998) Planning for product platforms. *Sloan management review*, 39(4), 19.

Robinson, P., Lowe, J. (2015) Literature reviews vs systematic reviews. *Australian and New Zealand journal of public health*, 39(2), 103-103.

Robson, C. (2002) *Real world research* (Vol. 2nd). UK: Blackwell Publishing.

Robson, C., (2011) *Real world research*: Wiley Chichester.

- Rogers, C.R. (1954) Toward a theory of creativity. *ETC: A review of general semantics*, 249-260.
- Romey, W.D. (1970) What is your creativity quotient? *School Science and Mathematics*, 70(1), 3-8.
- Rosenzweig, E.D., Roth, A.V., Dean Jr, J.W. (2003) The influence of an integration strategy on competitive capabilities and business performance: an exploratory study of consumer products manufacturers. *Journal of operations management*, 21(4), 437-456.
- Rowan, J., (1973) *The social individual*. Davis-Poynter.
- Rubin, H.J., Rubin, I., S. (1995). *Qualitative interviewing the art of hearing data*.
- Saberi, S., Yusuff, R.M., Zulkifli, N., Ahmad, M. (2010) Effective factors on advanced manufacturing technology implementation performance: a review. *Journal of Applied Sciences (Faisalabad)*, 10(13), 1229-1242.
- Sadler-Smith, E., Shefy, E. (2004) The intuitive executive: Understanding and applying 'gut feel' in decision-making. *Academy of Management Perspectives*, 18(4), 76-91.
- Sampson, R.C. (2005) Experience effects and collaborative returns in R&D alliances. *Strategic management journal*, 26(11), 1009-1031.
- Sandberg, J., Alvesson, M. (2011) Ways of constructing research questions: gap-spotting or problematization? *Organization*, 18(1), 23-44.
- Sarantakos, S., (2012) *Social research*: Macmillan International Higher Education.
- Sarmiento, R., Shukla, V. (2011) Zero-sum and frontier trade-offs: An investigation on compromises and compatibilities amongst manufacturing capabilities. *International Journal of Production Research*, 49(7), 2001-2017.
- Saunders, M.N., (2011) *Research methods for business students, 5/e*: Pearson Education India.
- Savenye, W.C., Robinson, R.S. (1996) Qualitative research issues and methods: An introduction for educational technologists. *Handbook of research for educational communications and technology*, 1171-1195.
- Schacht, W.H., (2009) *The Bayh-Dole act: selected issues in patent policy and the commercialization of technology*.
- Scheiner, C.W., Baccarella, C.V., Bessant, J., Voigt, K.-I. (2015) Thinking patterns and gut feeling in technology identification and evaluation. *Technological forecasting and social change*, 101, 112-123.
- Schilling, M.A., Hill, C.W. (1998) Managing the new product development process: strategic imperatives. *Academy of Management Perspectives*, 12(3), 67-81.
- Schmidt, G., Wilhelm, W.E. (2000) Strategic, tactical and operational decisions in multi-national logistics networks: a review and discussion of modelling issues. *International Journal of Production Research*, 38(7), 1501-1523.

- Schmidt, T. (2010) Absorptive capacity—one size fits all? A firm-level analysis of absorptive capacity for different kinds of knowledge. *Managerial and Decision Economics*, 31(1), 1-18.
- Schneider, A. (2015) Reflexivity in sustainability accounting and management: Transcending the economic focus of corporate sustainability. *Journal of Business Ethics*, 127(3), 525-536.
- Seidman, I. (1991) A structure for in-depth, phenomenological interviewing. *Interviewing as qualitative research*, 9-20.
- Shepherd, D.A., Shanley, M., (1998) *New venture strategy: Timing, environmental uncertainty, and performance*: SAGE Publications, Incorporated.
- Silverman, D., (2016) *Qualitative research*: Sage.
- Singhal, K., Singhal, J. (2012) Opportunities for developing the science of operations and supply-chain management. *Journal of Operations Management*, 30(3), 245-252.
- Smedlund, A. (2012) Value cocreation in service platform business models. *Service Science*, 4(1), 79-88.
- Smith, E.A. (2001) The role of tacit and explicit knowledge in the workplace. *Journal of knowledge Management*, 5(4), 311-321.
- Sol, J., Beers, P.J., Wals, A.E. (2013) Social learning in regional innovation networks: trust, commitment and reframing as emergent properties of interaction. *Journal of cleaner production*, 49, 35-43.
- Solaz-Portolés, J.J., Sanjosé, V. (2008) Types of knowledge and their relations to problem solving in science: directions for practice. *Sísifo. Educational Sciences Journal*, 6, 105-112.
- Soltani, E., K. Ahmed, P., Ying Liao, Y., U. Anosike, P. (2014) Qualitative middle-range research in operations management: the need for theory-driven empirical inquiry. *International Journal of Operations & Production Management*, 34(8), 1003-1027.
- Soriano, J.B., Lamprecht, B. (2012) Chronic obstructive pulmonary disease: a worldwide problem. *Medical Clinics*, 96(4), 671-680.
- Spanos, Y.E., Voudouris, I. (2009) Antecedents and trajectories of AMT adoption: the case of Greek manufacturing SMEs. *Research Policy*, 38(1), 144-155.
- Spithoven, A., Clarysse, B., Knockaert, M. (2010) Building absorptive capacity to organise inbound open innovation in traditional industries. *Technovation*, 30(2), 130-141.
- Squire, B., Burgess, K., Singh, P.J., Koroglu, R. (2006) Supply chain management: a structured literature review and implications for future research. *International Journal of Operations & Production Management*.
- Staber, U., Sydow, J. (2002) Organizational adaptive capacity: A structuration perspective. *Journal of management inquiry*, 11(4), 408-424.
- Stark, E.M., Bierly III, P.E. (2009) An analysis of predictors of team satisfaction in product development teams with differing levels of virtualness. *R&d Management*, 39(5), 461-472.

- Stern, P.N. (1994) Eroding grounded theory. *Critical issues in qualitative research methods*, 212-223.
- Stettner, U. and Lavie, D., 2014. Ambidexterity under scrutiny: Exploration and exploitation via internal organization, alliances, and acquisitions. *Strategic management journal*, 35(13), pp.1903-1929.
- Stine-Morrow, E.A., Parisi, J.M., Morrow, D.G., Greene, J., Park, D.C. (2007) An engagement model of cognitive optimization through adulthood. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 62(Special_Issue_1), 62-69.
- Sting, F.J., Loch, C.H. (2016) Implementing operations strategy: How vertical and horizontal coordination interact. *Production and Operations Management*, 25(7), 1177-1193.
- Stock, G.N., Greis, N.P., Fischer, W.A. (2001) Absorptive capacity and new product development. *The Journal of High Technology Management Research*, 12(1), 77-91.
- Storey, D.J. (2004) Exploring the link, among small firms, between management training and firm performance: a comparison between the UK and other OECD countries. *The International Journal of Human Resource Management*, 15(1), 112-130.
- Strauss, A., Corbin, J., (1990) *Basics of qualitative research*: Sage publications.
- Strauss, A., Corbin, J.M., (1997) *Grounded theory in practice*: Sage.
- Strauss, A. and Corbin, J., 1998. *Basics of qualitative research techniques*. Thousand Oaks, CA: Sage publications.
- Strauss, A.L., (1987) *Qualitative analysis for social scientists*: Cambridge university press.
- Subramanian, A.M., Choi, Y.R., Lee, S.-H., Hang, C.-C. (2016) Linking technological and educational level diversities to innovation performance. *The Journal of Technology Transfer*, 41(2), 182-204.
- Suchman, M.C. (1995) Managing legitimacy: Strategic and institutional approaches. *Academy of management review*, 20(3), 571-610.
- Suddaby, R., (2006) *From the editors: What grounded theory is not*.
- Sun, H., Zhang, P. (2006) The role of moderating factors in user technology acceptance. *International journal of human-computer studies*, 64(2), 53-78.
- Swink, M., Harvey Hegarty, W. (1998) Core manufacturing capabilities and their links to product differentiation. *International Journal of Operations & Production Management*, 18(4), 374-396.
- Tassej, G. (2014) Competing in advanced manufacturing: The need for improved growth models and policies. *Journal of Economic Perspectives*, 28(1), 27-48.

- Tatikonda, M.V., Rosenthal, S.R. (2000) Technology novelty, project complexity, and product development project execution success: a deeper look at task uncertainty in product innovation. *IEEE Transactions on engineering management*, 47(1), 74-87.
- Teddlie, C. (2005) Methodological issues related to causal studies of leadership: A mixed methods perspective from the USA. *Educational Management Administration & Leadership*, 33(2), 211-227.
- Teece, D. (1990) Firm capabilities, resources and the concept of strategy. *Economic analysis and policy*.
- Teece, D., Peteraf, M., Leih, S. (2016) Dynamic capabilities and organizational agility: Risk, uncertainty, and strategy in the innovation economy. *California Management Review*, 58(4), 13-35.
- Teece, D.J. (1989) Inter-organizational requirements of the innovation process. *Managerial and Decision Economics*, 35-42.
- Teece, D.J. (2007) Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. *Strategic management journal*, 28(13), 1319-1350.
- Teece, D.J. (2014) A dynamic capabilities-based entrepreneurial theory of the multinational enterprise. *Journal of International Business Studies*, 45(1), 8-37.
- Teece, D.J. (2018) Dynamic capabilities as (workable) management systems theory. *Journal of Management & Organization*, 24(3), 359-368.
- Teece, D.J., Pisano, G., Shuen, A. (1997) Dynamic capabilities and strategic management. *Strategic management journal*, 18(7), 509-533.
- Terjesen, S., Patel, P.C., Covin, J.G. (2011) Alliance diversity, environmental context and the value of manufacturing capabilities among new high technology ventures. *Journal of Operations Management*, 29(1-2), 105-115.
- Terjesen, S., Sullivan, S.E. (2011) The role of developmental relationships in the transition to entrepreneurship: A qualitative study and agenda for future research. *Career Development International*, 16(5), 482-506.
- Tether, B.S., Tajar, A. (2008) Beyond industry–university links: Sourcing knowledge for innovation from consultants, private research organisations and the public science-base. *Research Policy*, 37(6-7), 1079-1095.
- Thomé, A.M.T., Scavarda, L.F., Scavarda, A.J. (2016) Conducting systematic literature review in operations management. *Production Planning & Control*, 27(5), 408-420.
- Tidd, J., Bessant, J.R., (2018) *Managing innovation: integrating technological, market and organizational change*: John Wiley & Sons.
- Tödttling, F., Kaufmann, A. (1999) Innovation systems in regions of Europe—a comparative perspective. *European planning studies*, 7(6), 699-717.
- Torrance, E.P. (1965) Scientific views of creativity and factors affecting its growth. *Daedalus*, 663-681.
- Törrönen, J. (2002) Semiotic theory on qualitative interviewing using stimulus texts.

Qualitative Research, 2(3), 343-362.

Touray, A., Salminen, A., Mursu, A. (2013) The impact of moderating factors on behavioral intention towards internet: A transnational perspective. *Sustainable Solutions for Last Mile Internet Access in Developing Countries: Critical Success Factors*.

Tracey, M., Vonderembse, M.A., Lim, J.-S. (1999) Manufacturing technology and strategy formulation: keys to enhancing competitiveness and improving performance. *Journal of Operations Management*, 17(4), 411-428.

Tranfield, D., Denyer, D., Smart, P. (2003) Towards a methodology for developing evidence-informed management knowledge by means of systematic review. *British Journal of Management*, 14(3), 207-222.

Trnova, E. (2014) IBSE and Creativity Development. *Science Education International*, 25(1), 8-18.

Tu, Q., Vonderembse, M.A., Ragu-Nathan, T., Sharkey, T.W. (2006) Absorptive capacity: Enhancing the assimilation of time-based manufacturing practices. *Journal of Operations Management*, 24(5), 692-710.

Turner, C., Roy, R., Wiold, D. (1990) Cutting-edge technology: Materials: a new revolutionary generic technology? conditions and policies for innovation. *Technology Analysis & Strategic Management*, 2(3), 221-236.

Turner, S.F., Rindova, V. (2012) A balancing act: How organizations pursue consistency in routine functioning in the face of ongoing change. *Organization science*, 23(1), 24-46.

Tushman, M.L. and O'Reilly III, C.A., 1996. Ambidextrous organizations: Managing evolutionary and revolutionary change. *California management review*, 38(4), pp.8-29.

Tzortzaki, A.M., Mihiotis, A. (2014) A review of knowledge management theory and future directions. *Knowledge and Process Management*, 21(1), 29-41.

Unger, J.M., Rauch, A., Frese, M., Rosenbusch, N. (2011) Human capital and entrepreneurial success: A meta-analytical review. *Journal of business venturing*, 26(3), 341-358.

Vaaland, T.I., Heide, M. (2007) Can the SME survive the supply chain challenges? *Supply chain management: an International Journal*, 12(1), 20-31.

Van Maanen, J. (1982) Fieldwork on the beat. *Varieties of qualitative research*, 103-151.

Van de Ven, A.H., 1989. Nothing is quite so practical as a good theory. *Academy of management Review*, 14(4), pp.486-489.

Van Regenmortel, M.H. (2004) Reductionism and complexity in molecular biology: Scientists now have the tools to unravel biological complexity and overcome the limitations of reductionism. *EMBO reports*, 5(11), 1016-1020.

Vickery, S.K. (1991) A theory of production competence revisited. *Decision sciences*, 22(3), 635-643.

Vickery, S.K., Droge, C., Markland, R.E. (1993) Production competence and business strategy: do they affect business performance? *Decision Sciences*, 24(2), 435-456.

- Voss, C.A., Åhlström, P., Blackmon, K. (1997) Benchmarking and operational performance: some empirical results. *International Journal of Operations & Production Management*, 17(10), 1046-1058.
- Wacker, J.G. (1998) A definition of theory: research guidelines for different theory-building research methods in operations management. *Journal of Operations Management*, 16(4), 361-385.
- Walliman, N., (2016) *Social research methods: The essentials*: Sage.
- Wang, C.L., Ahmed, P.K. (2007) Dynamic capabilities: A review and research agenda. *International journal of management reviews*, 9(1), 31-51.
- Ward, P.T., Bickford, D.J., Leong, G.K. (1996) Configurations of manufacturing strategy, business strategy, environment and structure. *Journal of management*, 22(4), 597-626.
- Warren, C.A. (2002) Qualitative interviewing. *Handbook of interview research: Context and method*, 839-101.
- Wass, V.J., Wells, P.E., (1994) *Principles and practice in business and management research*: Dartmouth.
- Watson, G. (1987) Make me reflexive, but not yet: Strategies for managing essential reflexivity in ethnographic discourse. *Journal of Anthropological Research*, 43(1), 29-41. (1987) *Theories of group behavior*. Springer.
- Weick, K.E. (1999) Theory construction as disciplined reflexivity: Tradeoffs in the 90s. *Academy of management review*, 24(4), 797-806.
- Wernerfelt, B. (1984) A resource-based view of the firm. *Strategic management journal*, 5(2), 171-180.
- Westbrook, R. (1995) Action research: a new paradigm for research in production and operations management. *International Journal of Operations & Production Management*, 15(12), 6-20.
- Westbury, I. (2016) State-based curriculum-making: the Illinois Learning Standards. *Journal of Curriculum Studies*, 48(6), 783-802.
- Westhead, P. (1988) Manufacturing closures in Wales 1980-1984: a route to new firm formation.
- Wheel Wright, S.C. (1984) Manufacturing strategy: defining the missing link. *Strategic Management Journal*, 5(1), 77-91.
- White, G. (2009) Strategic, tactical, & operational management security model. *Journal of Computer Information Systems*, 49(3), 71-75.
- White, W., Krueger, J.W., Marketing, V.P., Sales, Æ., Midland, M. (2003) Antimicrobial Treatments: Everything Product Manufacturers Need to Know.
- Whybark, D.C. (1987) Evolving the manufacturing strategy. *Engineering Costs and Production Economics*, 12(1-4), 243-250.

- Wiggins, R.R., Ruefli, T.W. (2005) Schumpeter's ghost: Is hypercompetition making the best of times shorter? *Strategic management journal*, 26(10), 887-911.
- Wilding, R. (1998) The supply chain complexity triangle: uncertainty generation in the supply chain. *International Journal of Physical Distribution & Logistics Management*, 28(8), 599-616.
- Wilhelm, M., Blome, C., Wieck, E., Xiao, C.Y. (2016) Implementing sustainability in multi-tier supply chains: Strategies and contingencies in managing sub-suppliers. *International Journal of Production Economics*, 182, 196-212.
- Willms, J.D., Friesen, S., Milton, P., (2009) *What Did You Do in School Today? Transforming Classrooms through Social, Academic, and Intellectual Engagement. (First National Report)*: ERIC.
- (2013) *Cognitive Reserve*: Psychology Press.
- Winter, S.G. (2003) Understanding dynamic capabilities. *Strategic management journal*, 24(10), 991-995.
- Winter Sidney, G., Nelson, R. (1982) An Evolutionary Theory of Economic Change. *Rochester, NY: Social Science Research Network*.
- Wong, C.W., Wong, C.Y., Boon-itt, S. (2013) The combined effects of internal and external supply chain integration on product innovation. *International journal of production economics*, 146(2), 566-574.
- Wood, A., Britney, R. (1989) Production operations management: research and teaching opportunities in the 1990's. *Operations Management Review*, 8(3-4), 33-43.
- Wright, R.W., Brand, R.A., Dunn, W., Spindler, K.P. (2007) How to write a systematic review. *Clinical Orthopaedics and Related Research (1976-2007)*, 455, 23-29.
- Wu, C.-W., Pearn, W.-L. (2006) Bayesian approach for measuring EEPROM process capability based on the one-sided indices C_{PU} and C_{PL}. *The International Journal of Advanced Manufacturing Technology*, 31(1-2), 135-144.
- Yin, R.K., (2017) *Case study research and applications: Design and methods*: Sage publications.
- Youssef, M.A. (1992) Getting To Know Advanced Manufacturing. *Industrial Engineering*.
- Youtie, J., Shapira, P. (2008) Building an innovation hub: A case study of the transformation of university roles in regional technological and economic development. *Research Policy*, 37(8), 1188-1204.
- Yvonne Feilzer, M. (2010) Doing mixed methods research pragmatically: Implications for the rediscovery of pragmatism as a research paradigm. *Journal of mixed methods research*, 4(1), 6-16.
- Zacharakis, A., Shepherd, D.A. (2005) A non-additive decision-aid for venture capitalists' investment decisions. *European Journal of Operational Research*, 162(3), 673-689.

Zahra, S.A., Hayton, J.C. (2008) The effect of international venturing on firm performance: The moderating influence of absorptive capacity. *Journal of business venturing*, 23(2), 195-220.

Zahra, S.A. and George, G., 2002. Absorptive capacity: A review, reconceptualization, and extension. *Academy of management review*, 27(2), pp.185-203.

Zahra, S.A., Sapienza, H.J., Davidsson, P. (2006) Entrepreneurship and dynamic capabilities: A review, model and research agenda. *Journal of Management Studies*, 43(4), 917-955.

Zander, U., Kogut, B. (1995) Knowledge and the speed of the transfer and imitation of organizational capabilities: An empirical test. *Organization Science*, 6(1), 76-92.

Zhai, E., Shi, Y., Gregory, M. (2007) The growth and capability development of electronics manufacturing service (EMS) companies. *International Journal of Production Economics*, 107(1), 1-19.

Zhang, Q., Vonderembse, M.A., Cao, M. (2006) Achieving flexible manufacturing competence: the roles of advanced manufacturing technology and operations improvement practices. *International Journal of Operations & Production Management*, 26(6), 580-599.

Zhou, J., Shafique, M.N., Adeel, A., Nawaz, S., Kumar, P. (2017) WHAT IS THEORETICAL CONTRIBUTION? A NARRATIVE REVIEW. *Sarhad Journal of Management Sciences*, 3(02), 261-271.

Zollo, M. and Winter, S.G., 2002. Deliberate learning and the evolution of dynamic capabilities. *Organization science*, 13(3), pp.339-351.

Zott, C. (2003) Dynamic capabilities and the emergence of intraindustry differential firm performance: insights from a simulation study. *Strategic management journal*, 24(2), 97-125.

Appendices

Appendix A: Cardiff Business School Consent Letter to respondents

CARDIFF BUSINESS SCHOOL RESEARCH ETHICS

Consent Form –

This project seeks to explore the nature and dynamics of capabilities within organizations. The focus is on small and medium enterprises that engage in advanced manufacturing using advanced technologies and methods. The outputs from this project include a theoretical framework and methodology, which when validated, will act as templates for other organisations wishing to develop their in-house capabilities.

Participation in this project will involve taking part in interviews and observations concerning how companies develop capabilities that enhance their competitiveness. It may also involve the testing of theories and frameworks developed from the results of these questionnaires and interviews.

I understand that participation in this study is entirely voluntary and that I can withdraw from the study at any time without giving a reason.

I understand that I am free to ask any questions at any time. If for any reason I have second thoughts about my participation in this project, I am free to withdraw or discuss my concerns with Professor Mohamed Naim (NaimMM@cf.ac.uk)

I understand that the information provided by me will be held confidentially and securely, such that only the researcher can trace this information back to me individually. The information will be retained for up to one year and will then be anonymised, deleted or destroyed. I understand that if I withdraw my consent I can ask for the information I have provided to be anonymised/deleted/destroyed in accordance with the Data Protection Act 1998.

I give consent to participate in the study conducted by Mr Obiajulu Egbunike (EgbunikeO1@cf.ac.uk, PhD Student) of Cardiff Business School, Cardiff University, under the supervision of Professor M. Naim and Dr L. Purvis.

Many Thanks

Appendix B: Access letter to potential research respondents

Cardiff Business School

Date

Company Address

Dear *[name of contact]*

I am a research student at Cardiff University Business School, conducting my research into the **Nature and Dynamics of Capabilities in Advanced Manufacturing Small and Medium Enterprises**.

At this stage of my research, I am seeking a number of companies to recruit as my case studies in the exploration of organizational resources and capabilities. Having identified *[name of company]* as a small and medium sized company, your views as a practitioner will be an invaluable source of information to enrich this study. This research will involve in-depth interviews with employees at different levels of the organization, with a large input coming from senior and middle management. Each interview will last approximately one hour and will be conducted at the convenience of the interviewee. Observations, a second method of data collection will be employed to support the findings from the interviews.

For the duration of this study, you will be informed of any new findings and any further consent will be sought from you to continue with further interviews and observations.

Attached to this letter is a summary of my proposal as well as a consent form. The proposal provides some more details about the project, while the consent form indicates that all information collected will be confidential and all data analysed and disseminated for academic purposes will be anonymized.

If you have any further questions concerning this research study, please contact me or any of my supervisors:

Professor Mo Naim

Main Supervisor

NaimMM@Cardiff.ac.uk

Dr Laura Purvis

Second Supervisor

PurvisL@Cardiff.ac.uk

They are both aware that I will be approaching your company to request for access to interview some members of staff and will be willing to entertain any more questions concerning this project.

I look forward to your earliest response and hope that my request is favourably considered.

Thank you.

Obiajulu Egbunike
Cardiff University

Appendix C: Interview guide for unstructured interviews

The Nature and Dynamics of Capabilities in Advanced Manufacturing SMEs: A Strategic Framework and Methodology

INTERVIEW GUIDE

First Phase: Unstructured Interviews

Questions to be asked and topics that should be covered include:

1. Company Profile

- Name of your company
- Respondent position and number of professional years' experience
- Number of years of company operation
- What are your main products and/or services
- Number of employees
- 3-year sales revenues/profit

2. Operations/Manufacturing Strategy, Capabilities, Competition/Competitors, VRIN-ness of resources, SWOT.

- Do you have an operations/manufacturing strategy? What is the process through which this was developed? How were the critical factors (organizational and environmental) identified and by who?
- What are your order qualifiers i.e. the basic competitive characteristics that enable you compete in the marketplace?
 - i. How did/do you identify these capabilities and sustain them? Do these capabilities change and if they do, how do you renew them?
- What are your order winners i.e. those characteristics that cause your customers to choose your products over those of your competitors?
 - i. How did/do you identify these capabilities and sustain them? Do these capabilities change and if they do, how do you renew them?
- What do you regard as your main source of competitiveness e.g. innovation, quality, responsiveness, flexibility...?

3. Use of Advanced Manufacturing Technology

- Basic questions and discussion
 - i. What do you understand by Advanced Manufacturing technologies
 - ii. Who uses these technologies in your company and how and why did they start using them
 - iii. What are the factors that have influenced the use of these technologies

iv. How have you adopted and developed the skills and capabilities to use these technologies

- How are other SMEs/companies in your industry using these or other advanced technologies?

4. Forecasting the future of Advanced Manufacturing technologies and developing relevant capabilities

- What are your views regarding the future use of advanced manufacturing technologies in your company? How do you propose to identify and develop these capabilities (people + technology) and when? What challenges do you anticipate, if any?

Appendix D: Table of control data

Company	Company Size (Employees)	1 st Interview/ Duration (Minutes)	Interviewee(s)	Observation/ Duration (Minutes)	Other Information/Data Collection	2 nd Interview/ Duration (Minutes)	Interviewees
Company A	11 – 50	X (99)	Director	X (62)	Document & Social Media ³⁰		
Company G	50 – 250	X (208)	Engineering Manager & Technical Manager	X (166)			
Company H	11 - 50	X (203)	Founders (Director & Director)	X (81)	Document & Social Media ³¹	X (188)	Founders (Director & Director)
Company D	11 - 50	X (94)	Managing Director		Document ³²		
Company I	51 – 250	X (196)	R&D Manager & Design Engineer	X (188)		X (180)	R&D Manager
Company E	11 - 50	X (125)	CEO	X (77)	Document ³³	X (107)	CEO
Company B	11 - 50	X (87)	Chief Science Officer (1)	X (66)	Document ³⁴	X (83)	Chief Science Officer (2)
Company K	11 - 50	X (89)	Operations Manager				
Company C	11 - 50	X (103)	Centre Manager (1)	X (60)		X (90)	Centre Manager (2)
Company F	1 - 10	X (94)	CEO		Document & Social Media ³⁵	X (89)	CEO
Company J	51 - 250	X (115)	NPD Manager		Document & Social Media ³⁶		
Company L	11 - 50	X (91)	Director				

³⁰ Documents accessed for data included 1 company annual review report and various operational and marketing documents. Academic publications from collaborative R&D activities with university partners (widely available on academic databases) were also provided. In addition to these, their dedicated YouTube channel was also accessed for 6 videos. All documentation and videos described the company, their products, processes and also provided customer feedback.

³¹ Documents accessed included 2 company reports and a 60-minute online video documentary about the company history and ongoing operational progress

³² Documents accessed included 1 company annual report as well as several patent application documents for both the UK and US markets, available from academic databases. These documents provided detailed information about the company, its products, processes, collaborative activities and disruptive innovations.

³³ Documents accessed included 3 company provided documents which described their company, product development phases and collaborative partner documentation, one of which included the collaborative activities which had taken place and the challenges face by both organisations.

³⁴ Documents accessed included 1 company report and 5 academic publications, available on academic databases. These documents supported both interviews by providing additional information about the company's technology, collaborative projects with which partners as well as innovative products protected by patents.

³⁵ Documents accessed included 2 major (successful) grant proposals and 2 academic publications resulting from the collaborative partnerships with academic partners.

Two YouTube videos were also provided. All documentation provided more information about the company's operations in support of the interviews with the CEO

³⁶ Documents accessed included 2 company reports provided by the NPD Manager. Their dedicated YouTube channel which had 22 videos describing their operations, technologies and approaches to collaboration, knowledge sharing and innovation, was also accessed for further information and data.

Appendix E: Data collection tool used for systematic literature review

An evaluation of the philosophies of manufacturing capability research: A 30 year systematic review

Author(s)				Citations	
Title				Year	
Journal		Impact Factor			
Sector of Study					

No.	Research	Data	Comments
	Aim of Study?		
	Manufacturing Capabilities - Definition?		
	Key Findings?		
	Ontological and Epistemological Perspectives?	Positivist Interpretivist Critical realist Unclear	
	Research designs? Justification for? Explicit enough? Modification? Appropriateness? E.g. Qualitative research seeks meaning and understanding, described in narrative form/qualitative research is oriented towards theory construction.	Literature review Conceptual Surveys Longitudinal Case Study Experimental Other	
	Theoretical Approach	Deductive Inductive	
	Sample Size	How many interviews, case studies, surveys?	
	Reliability? Were conclusions supported by the data and/or analysis reported in overview; how were themes derived; were findings of relevant studies combined appropriately e.g. tabulation, framework development; any direct quotes from respondents?		
	Value? Related to current knowledge; new areas?		

Appendix F: Excel spreadsheets used to capture and share information regarding systematic review findings

The screenshot shows an Excel spreadsheet with the following data table:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
1	Human Resource Management																							
2	Learning, KM, Information																							
3	Evolution, upgrade, development																							
4	Strategies/configuration decision making																							
5	Combination, interaction, practices, measurements																							
6	Relationships btw cap leading to performance, performance																							
7	Outsourcing																							
8	Technology																							
9																								
108																								
109																								
110																								
111																								
112																								
113																								
114																								
115																								
116																								
117																								
118																								

Obi Egbunike

Update - Excel

Tell me what you want to do

File Home Insert Page Layout Formulas Data Review View Help

Clipboard

Font

Alignment

Cells

Editing

Avella and Vasquez-Bustelo (2011)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
1	Human Resource Management																							
2	Learning, KM, Information																							
3	Evolution, upgrade, development																							
4	Strategies/configuration decision making																							
5	Combination, interaction, practices, measurements																							
6	Relationships btw cap leading to performance, performance																							
7	Outsourcing																							
8	Technology																							
9																								
66																								
67																								
68																								
69																								
70																								
71																								
72																								
73																								
74																								
75																								
76																								

Cell X73 commented by Obiagulu

Type here to search

01:53 31/08/2019

Appendix G: Ethical Approval

SURNAME: Egbunike

ETHICS 1

STANDARD ETHICAL APPROVAL FORM



This form should be completed for every research project that involves human participants. It can also be used to identify whether a full application for ethics approval needs to be submitted. The researcher or, where the researcher is a student, the supervisor, is responsible for exercising appropriate professional judgement in this review. This checklist must be completed **before** potential participants are approached to take part in any research.

SECTION 1 - RESEARCH CHECKLIST

1.1	Does the study involve holding personal information (names, attributable information or personal identifiers of any form) on a database?	NO
1.2	Does the study involve participants who are particularly vulnerable or unable to give free and informed consent (children, people with learning disabilities, students in academically dependent relationships)?	NO
1.3	Will it be necessary for participants to take part in the study without their full knowledge and explicit consent (perhaps through covert observation)?	NO
1.4	Will the study involve discussion of sensitive topics (political or religious views, illegal activities, sexual activity, drug use and so forth) that could be uncomfortable to participants or harmful if divulged to others?	NO
1.5	Will the study involve potentially harmful procedures of any kind or be conducted in a hazardous environment that could expose the researchers or participants to higher risk than is encountered in normal life? http://www.cf.ac.uk/osheu/index.html	NO
1.6	Will financial inducements (cash, vouchers or a prize draws) be offered to participants?	NO
1.7	Will the study involve patients or patient data in the NHS?	NO

If you have answered 'NO' to all questions 1.1 to 1.7 above, please complete this form and submit TWO copies to Lainey Clayton in room F43. Both forms will be stamped as evidence of submission. One copy will be retained by the School for audit/office purposes and the other by the researcher/s. Undergraduate and postgraduate students should include/bind their copy of the form with their research report or dissertation.

If you have answered 'YES' to any of the questions above, you will need to complete a full ethical review form (ETHICS 2, available on Learning Central – CARBS RESEARCH ETHICS)

SURNAME: Egbunike

SECTION 2 PROJECT DETAILS

Title of Project:	The Nature and Dynamics of Capabilities in Advanced Manufacturing SMEs: A Strategic Framework and Methodology
Name of Lead Researcher:	Mr Obiajulu Egbunike
Status (please circle) :	Post Graduate Researcher
Names of other Researchers:	Professor Mohamed Naim Dr Laura Purvis
Department:	Logistics and Operations Management, Cardiff Business School
Email:	EgbunikeO@cardiff.ac.uk
Contact Address:	C28, Aberconway Building, Colum Drive, Off Colum Road, Cardiff. CF10 3EU
Telephone number:	02920879617
Start and Estimated End Date of Project:	October 2011 to August 2015

SECTION 3 STUDENTS ONLY

Module name and number	
Supervisor's or Module Leader's name	Professor Mohamed Naim Dr Laura Purvis
Email address	NaimMM@cf.ac.uk PurvisL@cf.ac.uk

SECTION 4

Briefly describe the study design to be applied in the project including methods of data collection and data analysis

This is an exploratory study into the nature and dynamics of capabilities in advanced manufacturing SMEs. The purpose of this study is to identify the processes involved in the identification, development and renewal of these capabilities over time. Data for this study will be collected from advanced manufacturing firms, specifically those in the Life sciences/biotechnology sector.

The Grounded Theory (GT) methodology will be used for this project.

This data from manufacturing firms will be collected through in-depth case studies, to be conducted with 4 companies. This will provide a means of comparison and the eventual development of a framework or methodology for capability identification, development and renewal using the data collected from the companies.

Qualitative data will be used in this project and the methods of data collection from the manufacturing firms will be twofold. The first and primary method for data collection will be through in-depth interviews. Due to the nature of the research project and the methodology adopted (GT), unstructured and semi - structured interviews will be used. The initial interviews will assume an unstructured approach, while the semi - structured interviews will take place as the interviews progress and a more streamlined focus to the research is developed. A second method of data collection, often encouraged by the GT Method, will be through non-participant observations. This method will be applied during the unstructured and semi-structured interview phases to enable a deeper understanding of the company specific methods of capabilities development

The interviews will be analysed with the use of a qualitative software package, NVivo 9. This software package allows the data to be manipulated by creating visual images for easy comparison, analysis and understanding.

Please find attached the interview guide which will be used for the interviews with the firms as well as the members of academic staff. Enclosed also is the access letter, which will be sent to all the proposed companies to be used as case studies.

ETHICS 1

SURNAME: Egbunike

Please attach a copy of the questionnaire and all briefing documents which will be given to participants

SECTION 5 DECLARATION

I/we hereby confirm that we have answered these questions to the best of our knowledge and will take all reasonable steps to ensure the independence and transparency of this research.

SIGNED:  DATE: 18/06/2012
PRINCIPAL RESEARCH INVESTIGATOR

SIGNED:  DATE: 15/6/2012
SUPERVISOR (WHERE APPROPRIATE)

APPLICATION APPROVED
RESEARCH ETHICS COMMITTEE
CARDIFF BUSINESS SCHOOL
CARDIFF UNIVERSITY