

Capabilities for Frugal Innovation in Developed Market Firms

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Abstract

Frugal innovation has proven a powerful approach to innovating using fewer resources. Mostly associated with emerging markets, some scholars and practitioners suggest the growing relevance of frugal innovation practices to developed markets. However, existing studies are primarily anecdotal, often lacking systematic empirical exploration. The present research explores how developed market firms incorporate frugal innovation activities into their normal innovation activities. In particular, this research focuses on firms operating from a developed market context in the Asia-Pacific region, and primarily targeting customers in emerging market contexts in the same region. More precisely, the present research answers the research question: How do strategic decision-making and knowledge integration activities enable capabilities for frugal innovation in developed market firms?

To answer the research question, the dynamic capability perspective is applied to review the literature of frugal innovation capability building in emerging markets. A multi-level (firm- and project-level) qualitative case study approach is then applied to analyse four in-depth purposive case studies of developed market firms involved in frugal product innovation. Thematic analysis reveals that the firms engage in frugal innovation for different reasons. A typology is developed that shows three categories of firm motivation based on the degree of empathy with market needs and the importance of activity being profitable. These categories, termed the Philanthro-Capitalist, Robin Hood, and Cost-Driven approaches, offer a new way to describe the reasons developed market firms pursue frugal innovation. The findings also show the firm-level and project-level activities underpinning distinctive capabilities for frugal innovation. A multi-level model connecting firm motivations and distinctive capabilities for frugal innovation is developed.

Keywords: *Frugal innovation; capability building; developed market firms; emerging markets; strategic decision-making; knowledge integration*

Dedication

In Memory of My Father, Dr. Fazal Subhan.

1st December 1942 – 2nd April 1995

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1. Introduction

This chapter sets the stage for this research on “Frugal innovations”, the good-enough quality yet substantially low-priced products from emerging markets. Empirical research on frugal innovation has mostly been conducted in an emerging market context. The emerging market context is defined as “countries whose national economies have grown rapidly, where industries have undergone and are continuing to undergo dramatic structural changes, and whose markets hold promise despite volatile and weak legal systems” (Luo & Tung, 2007, p. 483). While frugal innovation research in the emerging market context is increasing, as will be reviewed shortly, less is known about frugal innovation in the developed market context. In this research, the developed market context is defined as countries with high income or high GDP (gross domestic product) per capita and are highly developed in terms of their industrialised economy, technology infrastructure and capital markets (Majaski, 2019).

This research is a systematic empirical study of frugal innovation by firms within a developed market context. Despite practitioner and scholarly recognition of anecdotal examples and the growing relevance of frugal innovation in developed markets, there is a lack of systematic research on understanding frugal innovation activities taking place in firms based in developed markets. The present research therefore seeks to expand existing knowledge on frugal innovation in a different context to its common understanding. The four developed market firms explored in this research operate from a developed market context in the Asia-Pacific region, namely Australia and New Zealand. They primarily develop frugal innovation products for customers in emerging market contexts in the same region, namely in Papua New Guinea, Vanuatu, and Fiji. Hence, the research extends empirical knowledge about frugal innovation to include a region that up until now has been overlooked in frugal innovation scholarship.

1.1. Background and motivation

According to innovation scholars, the innovation literature contains considerably fewer empirical innovation studies within the emerging market context as compared to the developed market context (Lee, Lin, Wong, & Calantone, 2011; Yang, Wang, Zhu, & Wu, 2012). Because, historically, emerging markets were not considered capable of innovation (Ernst, Kahle, Dubiel, Prabhu, & Subramaniam, 2014; Govindarajan & Trimble, 2012a; Li &

Kozhikode, 2009; Porter & Stern, 2001), the innovation potential of firms innovating within the emerging market context was long ignored.

The appearance of innovations from the emerging markets of Brazil, Russia, India, and China—often labelled the BRIC countries—has challenged the traditional view. Some innovation scholars have speculated that emerging markets are incubating new business models and innovative uses of technology and will soon begin to transform the competitive landscape of global industries (Prahalad, 2005). Other innovation scholars confirm this speculation, suggesting that over the past two decades the global innovation landscape has been changing, and emerging markets are appearing as a new locus of a particular type of innovation characterised by good enough quality, and high-value yet substantially low-cost innovation from the customer's perspective (Govindarajan & Ramamurti, 2011; Juntiwassarakij & Petrick, 2011; Li & Kozhikode, 2009; Petrick, 2011; Zedtwitz, Corsi, Sørberg, & Frega, 2014). The low-cost yet high-value nature of this new innovation is different from traditional innovation within the developed market context, and is significantly changing the way that innovation is conceived, executed, and delivered (Brem & Wolfram, 2014; Ernst et al., 2014; Govindarajan & Ramamurti, 2011; Juntiwassarakij & Petrick, 2011; Subramaniam, Ernst, & Dubiel, 2015). Hence, emerging markets have started catching up with the developed world firms by developing their capabilities for innovation (Li & Kozhikode, 2009; Lim, Han, & Ito, 2013).

The low-cost high-value innovations from emerging market firms and their potential to capture global markets has attracted the attention of developed market firms for three main reasons. First, the potential threat from the newly apparent innovation activities of emerging markets; second, the potential opportunities for developed market firms in emerging markets; and third, the increasing trend toward and general awareness of cost and time minimisation in the entrepreneurial process in developed market firms. In terms of the threat, scholars argue that due to the lack of infrastructure coupled with huge populations in emerging markets, sustainability challenges are more urgent and firms in these markets are likely to resolve their environmental issues decades before firms in developed markets (Immelt, Govindarajan, & Trimble, 2009). Additionally, firms within emerging markets seem to be superseding developed market firms in certain sectors, such as biotechnology, renewable energy, water desalination, microfinance, automobile manufacturing and affordable housing through their low-cost, high-value innovations (Immelt, Govindarajan, & Trimble, 2009). Moreover, some emerging market firms are becoming significant players in a few technology-intensive sectors, including information technology, electronics and mobile communication, financial services, telecom services, health care, and car manufacture (Mathews, 2006; Prahalad, 2005). Hence,

firms within emerging markets are not only capturing their own markets, but they are increasingly finding ways to enter developed markets by identifying a growing segment of budget-oriented customers seeking value-for-money (Zeschky, Widenmayer, & Gassmann, 2011), resulting in growing alarm in firms within developed markets in terms of global market competition.

Some developed market firms have not only recognised the threat represented by large multinational firms from emerging markets in terms of global market competition, but also the tremendous growth opportunities offered by low-income segments in emerging markets (Agarwal, Brem, & Dwivedi, 2019; Agarwal et al., 2019; Rosca, Arnold, & Bendul, 2017). Emerging markets comprise more than half of the world's population, and therefore hold significant business opportunities in the form of innovative, affordable, yet good-enough quality products and services. Only a few developed market firms have acted on the enormous growth opportunities within emerging markets. These firms have started taking an interest in innovations from emerging markets and themselves become involved in practising innovation in an emerging market context (Agarwal et al., 2019; Hossain, 2018). For example, research and development (R&D) units of General Electric (GE) innovated a portable and low-cost \$800USD Electrocardiogram (ECG) machine within an emerging market. Their machine is battery operated and easy to use and repair compared with standard ECG machines, which typically cost \$5000USD (Govindarajan, 2012; Immelt et al., 2009). Such innovations by developed market firms within the emerging market context have caught the attention of managers in other developed market firms as a new opportunistic approach to competition in global markets.

An increasing trend towards low-cost innovation and growing awareness of resource minimisation (such as financial, environmental and/or time resources) within developed markets is another reason for the increased focus from developed market firms on frugal innovation. Resource minimisation activities such as lean management practices, deskilling of labour, environmental sustainability, along with a focus on the socio-economic circumstances of consumers are considered essential for achieving frugal innovation (Agarwal & Brem, 2017; Prahalad, 2012). The application of these low-cost innovation activities attracted interest from some developed market firms, who see relevance between frugal innovation and the concept of disruptive innovation as introduced by Christensen (Christensen, 1997; Christensen & Raynor, 2003). Disruptive innovation often introduces products and services of lesser quality compared to similar existing products in terms of simplicity and convenience, but which are less expensive and provide value to new or less-demanding customers (Christensen & Raynor,

2003). Similarly, some developed market firms consider frugal innovation as potentially disruptive to developed markets in a form of reverse innovation that sees frugal innovation developed first for emerging markets and later transferred to developed markets with the potential to create a new market with a lower price point or new applications (Brem & Wolfram, 2014; Corsi & Minin, 2014; Hang, Chen, & Subramian, 2010; Sinha, 2013). Developed market firms have therefore begun to set a new engineering culture, reestablish product development and manufacturing methods, reorganise organisational structures, reorient approaches towards innovation and often choose unspecialised, experimental, adaptive and lean approaches (Sinha, 2013). The new trend of adopting low-cost innovation or disruptive innovation activities within developed markets has in turn shifted the attention of other entrepreneurs in developed markets towards low-cost innovation and approaches such as frugal innovation.

The examples provided by developed market firms operating within emerging market contexts such as those mentioned above have also resulted in academic interest in the innovations these firms have commercialised, resulting in the introduction of the term “frugal innovation” (Zeschky et al., 2011). Despite increasing interest among scholars, to date frugal innovation has mostly been studied within the emerging market context. While some scholars and practitioners have presented practical examples of frugal innovation within developed markets (e.g., Radjou & Prabhu, 2015; Rosca, Arnold, & Bendul, 2017), these are primarily anecdotal and often lack systematic empirical exploration. As frugal innovation research has expanded, some studies have emphasised that frugal innovation is increasingly relevant in developed market contexts, and suggested the need for in-depth empirical exploration in the developed market context (Agarwal & Brem, 2017; Agarwal, Grottke, Mishra, & Brem, 2017; Barczak, 2012; Govindarajan & Ramamurti, 2011; Hossain, 2017, 2018; Nakata & Weidner, 2012; Subramaniam et al., 2015), particularly in terms of exploring the capabilities that enable firms operating in the different context of emerging markets to innovate (Subramaniam et al., 2015). However, this work is only recently emerging.

A few recent studies have used illustrations of frugal innovation in developed market contexts as part of ongoing attempts to clarify some definitional and conceptual issues around frugal innovation (Lim & Fujimoto, 2019; Melkas, Oikarinen, & Pekkarinen, 2019; Winkler, Ulz, Knöbl, & Lercher, 2019). However, researchers are yet to take account of the underlying activities and processes of frugal innovation in the developed market context. Only recently, did an empirical study by Altmann and Engberg (2016) examine frugal innovation by a developed market firm for emerging markets. The authors theorised that R&D activities based

in a developed country may be able to create a breakthrough product for emerging markets, depending upon the transferability of market and technical knowledge. Nonetheless, due to the limitations of their single case study, they acknowledge their findings have limited applicability and call for more focus on understanding the conditions of frugal innovation when the firm operates in a context that is qualitatively different to that of the customer. Taking account of the current body of knowledge, studying frugal innovation by firms operating in developed market contexts for customers in emerging market contexts remains an exciting and underdeveloped research avenue.

Considering more closely frugal innovation by developed market firms for customers in emerging market context, there are multiple reasons why the Asia-Pacific region presents a useful context to exploring capability development. Much of the initial frugal innovation research focuses on the emerging market context and is based on studies of the BRIC countries, as noted early. More recently scholars have explored frugal innovation in the UK, US, Canada and multiple European countries (e.g., Rao, 2017; von Janda, Kuester, Schuhmacher, & Shainesh, 2020; Winkler et al., 2019). However, to the researcher's best knowledge, no studies have explored frugal innovation in the Asia-Pacific region from either the emerging market context or the developed market context. This is surprising since both the developed market context, namely Australia and New Zealand, and emerging market context, namely Papua New Guinea, Vanuatu, and Fiji, exist in the Asia-Pacific region. From the developed market side, Australia and New Zealand are well known for their ingenuity, and ability to think outside the box and solve problems differently due to geographical distancing (Downs & Dickinson, 2018; J. Henderson, 2019; "Kiwi Ingenuity," n.d.), and also due to various socio-economic and environmental changes in the face of resource scarcity in developed markets contexts (Agarwal et al., 2019).

From the emerging market side, there are multiple small-sized nations in the Asia-Pacific regions that are classified as emerging market contexts (*World Economic Situation and Prospects*, 2019). The socio-economic and cultural environments of these emerging markets in the Asia-Pacific regions hold similar attributes to those commonly referenced for emerging markets in the literature of frugal innovation, such as institutional voids, lack of infrastructure, compromises on performance at the right price due to low income, lack of sustainable solutions, and unique preferences (Govindarajan & Trimble, 2012a). Therefore, empirical exploration of frugal innovation in the Asia-Pacific region contributes a novel empirical context for advancing frugal innovation.

This present research therefore addresses the lack of systematic and in-depth empirical exploration of frugal innovation product development by firms within developed market contexts that are focused on customers in emerging market contexts. By exploring the capabilities for frugal innovation within developed market firms, and with a focus on firms operating in Australia and New Zealand primarily to develop products for customers in Papua New Guinea, Vanuatu, and Fiji, the research seeks to reveal the capabilities and the underlying activities of new product development processes.

The rest of this chapter proceeds as follows. Next, section 1.2 describes frugal innovation as the main topic of the present research and explicates the scholarly conversation to which this research aims to contribute. Section 1.3 presents the identified research gap and articulates the research question. Section 1.4 then describes the implications of the present research and section 1.5 outlines the structure of the rest of the thesis. Finally, section 1.6 summarises the chapter.

1.2. Research topic

The term “frugal innovation” was first introduced in the academic literature by Zeschky et al. (2011). Within a relatively short period, frugal innovation scholars have developed multiple definitions and interpretations of the topic, with frugal innovation variously considered as:

- *An outcome (product or service)* (e.g., Cunha, Rego, Oliveira, Rosado, & Habib, 2014; Ernst et al., 2014; George, McGahan, & Prabhu, 2012; Santiago, Rohmer, Pichardo, & Reyes, 2019; von Janda et al., 2020; Weyrauch & Herstatt, 2016; Zeschky et al., 2011; Zeschky, Winterhalter, & Gassmann, 2014);
- *A process* (e.g., Agarwal et al., 2017; Basu, Banerjee, & Sweeny, 2013; Bhatti & Ventresca, 2013; Mayer & Bertoncelli, 2019);
- *A business model, strategy or management approach* (e.g., Adeleye, Debrah, & Nachum, 2019; Bhatti & Ventresca, 2013; Ernst et al., 2014; George et al., 2012; Prahalad, 2012; Radjou & Prabhu, 2015a; Winterhalter, Zeschky, Neumann, & Gassmann, 2017); or,
- *A combination of some or all of these dimensions* (e.g., Krishnan & Prashantham, 2019; Lan & Liu, 2017; Lu, Chang, Rong, Shi, & Yu, 2019; Soni & Krishnan, 2014; Tiwari & Herstatt, 2014a)

These multiple definitions and interpretations matter for two reasons.

First, alongside the multiple interpretations of frugal innovation, innovation scholars have devised several other terms. Some of that terminology shares commonalities with frugal innovation, including reverse innovation, jugaad, disruptive innovation, good-enough innovation, and affordable value innovation (see for e.g.,: Agarwal & Brem, 2012; Ananthram & Chan, 2019; Anderson & Markides, 2007; Brem & Wolfram, 2014; Ernst et al., 2014; Gadiesh, Leung, & Till, 2007; Govindarajan & Ramamurti, 2011; Hang et al., 2010; Hassani, Ionescu, & Mansour, 2019; Kingsnorth, Tongaonkar, & Awojobi, 2011; Lim & Fujimoto, 2019; Radjou, Prabhu, & Ahuja, 2012; Ramdorai & Herstatt, 2015; Rao, 2013; Rodríguez & Cunha, 2017; Singh, Gupta, & Mondal, 2012; Sinha, 2013; Winkler et al., 2019; Zeschky, Winterhalter, et al., 2014). Other studies have used collective terms for frugal innovation, including related terms such as constraint-based innovation (Agarwal et al., 2017; Molina-Maturano, Speelman, & De Steur, 2020), and low-cost innovation (Brem & Wolfram, 2014).

The frugal innovation related terminology most commonly explored in relation to developed markets is “reverse innovation” (e.g., Agarwal & Brem, 2012; Agarwal et al., 2019; Brem & Ivens, 2013; Dellermann, 2017, 2017; Govindarajan & Ramamurti, 2011; Govindarajan & Trimble, 2012a; Schuster, 2014; Sinha, 2013; Winkler et al., 2019; Zedtwitz et al., 2014; Zeschky, Widenmayer, & Gassmann, 2014; Zeschky, Winterhalter, et al., 2014). Reverse Innovation, is also known as “innovation blowback” (J. S. Brown, 2005), or “trickle up innovation” (Prahalad, 2005), and refers to innovations that are developed for customers in emerging markets and then later modified or improved for customers in developed markets (Agarwal & Brem, 2012; Agarwal et al., 2019; Brem & Wolfram, 2014; Govindarajan & Ramamurti, 2011; Govindarajan & Trimble, 2012a, 2012c; Immelt et al., 2009; Zedtwitz et al., 2014). Thus, reverse innovation involves finding a new market in the West for an innovation created for the East (Govindarajan & Ramamurti, 2011; Govindarajan & Trimble, 2012b; Zeschky, Widenmayer, et al., 2014; Zeschky, Winterhalter, et al., 2014). Understanding the term is particularly important in relation to the present research in order to establish how frugal innovation by firms in the developed market context for customers in emerging markets differs.

Second, further to these multiple definitions and interpretations, most frugal innovation studies have developed very context specific definitions and descriptions, but mostly around the emerging market context. Due to its unique environmental constraints presented as a combination of resource scarcity and institutional voids (Bhatti & Ventresca, 2013), the emerging market context is different from the developed market context, leading to differences in innovation activities. The definitions and characterisations of frugal innovation specific to the emerging market context become problematic when seeking to explore the phenomenon in

the developed market context (Weyrauch & Herstatt, 2016). As the focus of the present research is to respond to the call to extend the existing literature of frugal innovation by conducting a more in-depth and systematic empirical study in a different context, such as within developed markets, a definition or criteria for frugal innovation that is independent of context is necessary.

This research, therefore, adopts the definition presented in an empirical study by Weyrauch and Herstatt (2016), which suggests three key characteristics of frugal innovation that differentiate it from other types of innovations. These characteristics are: *(a) substantial cost reduction from a consumer perspective; (b) concentration on core functionalities; and (c) optimised performance level.* There are two reasons for adopting this definition. First, unlike previous definitions that rely on specific attributes that can differ from one context to another, Weyrauch and Herstatt (2016) suggest the three criteria (if all met simultaneously) are independent of specific attributes of target markets. This definition is therefore useful for the present research, which is conducted in the context of the developed markets rather than the more common context of frugal innovation—the emerging market. Second, it suggests characteristics of frugal innovation that differentiate it not only from other types of innovation within the emerging market, but also from more traditional innovation approaches, including the low-cost innovation approaches within developed markets.

More recent studies attempt to define and conceptualise frugal innovation, but only from the developed market perspective (e.g., Melkas et al., 2019; von Janda et al., 2020; Winkler et al., 2019). However, these scholars identify some shortcomings in Weyrauch and Herstatt's (2016) definition. For instance, Winkler et al. (2019) argue that the definition is weak from a methodological perspective because the data collection for the study was mostly done with German managers (even though they were managers of multinational companies). Instead, they suggest an evaluation model adapting the criteria suggested by Weyrauch and Herstatt, (2016), and introduce the term “second-degree frugal innovation” for frugal innovation within developed markets as an alternative. However, while valuable, their criteria conceptualise frugal innovation as from developed markets for developed markets, whereas the focus of the present research is exploring developed market firms doing frugal innovation for emerging market customers—but not limited to them. Another study by von Janda et al. (2020) also criticises Weyrauch and Herstatt's (2016) criteria on the grounds they do not incorporate the aspect of sustainability as mandatory for identifying frugal innovation. They argue that frugal innovation must be sustainable. The relationship between the frugal innovation construct and sustainability has been explored in several other studies, with most suggesting a positive

relationship (e.g., Albert, 2019; Bas, 2017; Bianchi, Bianco, Ardanche, & Schenck, 2017; Brem & Ivens, 2013; Hassani et al., 2019; Molina-Maturano et al., 2020; Rao, 2017; Rodríguez & Cunha, 2017; Rosca et al., 2017; von Janda et al., 2020). Nevertheless, it is important to note that Weyrauch and Herstatt, (2016) do not discount sustainability in relation to frugal innovation and therefore this aspect has been identified in the present research. While the above-mentioned recent studies are useful in broadening the concept of frugal innovation from a developed market perspective, the present research uses the Weyrauch and Herstatt, (2016) criteria as it was the most appropriate available definition at the time the research was conducted.

Scholarly research on frugal innovation is relatively new as the first academic paper using the term “frugal innovation” was published only recently (Zeschky et al., 2011). However, studies on frugal innovation are increasing rapidly, and several areas were revealed during the literature review for the present research. Briefly, scholars have mainly focused on four key areas:

1) Providing conceptualisation, frameworks and typologies of frugal innovation (e.g., Altgilbers, Walter, & Moehrle, 2020; Asakawa, Cuervo-Cazurra, & Annique Un, 2019; Basu et al., 2013; Bhatti & Ventresca, 2013; Brem & Ivens, 2013; Brem & Wolfram, 2014; Cai, Ying, Liu, & Wu, 2019; Cunha et al., 2014; D’Angelo & Magnusson, 2019; Farooq, 2017; George et al., 2012; Klarin, 2019; Melkas et al., 2019; Mourtzis, Zogopoulos, & Vlachou, 2019; Niroumand, Shahin, Naghsh, & Peikari, 2020; Steinfield & Holt, 2019; Tiwari & Herstatt, 2014a; von Janda et al., 2020; Weyrauch & Herstatt, 2016; Winkler et al., 2019; Zeschky et al., 2011; Zeschky, Winterhalter, et al., 2014). These studies contribute to differentiating frugal innovation from other innovation approaches and provide a better understanding of it in terms of its attributes and characteristics, thereby facilitating the study of frugal innovation from various aspects.

2) Identifying the context of emerging markets and their institutional voids as both an opportunity and critical success factor for frugal innovation (e.g., Govindarajan & Trimble, 2012a; Immelt et al., 2009; Juntiwassarakij & Petrick, 2011; Khanna & Palepu, 2013; Li & Kozhikode, 2009; Prahalad, 2010; Prahalad & Mashelkar, 2010; Tiwari & Herstatt, 2012a, 2014b). These studies provide the groundwork for understanding the relevance of frugal innovation within the resource-constrained environment of an emerging market context. As such, they contribute to understanding the context and its impact on the process of frugal innovation and its underlying activities.

3) *Understanding the managerial practices and strategic implications associated with incorporating frugal innovation within emerging markets* (e.g., Agarwal & Brem, 2012; Govindarajan & Ramamurti, 2011; Govindarajan & Trimble, 2012a; Immelt et al., 2009; Zedtwitz et al., 2014; Zeschky, Widenmayer, et al., 2014; Zeschky, Winterhalter, et al., 2014); and

4) *Exploring the process and capabilities for doing frugal innovation* (e.g., Agarwal et al., 2019; Basu et al., 2013; Cai et al., 2019; George et al., 2012; Lim et al., 2013; Malik, 2017; Prahalad, 2012; P. Ray & Ray, 2010; S. Ray & Ray, 2011; Rodríguez & Cunha, 2017; Šoltés, Kappler, Koberstaedt, & Lienkamp, 2018; Tiwari & Herstatt, 2014a). The latter two areas of research inform the current research and contribute to understanding the capabilities and underlying activities of firms within the emerging market context during their new product development process with frugal innovation outcomes. These studies not only provide insights into firm-level strategic approaches, but also explore processes at the project-level for successful frugal innovation.

The main scholarly conversation to which this present research contributes is around the capabilities for doing frugal innovation, which has mostly been studied within the context of emerging markets. From the review of the literature on frugal innovation, it appears that most studies have focused on either firm level strategic managerial approaches that enable successful frugal innovation development or on the process of new product development with frugal innovation outcomes. Below is the summary of the literature on the conversation to which this present research contributes.

1.2.1. Strategy-focused studies on capabilities for Frugal Innovation

The empirical studies on strategic and managerial approaches that facilitate building frugal innovation capabilities within emerging market firms provide insights into frugal innovation business models, strategic managerial approaches, and the role of social capital. The strategy-focused studies can be summarised as follows.

Existing studies within the literature on frugal innovation suggest that firms doing frugal innovation have a unique business model. Understanding this model is necessary for other firms intending to do frugal innovation. For instance, Prahalad and Mashelkar (2010) argue that firms within emerging markets have been able to develop radical business models by transforming almost every element of the value chain, thereby building disruptive business models. These firms not only hone existing capabilities but are also acquire and build new capabilities to solve problems—problems that often require technology development and collaborative approaches. Similarly, Winterhalter et al. (2017) adopt a qualitative case study

approach to investigate the business models for frugal innovation. Based on their exploration of the firm's value creation and value capturing mechanisms to achieve the value proposition for frugal innovation, they argue that frugal innovation could create entirely new markets instead of low-end segments of existing markets. George et al. (2012) emphasise the new business model for frugal innovation. They use the term inclusive innovation for innovation such as frugal innovation within the emerging market context, examining the enacting of new business models for doing such innovation as part of their exploration of organisational macro processes. They argue that organisational macro process influences a firm's ability to generate innovations that matter for inclusive growth.

Some scholars consider that the contextual attributes of emerging markets, such as environmental constraints (lack of institutions, infrastructure and resources), in combination with strategic managerial decisions enable the capabilities for frugal innovation. For instance, Ernst et al. (2014) report a quantitative study undertaken to explain why the challenging environment of emerging markets with its lack of institutions can facilitate a firm's ability to develop frugal innovation. They draw on institutional theory to derive and analyse three potential antecedents of frugal innovation for emerging markets, namely bricolage, local embeddedness, and standardisation. They cite other scholars (such as, Baker & Nelson, 2005; George et al., 2012; Halme, Lindeman, & Linna, 2012) in describing bricolage as the ability of the firm to improvise in a resource-constrained situation and suggest that bricolage equips the firm with skills to develop products in such environments. Similarly, discussing local embeddedness, Ernst et al. (2014, p. 4) argue "the extent to which a firm has relationships with local partners in emerging markets, helps firms overcome the institutional voids in the emerging markets". Finally, the third antecedent is the level of product standardisation relative to adaptation, which, according to these scholars, remains an issue of great importance due to the high diversity of emerging markets. Their findings suggest that, due to resource scarcity within emerging markets, firms use new approaches to solve problems or combine resources in new and creative ways to achieve affordable value innovation. The results of their studies suggest that bricolage and local embeddedness are positively related to frugal innovation, whereas standardisation has a negative impact. Their findings also suggest that increased local embeddedness is a critical strategy for firms to overcome the institutional voids within emerging markets. Moreover, a recent quantitative study by Cai et al. (2019) explores the drivers and capabilities of frugal innovation within emerging markets. The findings suggest that emerging market firms tend to achieve cost minimisation and value maximisation through higher levels of institutional leverage capability, bricolage capability, and perceived

dysfunctional competition. While institutional leverage capability helps in filling institutional gaps, bricolage capability helps overcome resource scarcity, including technology resources. Further, the perception of dysfunctional competition encourages emerging market firms to become involved in frugal innovation. Alongside such environmental constraints, a managerial focus on creating awareness, access, affordability, and availability also plays a crucial role in developing leapfrog technologies and frugal innovations (Bhatti & Ventresca, 2013; Prahalad, 2012). Thus, activities relating to strategic managerial decisions coupled with the contextual attributes of emerging markets, such as institutional voids and lack of infrastructure, appear to be contributing factor in enabling frugal innovation capabilities within emerging markets.

A firm's strategic decision making about the new product development process is also identified as a critical approach towards building capabilities for doing frugal innovation. For instance, Prahalad, (2012) describes four activities for managers in emerging market firms that facilitate capability building for doing frugal innovation, which he calls the 4As: awareness, access, affordability, and availability. Awareness refers to creating an awareness of a product or service so that consumers know what is available in the market. Enabling access refers to the portability of product or service for a remote location. Affordability means ensuring that the product and service are affordable for target customers. Finally, availability refers to building trust and a loyal base to ensure uninterrupted supply of the product or service. Prahalad (2012) suggests that through these 4As, managers can create opportunities for frugal innovation while external constraints can facilitate the creation of new products and business models. He further argues that developed market firms can learn several business practices from emerging markets that will enable them to become competitive globally. Such practices are "dramatic changes in price-performance (value), use of hybrid technologies, lean management, market development, deskilling of work, collaboration with NGOs and the public sector, and distribution and logistics in hostile conditions" (Prahalad, 2012, p. 12). Likewise, Ancarani, Frels, Miller, Saibene, and Barberio (2014) explore the strategies of multinational companies for succeeding in rural emerging markets. They suggest that managers in emerging markets can develop capabilities for frugal innovation by providing localised solutions, creating adaptive distribution systems, and building trusting relationship with all stakeholders.

Using a capability lens, Ansari et al. (2012) focus on leveraging social capital as a necessary means for building, increasing, and retaining frugal innovation capabilities. According to these authors, social capital enables firms to access the core resources and knowledge needed for the innovation process without having to pay the full market price for the resources and knowledge input, and, in particular, for the customisation of these inputs. They suggest that bonding social

capital among firms within emerging markets and bridging social capital between the subsidiaries of developed market firms and emerging market firms play a crucial role in capability building for doing frugal innovation within emerging markets.

In sum, these strategy-focused studies have mostly explored the managerial decisions and strategic approaches to frugal innovation product development to understand the firm-level activities that underpin the capabilities for frugal innovation. Managerial decisions relate to the 4As of awareness, access, affordability, and availability. Strategic approaches not only include adopting new innovative business models, but are involve leveraging social capital, bricolage and local embeddedness, providing localised solutions, and building trust-based relationships with stakeholders.

1.2.2. Process-focused studies on capabilities for Frugal Innovation

Studies with a focus on processes primarily explore the new product development processes of frugal innovation to understand the requisite capabilities of these firms. Some studies also directly apply the capability lens in order to understand the firm's capabilities for succeeding at frugal innovation within emerging markets. Altogether, these studies highlight certain underlying activities within new product development processes, such as: the innovator's approach towards product design, alliances or acquisition, collaboration, and openness to external knowledge—all of which are aimed at minimising the cost and maximising the value of the product from a consumer perspective. Almost all the process-focused studies reviewed have been conducted within the context of emerging markets. Therefore, in line with existing studies using a capability lens, the present research draws on the dynamic capability perspective to address the gap about frugal innovation studies in developed market context. The aim is to explore the activities underpinning the capabilities that enable firms within the developed market context to achieve frugal innovation. The existing process-focused studies on capabilities for doing frugal innovation are summarised in the following paragraphs.

The innovator's approach towards product design is one of the highlighted activities in the new product development process that underpins these capabilities. For instance, Ray and Ray (2011) place emphasis on the innovator's approach in their study of new product development processes of firms within emerging markets as a means to develop capabilities for frugal innovation. Using the TATA Nano car as a case study, Ray and Ray (2011) provide insight into building capabilities for innovating a low-cost, good enough quality car. Their findings suggest that TATA Motors sought to minimise resource input through combining existing component technologies with a focus on modular design. They successfully achieved architectural innovation for an altered price-performance package, modularity for

customisation, and collaborative partnerships with suppliers during the early design phase to lower innovation cost and reduce risks in component design. Ray and Ray's (2011) study explores the choices of the innovator regarding the use of technology, and in particular the use of existing technology in imaginative new ways for simplification and cost minimisation. Their study also highlights the innovator's choices regarding product design, and organisational practices within the new product development process of an emerging market firm with low-cost, good-enough quality objectives. These aspects are considered crucial in differentiating frugal innovation from other approaches to innovation. A highly motivated product development teams given full autonomy for design development and decisions can progress successfully by using frequent communication, establishing the culture of failure, establishing strong partnerships and collaboration with stakeholders, and developing a deep understanding of users and the local market (Šoltés et al., 2018).

Viswanathan & Sridharan (2012) also focus on product design approaches of innovators. In particular, their study identifies the approaches that are useful for articulating the design parameters necessary for frugal innovation. These approaches are: identifying product needs, which include both critical and key aspirational needs, and envisioning unfamiliar usage situations; designing a product for multiple purposes, flexibility, and sustainability; and conducting product development and delivery in such a way that it leapfrogs infrastructure deficiencies and makes use of available alternative resources. Other scholars within the literature on frugal innovation suggest that the mindset and ingenuity of emerging market innovators, coupled with unique customer needs and environmental constraints (such as the lack of institutions, infrastructure and resources), result in frugal innovations (Bhatti & Ventresca, 2013; Prahalad, 2012).

Basu et al. (2013) suggest design parameters for frugal innovation. In doing so they distinguish frugal innovation from conventional innovation based on its driver, process, location and core competencies. Through case studies, they explain the driver as the customer's need for low-cost and high-value products or services; the process as bottom-up as compared to the top-down process in conventional innovation; and the location as emerging markets. The ten core competencies of frugal innovation are described as: ruggedisation, being lightweight, mobile-enabled solutions, human-centric design, simplification, new distribution models, adaptation, use of local resources, green technologies, and affordability. Finally, they suggest that all ten competencies are crucial to pursuing the opportunities for firms within a resource scarce environment.

Lim et al. (2013) consider alliances with, or acquisition of foreign firms as an important underlying activity within the new product development process with a frugal innovation outcome. They suggest that building innovation capability can be achieved through creating a process that overcomes the deficiencies of in-house resources as well as the resource deficiencies of external to the firms. Their process-focused qualitative empirical study of the Tata Nano car explores the capability building process for frugal innovation, with an emphasis on alliances with or acquisition of foreign (developed market) firms for overcoming deficient in-house resources, knowledge, and capabilities. Their findings suggest that emerging market firms are building their innovation capability for frugal innovation with the help of in-house research and development (R&D), the acquisition of foreign firms, and the utilisation of resources supplied by external organisations and innovation technologies.

Scholars within the literature on frugal innovation also emphasise various collaborative approaches during new product developments. They consider these collaborations essential to creating and sourcing new capabilities for emerging market firms practising frugal innovation. For instance, Tiwari and Herstatt (2012b, 2014a) argue that access to open global innovation networks (OGIN) for collaborative development widens the firm's existing knowledge base and reduces market and technology uncertainty in their new product development practices. Moreover, they identify some emerging markets (e.g., India) with the potential to become leading markets for frugal innovation and suggest that economies of scale coupled with strong technological capabilities offset the disadvantages created by socio-economic deficiencies (Tiwari & Herstatt, 2014b). Prahalad and Mashelkar (2010) suggest various other collaborative approaches through which emerging market firms create or acquire new capabilities for doing frugal innovation. These approaches include collaboration with foreign partners, such as those from developed markets or even competitors, to obtain the technical expertise to develop new technologies and capabilities. They also assert that typically, the emerging market firm's ultimate motivation for building frugal innovation capability is the lack of capital, technology, and skills for audacious entrepreneurs in emerging markets.

Openness to external knowledge domains is also considered a critical underlying activity within the new product development process that contributes to building firms' capability for frugal innovation within emerging markets. For example, various explorative case studies within the emerging market of India (e.g., Tiwari & Herstatt, 2014a; Tiwari, Kalogerakis, & Herstatt, 2014) identify an approach to frugal innovation that emphasises forging new paths and utilising inventive analogies from inside and outside industry domains and disciplines. This

enables them to develop product solutions that minimise cost and maximise value, and hence engage in frugal innovation.

In sum, process-focused studies have mostly explored the new product development process, with frugal innovation outcomes to understand the activities that underpin capabilities for frugal innovation. In reviewing these studies, it appears that most of the frugal innovation activities within the new product development process are related to integrating knowledge resources both within and outside the firm.

Combining insights on the capabilities for frugal innovation from both strategy-focused and process-focused research reveals that the focus of scholars has mainly been exploring firm-level and process-level approaches. The firm-level studies highlight strategic and managerial decisions underpinning the capabilities that enable firms to successfully develop frugal innovation within emerging markets. On the other hand, the process-level studies mostly examine the knowledge integration activities, both inside and outside the firm, within the new product development process that underpin capabilities for frugal innovation. The literature review confirms that almost all the studies have been conducted in the context of the emerging market. The present research therefore attempts to fill this gap by conducting systematic empirical research on the firm's capabilities for frugal innovation within the developed market.

1.3. Research gap and research question

This subsection describes the identified research gap in more detail and is followed by the research question.

Scholars have identified that the consumer market for frugal innovation in emerging markets is rapidly increasing, but is not limited to only emerging markets (Pralhad, 2012). Instead, it has become equally relevant to a growing segment of budget-oriented, value-for-money customers in developed markets (Agarwal & Brem, 2017; Agarwal et al., 2017; Cunha et al., 2014; Hossain, 2017; Radjou & Prabhu, 2015a; Zeschky et al., 2011). Further, it is not only consumers in developed markets who are facing scarcity. The financial crises faced by governments due to dwindling natural resources is also pushing developed market firms to adapt frugal approaches (Radjou et al., 2012). Consequently, developed market firms are urged to look at emerging markets for frugal innovation (Cappelli, Singh, Singh, & Useem, 2010; Chen & Miller, 2010) and seek out learning opportunities beneficial for both markets (Govindarajan & Trimble, 2012c). Frugal innovation is seen as relevant, impactful, and technologically feasible for both emerging and developed markets (Bhatti & Ventresca, 2013). Additionally, applying frugal innovation to tap into the needs of a vast population of consumers will enable firms to extensively expand their market share and ultimately stay competitive in

global markets. This research therefore supports the view that in today's era, being involved in frugal innovation is not an option for developed market firms; rather it is a source of oxygen to enable them to survive and compete with the giants emerging from emerging markets (Immelt et al., 2009). Also, in the face of challenges associated with globalisation, sustainability and motivating drivers such as demographic and environmental change, frugal innovation is becoming equally relevant for both emerging and developed markets (Agarwal & Brem, 2017).

Despite the identification of frugal innovation as a potentially relevant alternative model for organising innovation in developed markets by some researchers and practitioners, and the examples of frugal innovation from developed markets being reported in the literature (Agarwal & Brem, 2017; Prahalad, 2012; Radjou & Prabhu, 2015a; Subramaniam et al., 2015), the lack of frugal innovation studies within the developed market context reveals a gap in the literature (Agarwal et al., 2017; Hossain, 2017; Pisoni, Michelin, & Martignoni, 2018).

A review of the literature reveals only a few studies on frugal innovation focus primarily on developed market firms organising frugal innovation activities, but within emerging markets. Zeschky et al. (2011), for example, is among the initial studies that have researched the challenges faced by developed market firms when organising frugal innovation activities in emerging markets. Their findings suggest that developed market firms must build organisational structures and capabilities to enable the development of frugal innovation, and that building such capabilities is dependent upon the ability of R&D teams, including in understanding the local customers and environment. Consequently, the R&D subsidiaries of developed market firms should have a high degree of autonomy. More precisely, they suggest that frugal innovation results from the unique value architecture that comes from meeting basic customer needs at a low cost. Therefore, developed market firms should focus on low-cost manufacturing of products with low-cost design and materials, and minimal functionality and features.

In a later study, Zeschky et al. (2014) extend their research on subsidiaries of developed market firms organising frugal innovation in emerging markets. Within these firms, the research focus was frugal innovations subsequently launched in developed markets (a concept known as reverse innovation). They suggest that such frugal innovations are designed and developed in the R&D unit located in emerging markets and facilitated by subsidiary access to corporate technological resources. Other scholars (e.g. Agarwal & Brem, 2012) suggest that for developed market firms (through their subsidiaries) to be successful in emerging markets, they need to implement end-to-end localisation and core values identification. Such capabilities are crucial for surviving in emerging markets and developing frugal innovations.

Another more recent qualitative case study (Agarwal et al., 2019) explores the process of developing frugal innovation in developed market firms operating in emerging markets by setting up subsidiaries. Their findings suggest four critical success factors for the development of frugal innovation: employing local R&D resources; the supporting role of senior management; collaboration between headquarters and the subsidiary; and introduction of new product lines. They conclude that building competence around these factors is crucial to establishing a successful subsidiary R&D center in an emerging market.

All the studies mentioned above contribute to understanding around the capabilities required to engage in frugal innovation in emerging markets. The Siemens company initiated a project called SMART, which stands for “simple, maintenance-friendly, affordable, reliable and timely to market”. This is one example of the frugal innovation being carried out by a handful of research and development (R&D) units of developed market firms within emerging markets. According to Siemens, SMART products cost 40% to 60% less than products designed in developed markets. One example of a SMART product is the Fetal Heart Monitor (FHM), which cost significantly less compared to the ultrasound machines used for the same purpose (Radjou & Prabhu, 2013).

As already noted, to date only a few recent studies are identified in the frugal innovation literature with a focus on developed markets firms involved in frugal innovation. For instance Rao, (2017) reports an engineering focused study of developed market firms based in the UK, US, Canada and Europe who are applying a low-cost philosophy in developing sophisticated frugal innovations using advanced science and technology. The study introduces the term “advanced frugal innovation” to describe the use of science and technology to achieve frugality in resource utilisation.

Another qualitative case study research by Winkler et al. (2019) introduces the idea of second-degree frugal innovation, based on the three-criteria model by Weyrauch and Herstatt, (2016), to suggest an evaluation model specifically for frugal innovation in developed markets. Another study identified in the frugal innovation literature is by von Janda et al. (2020). Based on their multi-method study of both emerging market and developed market firms, they describe product-oriented product frugality as a four-dimensional construct, incorporating cost of consumption, sustainability, simplicity and basic quality. However, while contributing new knowledge to the literature of frugal innovation, these studies mainly focus on understanding frugal innovation criteria from the perspective of the developed market. Further, apart from developed market firms practising frugal innovation within emerging markets, the frugal innovation literature reports only a few practical examples of firms within the developed

market context that are trying to introduce the idea of doing frugal innovation into their normal innovation activities. The examples reported by Radjou and Prabhu (2015a) in their recent book on frugal innovation are Raspberry Pi, Qarnot Computing, SwipeSense, Cellscope, Airbnb, and BlaBlaCars.

Little systematic or in-depth empirical attention has so far been allocated to understanding how developed market firms are incorporating frugal innovation in their normal innovation activities in the context of a developed market. Therefore, the related capability building of developed market firms doing frugal innovation remains unexplored. This gap will be addressed by the present research.

Specifically, the present research focuses on those firms within the developed market that primarily target customers within emerging markets, but not exclusively. Within the developed market context and from the developer's perspective, the subject of the present research is firms in Australia and New Zealand targeting emerging markets in the Asia Pacific region, particularly Pacific Islands such as Papua New Guinea, Vanuatu, and Fiji, but not limited to them. The recent frugal innovation literature includes several studies on developed countries such as the UK, US, Canada and in Europe and their involvement in frugal innovation (e.g., Rao, 2017; von Janda et al., 2020; Winkler et al., 2019). However, to the best of the researcher's knowledge, Australian and New Zealand firms involved in frugal innovation related activities have received no scholarly attention so far. This scholarly neglect of the developers of frugal innovation in Australia and New Zealand provides solid grounds for conducting a systematic empirical exploration of this region. As described previously in more detail in Section 1.1, the primary focus of the present research on the Asia Pacific region is from the developer's perspective in Australia and New Zealand, and the emerging market customer's perspective in the Pacific Islands.)

Exploring the firm's capabilities for frugal innovation within the developed market is an interesting research avenue. This is because, firstly, emerging markets are different from developed markets due to economic conditions, the lack of institutions, and the socio-economic culture (Govindarajan & Trimble, 2012c; Porter & Stern, 2001; Sheth, 2011). Given the radically different context of the emerging market, for most managers of firms within developed markets, addressing emerging market needs may be easier said than done (Subramaniam et al., 2015). Secondly, scholars also suggest that the activities of emerging market firms, including the product development process, are radically different from developed market firms and emerging market firms operate with fundamentally different capabilities (Brem & Wolfram, 2014; Subramaniam et al., 2015; P. Williamson & Zeng, 2007,

2009). Therefore, the present research's exploration of the capabilities for doing frugal innovation within developed market firms could reveal a new set of capabilities and underlying activities through new product development processes. Consequently, the present research has potential to expand the knowledge and understanding of frugal innovation activities within developed market firms in particular, and innovation management in general. To this end, the present research aims to explore the following research question, and its theoretical and practical implications.

Research Question:

How do strategic decision-making and knowledge integration activities enable capabilities for frugal innovation in developed market firms?

1.4.Theoretical framework

The theoretical framework developed to address the above-mentioned research question applies the dynamic capability perspective and uses this perspective to interpret the frugal innovation capability building literature in the emerging market. The theoretical framework underpins an empirical investigation into new product development projects that explores the strategic decision-making related activities and their cost minimisation and value maximisation objectives in a firm-level analysis, and the knowledge integration related activities to achieve cost minimisation and value maximisation at the project-level. Consequently, the theoretical framework infers that such a firm-level and project-level investigation could potentially identify the distinct capabilities for frugal innovation within the developed market firm, and the underlying activities enabling those capabilities. The developed theoretical framework also contains the initial theoretical model to address the research question.

1.5.Research methods

To answer the research question, this research is informed by the interpretivist paradigm and adopts a qualitative case study approach. It draws on four in-depth case studies selected through purposive sampling. The following criteria were used to select the cases: 1) A firm at least three years old based in the developed market context and doing tangible product innovation to meet an existing need in an emerging market, and which can count on services, but is itself not primarily a service; 2) The innovation must be offered at a significantly reduced price as

compared to an immediate product substitute, focus on core functionalities, and have an optimised performance level.

The unit of analysis is new product development projects within developed market firms involved in frugal innovation for emerging markets. The present research conducts a multi-level analysis at the firm-level and the project-level. The data collection occurs in two rounds. The first round involves semi-structured interviews, with both a current and retrospective approach, triangulated with relevant reports and archival data. In the second round, fresh data is collected after analysis of the stage one data to cross-validate the findings. The collected data is analysed through thematic analysis, according to the framework suggested by Eisenhardt (1989a), which she believes provides a nearly complete roadmap as compared to previous frameworks for executing qualitative case study research. Thus, the analysis is carried out in an iterative manner, moving to and fro between the literature and associated initial theoretical framework, data, emerging themes, and findings (Eisenhardt, 1989a; Miles & Huberman, 1994). Finally, the quality of this research is assessed using the techniques for the case study method suggested by Riege (2003).

1.6. Research findings

Drawing on in-depth case studies of four cases, the findings of the present research suggest a typology of firm's motivational behaviour. In particular, two dimensions seem to differentiate the motivation to engage in frugal innovation by the firms: (a) empathy with market need, and (b) profitability. Identifying these two dimensions of motivation to engage in frugal innovation in turn enables this research to establish three categories of developed market firm engaged in frugal innovation, according to their Philanthro-Capitalist, Robin Hood, or Cost-Driven approach. Moreover, the present research details the strategic decision-making and knowledge integration activities that underpin capabilities for frugal innovation within developed market firms. Furthermore, the findings identify the building of capabilities for doing frugal innovation within developed market firms.

1.7. Research contribution

The present research produces new insights through a systematic empirical exploration of frugal innovation from a developed market context, thereby extending the existing literature on frugal innovation. To the best of the researcher's knowledge, this present research is first to provide empirical evidence about activities that enable capabilities for frugal innovation within

developed market firms in Asia Pacific region such as Australia and New Zealand who targeted emerging market in Pacific Islands such as Papua New Guinea, Vanuatu and Fiji, but not limited to them. As previously described, most of the frugal innovation research conducted so far is within emerging markets. The present research emphasises the importance of frugal innovation in a developed market context, and brings fruitful insights that challenge the preconceived notion that firms within a developed market context are not able to do frugal innovation. It provides in-depth understanding by highlighting the activities that underpin capabilities for frugal innovation in the developed market context, and reveals the distinctive capabilities of developed market firms for doing frugal innovation. From a practical perspective, the present research implies managerial recommendations for firms within developed markets concerning key activities, practices, and capabilities for doing frugal innovation.

1.8. Thesis structure

This section summarises the structure of the thesis.

- Chapter One “sets the scene”. It introduces the concept of frugal innovation, outlines current understanding of the topic, and identifies the research gap. It then states the research question and the implications of this research in terms of its contribution to the limited literature on frugal innovation.
- Chapter Two provides the literature review and develops a theoretical framework to guide the empirical investigation. It applies the existing literature on capability building for doing frugal innovation within emerging markets as the theoretical lens, alongside a dynamic capability perspective. It also explains why this lens is the most suitable for addressing the research question as compared to other potential theoretical lenses. Finally, it presents an initial theoretical model for this thesis.
- Chapter Three outlines the research methods. It includes the research design, methodological approach, data sampling approach, and data collection and data analysis techniques used to answer the research question. It also justifies the suitability of each of these methods.
- Chapter Four provides a within-case analysis of the four in-depth case studies. The case studies are the products/projects of developed market firms in which frugal innovation activities are incorporated.
- Chapter Five presents the cross-case thematic analysis. Firstly, it presents a typology of developed market firms’ strategic motivation for engaging in frugal innovation. Next, it

details the cross-case analysis, describing the activities underpinning capabilities for frugal innovation in these firms. Finally, it illustrates the revised and extended conceptual model.

- Chapter Six presents the discussion and conclusions. After providing an overview of the research and the key findings, it discusses the theoretical implications of this thesis and its contribution to the limited literature of frugal innovation. Later, it outlines the implications derived for management practices. Finally, it describes the limitations and potential future work, followed by concluding remarks.

1.9. Chapter summary

In summary, Chapter One has presented the research topic of frugal innovation and explained its current understanding in the literature. It then identified and presented the research gap, followed by the research question. It also outlined the implications of this research for the limited literature of frugal innovation and practitioners. Finally, it outlined the structure of the rest of the thesis.

2. Literature Review and Theoretical Framework

This chapter reviews the literature on dynamic capability and frugal innovation and develops the theoretical framework for answering the main research question for this research. The dynamic capability perspective provides the basis for conducting a multi-level empirical analysis of strategic decision making at the firm level and knowledge integration at the project-level. Dynamic capability is also applied to review the literature on frugal innovation to understand the underlying activities that enable capabilities for frugal innovation within an emerging market context.

The theoretical framework “explains, either graphically or in a narrative form, the main things to be studied—the key factors, concepts, or variables—and the presumed relationship among them” (Miles & Huberman, 1994, p. 18). It is a tentative theory of the phenomenon under investigation and informs the rest of the research design in terms of refining goals, selecting appropriate methods, identifying potential validity threats, and helps in justifying the research (Maxwell, 2012, p. 39). The aim in developing a theoretical framework for the present research is to address all the factors mentioned above.

The chapter begins with a basic understanding of the theoretical framework and its objectives for the present research. Next, it presents a review of the theories and literature that can be used as a lens in developing the theoretical framework, which provides a guide for the rest of the research project and contributes to the selection of appropriate data collection and analysis methods (Huff, 2009). Section 2.1 presents a review of theories and their assumptions relating to the construct organisational capabilities to evaluate its suitability for the present research and select the appropriate lens for developing the theoretical framework for this research. The theories reviewed are the resource-based view, the knowledge-based view, and the dynamic capability perspective. After reviewing these theories, the dynamic capability perspective is selected as the theoretical lens to develop the theoretical framework. Section 2.2 details how the dynamic capability perspective can be applied as the theoretical lens at both the firm level and the project level. Section 2.3 applies the dynamic capability perspective to the literature on frugal innovation to understand the underlying activities that enable capabilities for frugal innovation within an emerging market context. This section also identifies the drivers of frugal innovation in the emerging market context. It then describes the implications of the literature on capability building for frugal innovation in emerging markets

and presents the initial theoretical model. Finally, section 2.4 provides a summary of the chapter.

2.1. Dominant perspectives on organisational capabilities

This section reviews and conceptualises the dominant theoretical perspectives on the construct of organisational capabilities—the resource-based view, the knowledge-based view and the dynamic capability perspective. Each theory is reviewed to evaluate its suitability and application for the present research.

There are three schools of thought regarding the firm's capabilities as a key factor for surviving in the competitive global market. These are the resource-based view (RBV) (J. Barney, 1991; Grant, 1991; Wernerfelt, 1984), the knowledge-based view (KBV) (Grant, 1996b; Kogut & Zander, 1992a), and the dynamic capability perspective (Eisenhardt & Martin, 2000; Teece & Pisano, 1997). These schools of thought are neither mutually exclusive nor contradictory; instead they can best be conceptualised as providing a theoretical continuum in relation to each other (Acedo, Barroso, & Galan, 2006; Helfat, 2003; Hoopes & Madsen, 2008; Kaplan, Schenkel, Krogh, & Weber, 2001; Kraaijenbrink, Spender, & Groen, 2010; Theriou, Aggelidis, & Theriou, 2009). The concept of capability was first introduced in RBV as an essential resource, whereas extensive work on capability has been done in the dynamic capability perspective, thus making them extensions of RBV (Barney, 2001; Grant, 1996b; Priem & Butler, 2001). A detailed explication of each of these theories follows, including a critical review on why dynamic capability is considered as the most suitable lens for the present research.

2.1.1. Resource-based view (RBV)

This section reviews RBV for its suitability and relevance in building the theoretical framework for this research. It begins with the core assumptions of RBV, followed an exploration of its static and content-specific focus. Later, the limitations of RBV with regard to the present research are reviewed.

RBV suggests the firm is a bundle of heterogeneous resources and capabilities that can be described as valuable, rare, inimitable and non-substitutable (VRIN), and which provide a sustainable competitive advantage (Barney, 1991; Conner, 1991; Wernerfelt, 1984). The core assumptions of RBV focus on the firm's internal VIRN resources (both tangible and intangible) and capabilities (i.e., the capacity to perform activities through an integrated set of resources) for achieving sustainable competitive advantage, and answer the question of why firms in the same industry differ in their performance (Barney, 1991; Kraaijenbrink et al., 2010).

RBV has long been considered a static approach (Newbert, 2008; Priem & Butler, 2001). The static approach of RBV emerged from research by Barney (1991), which presents a static content list for competitive advantage, interpreting RBV through the VRIN framework and arguing that firms possessing VRIN will enjoy improved performance in the short term. However, with this interpretation of RBV, the process through which particular content (resources) produces output (competitive advantage) remains a black box (Lawrence, 1997; Priem & Butler, 2001). According to Priem and Butler (2001), researchers were commonly using “resources” as an independent variable and “competitive advantage” as a dependent variable with a high level of abstraction. They argued that the static argument of RBV is merely descriptive. However, this missing link in RBV was identified early on by Mahoney and Pandain (1992: 365), who argued that “[a] firm may achieve rents not because it has better resources, but rather the firm’s distinctive competence involves making better use of its resources”.

In addition, RBV conceptualises capability more from its content perspective rather than its process perspective. RBV scholars have tended to focus mainly on delineating the concept of capability. For example, Grant (1991) suggests that organisational routines are an organisational capability. For Amit and Schoemaker (1993), capability is the capacity to deploy resources by using organisational processes. They describe capabilities as information-based tangible or intangible processes that are specific to the firm and developed through multifarious interactions between the firm’s resources over time. Despite these various delineations, the original RBV term has been criticised as all-inclusive and vague (Priem & Butler, 2001), and leading to unworkable definitions of resources (Kraaijenbrink et al., 2010). Moreover, the distinction between resources and capabilities is not clear with regard to what is internal to the firm or can be outsourced, and if resources enable capabilities or capabilities create resources (Kaplan et al., 2001; Theriou et al., 2009).

Considering RBV’s core assumptions, it is useful in the initial conceptualisation of capabilities and has provided an essential framework for understanding strategies for achieving and sustaining competitive advantage within the firm. However, it does not explain the actual process for capability building through which firms can achieve and sustain a competitive advantage (Eisenhardt & Martin, 2000). Further, due to the static conceptualisation provided by RBV, empirical approaches using RBV have mostly focused on the content perspective of capability, and firm-level empirical exploration has been dominated by quantitative research (Priem & Butler, 2001). Helfat and Peteraf (2003) attempt to identify and address the missing link in RBV, namely the process for converting resources into competitive advantage. They

propose a dynamic version of RBV and explain the capability life cycle. Nevertheless, their dynamic RBV focuses on the evolution of organisational capabilities, whereas the purpose of the present research is to undertake a multi-level, in-depth empirical exploration of activities that enable capabilities for doing frugal innovation within developed market firms. Therefore, RBV may not be a suitable theoretical lens for the present research.

2.1.2. Knowledge-based view (KBV)

This section reviews KBV for its suitability and relevance to building the theoretical framework for the present research. It begins with providing a basic understanding of KBV as an extension of RBV (Grant, 1996b), followed by its core assumptions. Next, it reviews static and dynamic frameworks for KBV. Finally it explicates the limitations of KBV with regard to the present research.

The KBV perspective emerged as an extension of RBV. The proponents of KBV consider RBV insufficient, arguing that it considers knowledge as a generic resource whereas it possesses unique characteristics (Conner & Prahalad, 1996; Grant, 1996b; Kogut & Zander, 1992a, 1996, 2003; Nahapiet & Ghoshal, 1998). These scholars claim that KBV considers knowledge as the most strategic resource that can be acquired, transferred or integrated—both within and outside the firm—to achieve sustainable competitive advantage. They further suggest that it is heterogeneous knowledge bases and capability that determine sustained competitive advantage. Thus, KBV defines organisational capability as “a firm's ability to perform repeatedly a productive task which relates either directly or indirectly to a firm's capacity for creating value through effecting the transformation of inputs into outputs” (Grant, 1996a, p. 377). According to KBV, firms are knowledge creating entities and exist because they are more efficient at providing the means to manage the knowledge-intensive process than is possible in market transactions, and therefore they exist to create, transfer and transform knowledge into competitive advantage (Grant, 1996b; Kogut & Zander, 1992a, 2003). The competitive advantage achieved through organisational capability depends upon the efficiency of knowledge integration, as a firm can exist only if its knowledge conversion rate is higher than that of the market (Grant, 1996b; Ikujiro Nonaka, 1994; Ikujiro Nonaka & Toyama, 2003).

KBV is applied differently by two streams of scholars. One stream focuses on the static framework of KBV, and the other on the dynamic framework of KBV. The static framework considers knowledge as a resource—an unambiguous, reducible and easily transferable construct (Argote & Ingram, 2000; Ikujiro Nonaka & Takeuchi, 1995). This KBV approach is directly linked to RBV (Acedo et al., 2006). On the other hand, the dynamic framework for

KBV considers knowledge as a process, whereby knowledge is associated with processing information (Blackler, 1995; Eisenhardt & Santos, 2001; Spender, 1998). Therefore, KBV has been considered both an individual- and firm-level theory and KBV-based empirical exploration has been undertaken both quantitatively and qualitatively.

According to Foss (1996; n.d.; 1998), the point of departure for dynamic KBV is the Penrose (1959) theory of the internal processes that drive the firm's growth and lead to a sustainable competitive advantage. Within the processual perspective, knowledge is considered equivocal, dynamic and context-dependent (Newell, Robertson, Scarbrough, & Swan, 2009). Spender (1998) suggests that knowledge and learning be considered as processes that generate, distribute and apply knowledge. Thus, firms play a dual role in knowledge generation and knowledge application. These knowledge-based activities are termed knowledge exploration and exploitation by March (1991), who views firms as knowledge storing entities within the literature of organisational learning, which underlies knowledge-based thinking. According to March (1991), knowledge exploration leads to an increase in the stock of knowledge through search, variation, risk-taking, experimentation, play, flexibility, discovery, and innovation. Knowledge exploitation, on the other hand, relates to knowledge deployment for innovation through refinement, choice, production, efficiency, selection, implementation, and execution. Kogut and Zander (1992b) consider the firm a repository of capabilities and a knowledge integrating institution (Kogut & Zander, 1993), where social knowledge is embedded in the individual relationships that are structured according to organising principles. These scholars suggest that although challenging, understanding the knowledge base of the firms leads to firm capabilities that increase competitiveness, growth and survival. Complementing these views, Nonaka and Takeuchi (1995) provide a framework to understand individual and organisational knowledge. Suggesting a knowledge spiral, they argue that organisational knowledge should be considered as the iterative and continuous interplay between tacit and explicit knowledge, both at the individual and organisational level, thereby advancing the multi-layered role of knowledge as a source of competitive advantage. Subsequently, the firm is considered a knowledge creating entity in the knowledge creation process (Kusunoki, Nonaka, & Nagata, 1998; I. Nonaka, 2006; Ikujiro Nonaka, 1991, 1994).

While KBV puts indirect emphasis on the capability building process by considering knowledge as its foundation (Grant, 1996b, 1996a), nevertheless the primary emphasis of KBV is knowledge processes (Kraaijenbrink, 2012). The focus of the KBV inclines more towards the characteristics of knowledge, whereas capability is considered as the output. Consequently,

KBV alone may not be a suitable theoretical lens to understand the activities that enable capabilities for doing frugal innovation within developed market firms.

2.1.3. Dynamic capability perspective

This section reviews the dynamic capability perspective for its suitability and applicability for building the theoretical framework for the present research. The section begins with the basic understanding and core assumptions of the dynamic capability perspective. Next, it explicates understanding of dynamic capability perspective according to two main streams of scholarship, and reviews both streams focusing on their commonalities.

Dynamic capability is defined as “the firm’s ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments” (Teece & Pisano, 1997, p. 516). The concept of dynamic capability has been defined by several other scholars in various ways (see Table 1). Nevertheless, a common thread is that dynamic capabilities are organisational processes built rather than bought in the market. Moreover, dynamic capabilities are intentional efforts to change the firm’s resource base and thus impact the firm’s value creation (Ambrosini & Bowman, 2009; Ambrosini, Bowman, & Collier, 2009).

Table 1 Dynamic capability as defined by multiple scholars

Scholars	Definitions of dynamic capability
Eisenhardt and Martin (2000, p. 1107)	“The firm's processes that use resources--- specifically the processes to integrate, reconfigure, gain and release resources--- to match and even create market change.”
Zollo and Winter (2002, p. 340)	“A learned and stable pattern of collective activities through which the organization systematically generates and modifies its operating routines in pursuit of improved effectiveness.”
Winter (2003, p. 991-993)	“Extension, modification, and creation of ordinary capabilities”
Zahra, Sapienza, and Davidsson (2006, p. 918)	“Abilities to reconfigure a firm’s resources and routines in the manner appropriate by its principal decision maker(s).”
Wang and Ahmed (2007, p. 35)	“Behavioural orientation to continuously integrate, reconfigure, renew, and recreate its resources and capabilities, focusing on upgrading and reconstructing its core capabilities in line with dynamic, changing environment to obtain and sustain competitive advantage.”

Scholars	Definitions of dynamic capability
Helfat et al. (2009, p. 4)	“Capacities of a firm to purposefully create, extend, and modify its resource base.”

Apart from the commonalities in its multiple definitions, the construct of dynamic capability has been substantially applied and developed under the influence of two seminal works: Teece and Pisano (1997) and Eisenhardt and Martin (2000). According to Teece (2014) and Teece and Pisano (1997), building capabilities require abilities such as sensing, seizing and reconfiguring/transforming. Sensing refers to the organisational processes through which technological opportunities concerning customer needs are identified, developed, co-developed and assessed. Seizing refers to the process through which firm mobilise resources and capture value by addressing needs and opportunities. Finally, transforming or reconfiguring means continued renewal.

On the other hand, Eisenhardt and Martin (2000, p. 1107), define dynamic capability as:

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.

Eisenhardt and Martin (2000) thus consider dynamic capability as an identifiable, specific, organisational and strategic process that aims to integrate resources such as strategic decision making, product development routines and alliances, whereby managers combine their varied skills and functional backgrounds to create profit-generating products or services. They argue that in integrating resources, such as within product development routines, managers combine their varied skills and resources to create new products or services by which firms survive in the turbulent business environment. Innovation scholars also support such an understanding of integrating knowledge and resources within product development routines. For instance, they suggest that similarly to integrating resources in product development routines, processes such as reconfiguration of resources through transfer processes, replication routines and knowledge creation routines for gain and release of resources are critical dynamic capabilities for firms (Clark & Fujimoto, 1991; Dougherty, 1992; Helfat & Raubitschek, 2000).

There also exist contradictions between these seminal works of Teece and Pisano (1997) and Eisenhardt and Martin (2000) (Peteraf, Di Stefano, & Verona, 2013). For instance, Teece and Pisano (1997) suggest dynamic capability is distinctive and heterogenous in nature across organisations, and heterogeneity evolves and builds over the years. In contrast, Eisenhardt and

Martin (2000) argue that dynamic capability can be distinctive, but only in the details as specific dynamic capability also exhibits commonalities associated with processes across organizations, which are often labelled “best practices”. These differences can be overlooked by applying certain conditions to the Eisenhardt and Martin (2000) perspective that are consistent with Teece and Pisano (1997). For example, in moderately dynamic settings, a more detailed look at the individual details may allow differentiation between similar best practices due to differences in experience, competitive context, added value and timings (Peteraf et al., 2013). Hence, Peteraf et al. (2013) suggest that understanding both perspectives is necessary to see the complete picture and explore the interlinked dynamic bundle.

Nevertheless, these differences are considered mere differences in perspective, and both approaches can work within the firm, either sequentially or simultaneously (Peteraf et al., 2013). Further, both perspectives have the common objective of showing how firms build and refresh their capabilities in responding to change in the external business environment and competition. Therefore, this research does not intend to involve itself in the debate about differences in the approaches. Instead, it focuses on their commonalities (Eisenhardt & Martin, 2000; Teece & Pisano, 1997) regarding the capability building process, which they consider the dynamic capability provided by the organisational and strategic routines through which firms build new capabilities and develop new sources of competitive advantage.

However, the differences between the above-mentioned seminal works have led to multiple critiques, including with regard to lack of specificity and precision (Grant & Verona, 2015), tautological definitions (Arend & Bromiley, 2009) and measurables for empirical work (Arend & Bromiley, 2009; Grant & Verona, 2015; Newbert, 2007). The common critique around the lack of specificity and precision arises mainly from their contradictions leading to inconsistent interpretation and tautological definitions (Salvato, 2003; Zahra, Sapienza, & Davidsson, 2006), which is seen as a reflection of the lack of a coherent theoretical foundation (Arend & Bromiley, 2009).

First, the critiques around the contradictions leading to inconsistent interpretation can be elaborated as follows. Whereas Teece and Pisano (1997) suggest that dynamic capabilities result in the firm being able to sustain their competitive advantage, especially in high-velocity markets, Eisenhardt and Martin (2000) claim that high-velocity markets can be beneficial, but are not an essential condition. In response to this contradiction Zahra et al. (2006) suggest that dynamic capabilities can be very valuable in the high-velocity market condition, but having a high-velocity market is not a necessary component of dynamic capability. These different claims result in confusion and inconsistent interpretation of the dynamic capability

phenomenon. Another problem with circular definitions of the dynamic capability perspective is the disagreement over whether dynamic capability refers to substantive capability in high-velocity markets, or to the organisation's ability to alter existing substantive capability irrespective of market conditions (Zahra et al., 2006).

Second, concerning the tautological aspect of the dynamic capability perspective, Arend and Bromiley (2009) argue that many theoretical and empirical concerns about the dynamic capability perspective have broad similarities with the concerns raised in relation to RBV. They further argue that just as some research relates anything regarding inter-firm differences to RBV, others may ascribe anything related to change to the dynamic capability perspective, weakens its rigour and credibility, therefore rendering the dynamic capability perspective tautological. In response to these critiques, Teece (2014) argues that the even though the presence of dynamic capability is necessary for long-run growth and profitability, nevertheless these dynamic capabilities are worthless if tied with bad strategies.

The third critique of the dynamic capability perspective is that, empirically, it is not yet measurable and presents substantial empirical challenges (Arend & Bromiley, 2009; Grant & Verona, 2015; Newbert, 2007). The existing measures of dynamic capabilities are still unclear as they are unrelated in general, whereas the traditional measurement approach looks for correlations between diverse measures of the same construct (Arend & Bromiley, 2009). According to Grant and Verona (2015), even though scholars have attempted through statistical testing to achieve some dimensions of construct validity, nevertheless, critical impediment to construct reliability and validity in measuring this construct is still unrecognised. They further argue that similarly to quantitative studies, within qualitative studies there are problems relating to reliable and valid identifiers of constructs, although less attention has been given to the problems of identifying capabilities. Thus, they suggest that the lack of specificity and precision in identifying capabilities remains a fundamental problem within the qualitative case research.

Some of the critiques mentioned above are, however, addressed in work following the Eisenhardt and Martin (2000) approach, which considers dynamic capability as identifiable and specific processes such as alliancing, product development, and strategic decision making. Although Eisenhardt and Martin's (2000) approach appears slightly different from that of Teece and Pisato (1997), it has significantly expanded the applicability of the dynamic capability perspective (Peteraf et al., 2013). In particular, the perspective of Eisenhardt and Martin (2000) has been substantially referenced in the literature on product development and innovation (e.g., S. L. Brown & Eisenhardt, 1995; Hisham Hamid Hawass, 2010; Kashan &

Mohannak, 2015; Maniak, Midler, Beaume, & von Pechmann, 2014; Marsh & Stock, 2003, 2006; Verona & Ravasi, 2003).

The present research also attempts to respond to some of the critiques mentioned above. First, it is more inclined towards Eisenhardt and Martin's (2000) definition of dynamic capability as an identifiable and specific process and incorporates this definition in building the theoretical framework. Studying this specific and identifiable process in order to explore dynamic capability will also overcome the lack of valid critique on sensing, seizing and transforming processes, as suggested by Teece (2007). Second, consistency in construct identifiers, and the face validity and discriminant validity of this empirical research will be achieved through triangulating multiple sources of case data, as suggested by Grant and Verona (2015). Third, considering the fore-mentioned critiques around research methodology, this present research intends to conduct qualitative case-based research. A qualitative empirical examination of integrating knowledge resources for capability building (discussed in detail later in this section) may overcome some of the critiques relating to empirical work as the focus is an identifiable specific process. Fourth, with regard to the analysis, the present research complements the views outlined in the most well-known dynamic capability scholarly works (Eisenhardt & Martin, 2000; Teece & Pisano, 1997), and others (e.g., Grant & Verona, 2015; Salvato & Rerup, 2011; Teece, 2014), which consider capability building as a multi-level process in order to acquire in-depth understanding of the process. Consequently, the focus of the present research will be on firm-level strategic decision making and the underlying project-level activities that enable capability building, as further discussed in the following section.

In sum, the key take-aways are that the dynamic capability perspective is a theoretical response to the limitations of RBV and KBV, which is considered both an extension of RBV and as related to KBV (Ambrosini et al., 2009; Helfat & Peteraf, 2009). Dynamic capability emerged in the 1990s (Teece & Pisano, 1994, 1997; Teece, Pisano, & Shuen, 1990) with the argument that firms need to go beyond RBV, as the bundle of resources is not enough. The firm's mechanisms for learning and accumulating new skills and capabilities must be considered, as well as the forces that limit the rate and direction of this process. The main issue addressed in the dynamic capability perspective is how a firm can build and continue to refresh or reshape capabilities in a rapidly changing environment (Teece, 2007, 2014; Teece & Pisano, 1997).

Unlike RBV's focus on creating Ricardian rent, dynamic capability focuses on creating Schumpeterian rent, where by a firm continues to exist if it leverages and develops capability earlier, more inventively or more casually than its competitors (Amit & Schoemaker, 1993;

Eisenhardt & Martin, 2000; Leonard-Barton, 1992; Teece & Pisano, 1994). Subsequently, the firm's competitive advantage is dependent on specific organisational and managerial processes that contribute to renewing the firm's capabilities. The dynamic capability perspective was developed against the presumed context of a business environment where there is intense global innovation-driven competition (Teece, 2014). Consequently, for innovation-based competition, price/performance rivalry, and the creative destruction of existing competencies, the dynamic capability approach is highly relevant (Teece, 2014; Teece & Pisano, 1997).

Unlike KBV, the focus of the present research is not only to examine the micro-processes of capability building, such as the knowledge integration processes, but it also aims to explore firm-level strategic decision making. Consideration of strategy is critical to studying the capability building process, as Teece (2014) suggests that strong dynamic capabilities are worthless if tied with bad strategies. Consequently, the dynamic capability perspective not only focuses on knowledge integration processes in capability building, but also has the potential to show how these knowledge integration processes are linked with the firm's strategy in achieving sustainable competitive advantage.

The dynamic capability perspective is therefore considered the theory most suited to the study of organisational innovation (Lawson & Samson, 2001), and the appropriate lens to explore capabilities for doing frugal innovation in developed market firms.

2.2. Multi-level review of dynamic capability perspective

This section details a multi-level review of the dynamic capability perspective to explain how it can be applied at both the firm-level and the project-level as the theoretical lens for this research. In order to attempt bridging the micro-macro gap, this research takes a multi-level approach (Hitt, Beamish, Jackson, & Mathieu, 2007). Following a multi-level approach also enables theorising about the interconnections between firm-level strategic decision-making activities and project-level knowledge integration activities, hence providing a more comprehensive understanding.

2.2.1. Firm-level analysis: Strategic decision making

For the firm-level analysis, the focus of the present research is on strategic decision making. From the literature on dynamic capability and strategy, it can be seen that dynamic capability encompasses strategic decision making at the firm level (Eisenhardt, 1989b, 1999; Fredrickson, 1984; Helfat & Martin, 2015; Teece, 2014). According to Eisenhardt and Martin (2000, p. 1107), **strategic decision making** is defined as “a dynamic capability in which managers pool

their various business, functional, and personal expertise to make the choices that shape the major strategic moves of the firm". They further argue that such strategic decisions contribute to manipulating resources into new value-creating strategies, and as a consequence create value for the firm in changing market conditions.

According to Eisenhardt (1999), the term strategy encompasses two fundamental questions: Where do you want to go?; and, How do you want to get there? However, the traditional approach focuses only on the "where" question, and even if the "how" question is implied, it appears very late. She describes strategy as strategic decision making in a rapidly changing environment. By considering strategic decision making as a fundamental dynamic capability in successful firms, she argues for strategic decision making as those decisions that change the firm's direction, generate new competitive advantage, and arise more often in rapidly changing markets. She suggests that unlike traditional firms, successful firms often adopt different perspectives where strategy combines the questions of "where" and "how" to create continuous competitive advantage. Four approaches emerge from her research highlighted "how [...] firms build dynamic capability for strategic decision making". These four approaches are: building collective intuition, stimulating quick conflicts, maintaining the pace, and diffusing politics. Likewise, Rumelt, (2011, p. 6) defines strategy as "a coherent set of analyses, concepts, policies, arguments, and actions that respond to a high-stakes challenge". He suggests three main elements of good strategy, as follows: (a) a diagnosis, (b) a guiding policy, and (c) coherent action. Based on this conceptualisation of strategy, Teece (2014) suggests that the nature of managerial orchestration required for (a) diagnosis is entrepreneurial, while it is administrative for (b) a guiding policy, and leadership for (c) coherent action. This means managers need to identify changing market needs and technological trends, develop the right approach to tackle the change, and finally implement the plan through feasible coordinated policies, resource commitment and actions designed to carry out the policy.

Teece (2014) argues that the strategic decision-making skills of competent managers play a vital role in value creation, not only for shareholders and employees but also for customers. He also suggests that managers are critical to resource allocation and economic activity and play a key role in cost reduction. These factors have been empirically tested by some scholars within the dynamic capability literature. For example, in their study, Adner and Helfat (2003) concluded that dynamic capability resides in individual managers and the top management team. Such an understanding emphasises the ability of the CEO and top management team in recognising changing market needs and technology trends so as to guide the firm towards that change. Similarly, Dosi, Faillo, and Marengo (2008) recognise that dynamic capability partly

resides in managerial decisions through which firms survive in a turbulent business environment. Thus for objectives such as innovation, firms require the leadership of entrepreneurial managers, who can gather information, make an assessment and direct the development and deployment of non-priced assets in value-enhancing ways (Teece, 2014). This implies that successful strategic decision making can enable firms to deploy scarce resources to create high value that in turn enables them to meet current market needs and technological trends. Moreover, for innovation related ambitions, managerial orchestration is also required, along with a pricing system, in order to allocate scarce resources against unlimited wants, because it is the managers who allocate resources (Teece, 2014).

Hence, knowing that strategic decision making is considered a firm-level phenomenon (Fredrickson, 1984), the empirical research focus of this research will be on strategic decision making carried out by top management such as the CEO, executives and other similar high-level managerial roles. Specifically, the empirical focus will be around strategic decision making and managerial orchestration for achieving the frugal innovation objectives of new product development projects within developed market firms.

2.2.2. Project-level analysis: New product development

To empirically examine the micro-processes underlying capability building, this research also takes a project-level approach. Since the dynamic capability perspective lacks underlying theory at the micro-level (Arend & Bromiley, 2009; Salvato, 2003), adopting this approach has the potential to contribute to an area lacking in this perspective. More specifically, the present research builds on Eisenhardt and Martin (2000), who consider integrating resources within product development processes a dynamic capability. As mentioned earlier, Eisenhardt and Martin (2000) describe dynamic capability as identifiable and specific processes, therefore making empirical research operational and overcoming the non-operational critique of dynamic capability (Mosakowski & McKelvey, 1997; Priem & Butler, 2001; O. Williamson, 1999).

Innovation scholars have also used the Eisenhardt and Martin (2000) approach in studies where product development projects are conceptually and empirically considered an essential unit of analysis and the most critical context for understanding the capability building process (Danneels, 2002; Iansiti & Clark, 1994; Kashan & Mohannak, 2015; Marsh & Stock, 2003, 2006; Verona & Ravasi, 2003). For instance, Iansiti & Clark (1994, p. 566) suggest that:

Product development provides a powerful window through which to study the challenge of creating new knowledge and capturing it in the firm's capabilities [...] and that the

capacity for problem-solving that underlies effective product development is also a critical ingredient in dynamic capability.

Similarly, Danneels (2002) suggests product innovation is a dynamic capability based on the argument that new product development is related to the renewal of a firm's competence. He further suggests that product innovation functions as a tool for organisational learning and enables refreshing and reshaping of firms. This understanding aligns with Teece and Pisano's (1994) view of dynamic capability as a subset of the competence through which firms create new products or processes inside the firm that could be innovations. Thus product development and innovation are considered essential processes for the survival and renewal of organisation in competitive markets (S. L. Brown & Eisenhardt, 1995) and critical context for studying the micro-processes of dynamic capability.

To develop a fine-grained understanding of knowledge integration processes within new product development projects, the present research seeks to complement the understanding of knowledge as a foundation of the capability building process, which involves integration of knowledge to perform discrete productive tasks (Grant, 1996a; R. M. Henderson & Clark, 1990; Iansiti & Clark, 1994; Petroni, 1998). There are two reasons for adopting this approach. First, knowledge is the most frequently referenced object in integration towards building capability (R. Henderson, 1994; Hoopes & Madsen, 2008; Hoopes & Postrel, 1999; Iansiti & Clark, 1994; Iansiti & Khanna, 1995; Kogut & Zander, 1992a; Teece, 2012; Verona & Ravasi, 2003). Second, knowledge is a crucial input into all production processes, such as a new product development process, whereas organisational capability is considered an output of knowledge integration (Grant, 1996a).

Adopting a knowledge integration approach to the product development process also has relevance within the literature on frugal innovation capability building in emerging markets. Most of the frugally innovative product development within emerging market firms involves extensive integration of the external knowledge held by customers, distributors, partners and suppliers with the firm's internal knowledge. Additionally, such an understanding of the capability building process aligns with Teece (2014), who suggests that dynamic capability demands both external and internal orientation. Thus, to understand the activities that enable capability building, the knowledge integration approach is useful because capabilities are built by integrating the specialist knowledge of individuals both inside and outside the organisation, and are associated with organisational competencies and routines (Grant, 1991; Teece & Pisano, 1994).

The empirical examination of the knowledge integration process: For the empirical examination of the knowledge integration process that enables capability building, the present research looks into prior empirical studies that focus on the knowledge integration process underlying capability building process. The main intention is to evaluate and select suitable approaches to draw upon in order to achieve the research objectives. The most prominent attempt is a study by Grant (1996a), which identifies two primary integration mechanisms: (i) Direction, and (ii) Organizational routines. While direction increases the complexity of knowledge, by integrating tacit knowledge, organisational routines reduce the cost of communication and provide flexibility of application. Grant (1996a) also identifies three characteristics of knowledge integration. The first is the efficiency of knowledge integration; that is, the extent to which the capability accesses and utilises the knowledge. The crucial factors that determine the efficiency of knowledge integration within the firm are the level of common knowledge, the frequency and variability of task performance, and an organisational structure designed with regard to reducing the extent and intensity of the communication needed to achieve integration. The second characteristic is the scope of knowledge integration. This is the breadth of knowledge, which needs to be wide so that it is hard for the competitor to replicate. Third is the flexibility of knowledge integration, which represents the ease with which capability can access new knowledge and reconfigure existing knowledge. Although this approach towards knowledge integration has been widely accepted, it is only useful for identifying characteristics and factors that facilitate the knowledge integration process. As it does not explain the actual micro-processes involved in knowledge integration processes, it is therefore not suited to the scope of this research.

Other scholars within the dynamic capability literature have also considered the knowledge integration process as a critical underlying micro process for understanding the process of capability building. For instance, Verona and Ravasi (2003) suggest continuous innovation as a dynamic capability focused on knowledge creation and absorption, knowledge integration and knowledge reconfiguration. Their empirical analysis involves four dimensions: (1) the actors, (2) the structure and systems, (3) the physical resources, and (4) the organisational culture. Within their analysis, the building blocks for knowledge integration involve technically expert staff as the actor; cross-functional teams, competence centres and multi-job systems etc. as the structures and system; horizontal physical resources; and an organisational culture with openness to creativity and which encourages interaction through departmental identification. Their study, however, takes a firm-level approach, and knowledge integration is only one of the three processes examined at the firm-level. Therefore, their study may not be

useful for a project-level empirical examination of the activities underpinning capabilities and thus for the present research.

Two studies have explored knowledge integration as a critical underlying micro-process of dynamic capability (Marsh & Stock, 2003, 2006). The research builds on the conceptualisation provided by Eisenhardt and Martin (2000) to suggest that intertemporal integration in the new product development process is a dynamic capability. Although the work is mainly focused on knowledge integration within the firm, nevertheless the empirical approach adopted by Marsh and Stock (2003, p. 139) has been widely accepted. They argue:

The ability of the organization to acquire, to distribute, to interpret, to retain, and to apply the knowledge developed in prior new product development activities will influence its ability to integrate intertemporally and its ability to transform its existing capabilities into new ones in order to adapt to current marketing and technological requirements.

The underlying processes suggested by them within knowledge integration process are; (a) knowledge acquisition, (b) knowledge distribution, (c) knowledge interpretation, (d) knowledge retention, and (e) knowledge application. All these knowledge processes mainly relate to marketing, technological and project management knowledge.

However, in Marsh and Stock's (2006) later attempt to empirically examine their suggested knowledge integration processes, only two of the five processes were tested through a quantitative approach. One could speculate that the unobservable nature of some of the processes suggested by Marsh and Stock (2003, 2006) could be their primary reason for not empirically testing all five processes. This assumption also provides grounds for conducting a qualitative empirical examination that allows an examination of the unobservable phenomena. Moreover, although potentially beneficial for the present research, their approach is not sufficient in itself as it only focuses on the firm's internal knowledge integration. When considering the activities enabling capabilities for doing frugal innovation in emerging markets, firms are significantly involved in integrating knowledge from both inside and outside the firm. Nevertheless, adapting the knowledge processes suggested by these scholars could be useful if these knowledge processes are examined for both external and internal knowledge integration, and if the empirical work takes the form of a qualitative study.

A prominent study within the dynamic capability perspective that focuses on both external and internal knowledge integration is that of Iansiti and Clark (1994). The authors consider knowledge as the foundation of capability, and problem-solving activity within new product development projects as a driver of the capability building process. Their study mainly focuses on deepening the understanding of processes and activities underlying capability building

within firms. Based on an investigation of the impact of internal and external integration on dynamic capability, they suggest the capacity to integrate diverse knowledge bases within product development activities to solve the problem in hand results in building new capabilities within the firm. This understanding of building new capabilities appears to be a useful approach for exploring the knowledge integration process underpinning dynamic capability and is therefore applied in the present research.

Iansiti and Clark (1994) suggest two dimensions of knowledge integration within a new product development project: 1). External knowledge integration, and 2). Internal knowledge integration.

1) External knowledge integration

Iansiti and Clark (1994) further categorise external knowledge integration into customer integration and technology integration, which are defined as follows:

- ***Customer integration:*** “Customer integration is the capacity to link information and knowledge about future customers and their use of the product to the development process and the details of engineering” (Iansiti & Clark, 1994, p. 570).
- ***Technology integration:*** “Technology integration is the capacity to link the evolving base of technical knowledge (both inside and outside the firm) to the existing base of capability within the organisation” (Iansiti & Clark, 1994, p. 570).

Customer integration focuses on routines and mechanisms through which firms can forecast customer requirements (Clark & Fujimoto, 1991). Iansiti and Clark (1994) further argue that individuals within the firm implement mechanisms through which they can interpret current market information and forecast customer needs and wants. They suggest that the vision of the market must be translated into precise objectives and implemented within the firm. Therefore, it is crucial for firms to build new competencies to develop products according to customers’ expectations. They further suggest that individuals in the firm involved in concept development must consider the role of environmental concern in the customer’s buying decision and pay attention to details that bring customer satisfaction. They also suggest the customer integration process implies mutual adaptation between the organisation and its market, stating that organisational competencies are influenced by the customer needs, and the competence base may influence customer needs.

With regard to technology integration, Iansiti and Clark (1994) suggest that technology integration involves the problem-solving activities performed to match new technical knowledge with a firm’s existing competencies and complex architecture. For instance, the

focus of the technology integration process is to ensure that the new technological concept is compatible with the firm's existing manufacturing capabilities, or, alternatively, whether these need to be adapted. Also, the fabrication process may need to be altered for new materials, and overall production capabilities changed to employ a new approach. Additionally, the training level and experience of the plant workforce and the engineering staff may have to be altered in order to handle the new technology.

Iansiti and Clark (1994) argue that the most critical capacity in external knowledge integration involves tapping the source of new information, which involves communicating and coordination with customers, suppliers, distributors and foreign partners, and combining their knowledge with the firm's existing knowledge to build new knowledge. This implies that critical skills and routines in conducting external integration are the ability to understand the relevance and compatibility of new possibilities with the firm's existing capability base to frame and evaluate the possible approaches and select the most appropriate option.

2) *Internal knowledge integration*

The second dimension of the knowledge integration process suggested by Iansiti and Clark (1994, p. 569) is internal knowledge integration, which they define as "the capacity for extensive coordination between different specialised subunits within an organization, and explicitly targets the implementation of a given project concept". Based on this definition, they suggest that internal integration involves cross-functional project teams and overlapping problem solving among different functional departments of the organisation. Additional skills associated with internal integration are the capacity for coordinating, and leadership and organisational routines that facilitate efficient communication within the firm and timely use of new knowledge.

Iansiti and Clark (1994) also highlight the relevance of external integration of customer and technology knowledge in the concept development stage of product development as these are critical drivers for the renewal of the firm's capabilities. On the other hand, they consider internal integration to be linked with the implementation stage of the project and it impacts speed, efficiency of productivity and performance. Additionally, they argue that during the concept development phase, the focus of capability building is on identifying possible courses of action, conceptualising desired outcomes and developing a road map for new knowledge creation and implementation. In the implementation phase of product development, however, the project focuses on creating the assets and routines required for the designed road map and captures new knowledge in the form of new skills, new technical systems, and change in

managerial systems within the firm to in turn enable new capability building. Furthermore, they argue that in the concept development stage, the firm goes beyond what it already knows and frames the capability building activities needed to achieve the desired outcome. In contrast, activities in the implementation phase are linked to the firm's internal integration of existing specialised knowledge bases, skills and technical and managerial systems. Thus, the theoretical framework of the present research is informed by the knowledge integration approach suggested by Iansiti and Clark (1994). This view of knowledge integration as both internal and external to the firm during new product development appears useful for understanding the project-level activities that enable capabilities for frugal innovation within developed market firms.

Table 2 Initial theoretical framework based on dynamic capability

Activities underpinning dynamic capability			
Firm-level strategic decision making		Project-level knowledge integration	
Entrepreneurial decisions	Administrative and leadership decisions	Internal knowledge integration	External knowledge integration <ul style="list-style-type: none"> • Customer knowledge • Technology knowledge

Summarising the main points from 2.2.1 and 2.2.2, dynamic capability explains how firms can build and continue to refresh capabilities in a rapidly changing environment (Teece, 2007, 2014; D. Teece et al., 1997) with intense global innovation-driven competition (Teece, 2014). Two influential works (Eisenhardt & Martin, 2000; Teece & Pisano, 1997) agree on the detail of how dynamic capability can be applied at the firm level, where strategic decision making is considered a dynamic capability. At the project level, however, the present research is inclined more towards the Eisenhardt and Martin (2000) perspective, where integrating (knowledge) resources within product development processes is considered a dynamic capability. Thus, the dynamic capability perspective is used to develop a theoretical framework for the present research and applied in both the firm-level and project-level empirical examination to understand the activities that enable capability building for frugal innovation within the developed market firm (see Table 2).

2.3. Capability building for Frugal Innovation in emerging market firms

This section reviews the literature on capability building for frugal innovation in emerging markets using the dynamic capability perspective. Because frugal innovation in emerging

markets is still a nascent area of research with limited empirical work (Cunha et al., 2014), there is less scholarly work on capability building for frugal innovation in this context. Consequently, there is less literature to review for the purposes of this research.

This section first identifies the key drivers of frugal innovation within the emerging market context. Next, it uses the dynamic capability perspective to interpret the existing studies on capability building for doing frugal innovation in emerging market firms and identifies the firm activities that enable those capabilities. Understanding the frugal innovation drivers and activities that underpin capabilities for doing frugal innovation in emerging market firms is crucial. Especially because exploring similar activities within developed market firms provides a starting point for analysing the capabilities for frugal innovation within developed market firms. The primary intent is therefore to predict the activities that potentially enable the capabilities necessary to do frugal innovation within developed market firms, to provide guidelines for data collection and analysis.

2.3.1. Drivers of Frugal Innovation in emerging market firms

The studies on frugal innovation reveal that the key drivers of frugal innovation in firms within the emerging markets are cost minimisation and value maximisation from the consumer perspective, thereby providing the solution to an existing problem that is fit for purpose and fit for the socio-economic environment of the emerging market context. A study on frugal innovation capability building by Lim et al. (2013) focuses on innovation practices in emerging markets. The findings reveal that firms are building innovation capabilities through developing low-cost and high-value innovative products and services. Similarly, a study by Juntiwassarakij and Petrick (2011) suggests that the core of the frugal innovation phenomenon within emerging markets has two aspects. First, raw ideas are combined with proven ideas relating to market needs and there is a keen focus on responding to socio-economic necessities with lean-featured products that provide essential functionalities, initially to the local market and potentially to global markets. Second is the combination of raw ideas and proven ideas relating to technology and a strong focus on techno-economic affordance in the form of rich-featured products to enable technological and process enhancement, initially within local markets and potentially for global markets. A recent empirical study by Weyrauch and Herstatt (2016) validates these attributes of frugal innovation within emerging markets and suggests criteria for frugal innovation that differentiate frugal innovation from other types of innovation. The criteria are: 1) substantial cost reduction (from the consumer perspective such as price and cost of ownership); 2) concentration on core functionalities (resulting in reduced complexity and ease

of use without compromising on providing essential functions and benefits); and 3) optimised performance level (such that it meets the intended need and maximises value for the consumer). For innovation to be considered frugal, it must meet all three criteria suggested by these scholars.

Radjou and Prabhu (2015) highlight the two most important activities for developing frugal innovation, namely resource minimisation (natural resources, capital, time) and value maximisation (for consumers, shareholders and society). Similarly, Basu et al. (2013) characterise activities toward cost minimisation and value maximisation as drivers of frugal innovation. They consider these activities have the potential to identify the existing needs of customers. Further, a recent quantitative study by Cai et al. (2019) on the drivers and consequences of frugal innovation within emerging markets reports cost innovation and affordable value innovation as the two dimensions that positively affect the performance of the firm.

Thus, most studies in the frugal innovation literature emphasise cost minimisation and value maximisation from a consumer perspective as the key drivers of frugal innovation in emerging markets (see Table 3). In line with the focus of the present research, these two drivers of frugal innovation are considered a useful context to explore the activities that enable capabilities for doing frugal innovation in developed market firms.

Table 3 Drivers of Frugal Innovation in emerging markets

Authors	Scholarly understanding of the key drivers of Frugal Innovation
Anderson and Markides (2007)	Target the price-sensitive customers of an emerging market with low price products that give value to the customer according to their expectations
P. Ray and Ray (2010)	The resource constrained innovation specifically practised by resource constrained organisations for resource constrained customers, and focusing on architectural innovation to meet the demands of customers with low purchasing power and lacking knowledge and understanding of technology
Prahalad (2012)	Focusing on the 4As: awareness, access, affordability and availability
Zeschky et al. (2011)	Frugal innovation products provide very high customer benefits at a very low cost and price. The essential factors for frugal innovation are affordability, simple design, less features/functionality, low-cost manufacturing and low-cost material, but good enough product innovation to solve the existing problem of a large number of customers
Agarwal and Brem (2012)	Frugal innovation involves designing solutions for low-income market segments with end to end localisation and core value identification

Authors	Scholarly understanding of the key drivers of Frugal Innovation
Tiwari and Herstatt (2012a, p. 98)	"Seek to minimise the use of the material and financial resources in the complete value chain (development, manufacturing, distribution, consumption, and disposal) with the objective of reducing the cost of ownership while fulfilling or even exceeding certain pre-defined criteria of acceptable quality standards."
Radjou, Prabhu, and Ahuja (2012, p. 4)	"An innovative fix; an improvised solution born from ingenuity and cleverness" and "doing more with less".
George et al. (2012, p. 661)	"The development and implementation of new ideas which aspire to create opportunities that enhance social and economic wellbeing for disenfranchised members of society."
Lim et al. (2013, p. 393)	"... resource-saving product for low-income consumers".
Kahle et al. (2013, p. 221)	"Frugal innovations may need to be low-cost; they must nevertheless offer high value to low income customers."
Basu et al. (2013, p. 1)	"Ability to generate considerably more business and social value while significantly reducing the use of scarce resources."
Prabhu and Gupta (2014, p. 3309)	"Frugal innovations in products are vital in developing countries to reach price-sensitive customers that seek robust products at low prices."
Zeschky, Winterhalter, et al. (2014, p. 23)	"Entirely new market-specific solutions that are characterized by high value and at much lower price points than existing solutions."
Soni and Krishnan (2014, p. 31)	"Meeting the desired objective with a good enough, economical means."
Cunha et al. (2014)	Product innovation within the economic condition where affluent customers are scarce, yet which focuses on value maximisation.
Ernst et al. (2014, p. 1)	"Tapping successfully into low-income segments in emerging markets requires the development of new products that meet the low-price expectations while at the same time, offering also values to customers in these segments."
Brem and Wolfram (2014, p. 19)	"A derived management approach, based on jugaad, which focuses on the development, production, and product management of resource-saving products and services for people at the BoP by achieving a sufficient level of taxonomy and avoiding needless costs."
Radjou and Prabhu (2015b, p. 1)	"Ability to generate considerably more business and social value while significantly reducing the use of scarce resources."

Authors	Scholarly understanding of the key drivers of Frugal Innovation
Weyrauch and Herstatt (2016, p. 12)	“Innovations are frugal if they simultaneously meet the criteria substantial cost reduction, concentration on core functionalities, and optimised performance level.”
Rosca et al. (2017, p. 134)	“Frugal innovation is an inclusive approach to innovation that maximises value for customers, shareholders, and society e while significantly reducing the use of financial and natural resources in developing countries.”
(Cai et al., 2019, p. 6)	“Frugal innovation (i.e., cost innovation and affordable value innovation) is positively related to the performance of emerging-market firms.”

2.3.2. Firm-level cost minimisation and value maximisation

This section uses the dynamic capability perspective to review and interpret the underlying activities at the firm level that enable the capabilities for frugal innovation in emerging market firms. The scholarly work on firm-level strategic decision making for frugal innovation in emerging markets that relates to capability building is very limited, meaning this a shorter section as compared to other sections. Although the literature on frugal innovation relating to firm strategies is recent and fragmented (Pisoni et al., 2018), the review identified various firm-level cost minimisation and value maximisation related strategic decisions that enable capabilities for frugal innovation in firms within emerging markets. Most of these strategic decisions relate to managerial decisions such as the framework for strategic innovation, decisions around price control, decisions related to collaboration and knowledge integration with foreign partners, suppliers, distributors and vendors, and other strategic managerial decision around adopting the clean slate approach or new business models. These strategic decisions are discussed in more detail below.

Managers play a key role in a firm’s strategic decisions relating to cost minimisation and value maximisation and in enabling capabilities for frugal innovation. Therefore, top management support, commitment and motivation is crucial to firm-level strategic decision making for frugal innovation (Niroumand et al., 2020). According to frugal innovation scholars, firms doing frugal innovation in emerging markets differ from developed market firms in terms of developing new strategies for three reasons (Anderson & Markides, 2007; Prahalad, 2005). First, unlike developed market firms where the focus is usually on finding new customers, emerging market firms doing frugal innovation instead concentrate on issues of product affordability. Second, developed market firms focus on creating new product features, whereas the focus in emerging markets firms remains adapting existing products to

the customer with few resources or a different cultural background. Third, the emerging market is more inclined towards establishing basic market constituents instead of creating new business models or competing strategies.

Recognising these differences, Anderson and Markides (2007) and Prahalad (2005) have suggested a framework for strategic innovation called the Four As—acceptability, affordability, availability and awareness—which has subsequently been empirically validated by Prahalad (2012). According to the 4As framework, new customers are people to whom the product becomes affordable concerning price. Additionally, the framework suggests a strategic approach concerning acceptability is also crucial and must be customised to ensure price-performance. Further, the product must be culturally acceptable to the customer in terms of their satisfaction. Moreover, the new features of the product are adapted to customer needs so that it is acceptable due to the ease of use, and easy distribution in terms of portability therefore promote availability for consumers who are hard to reach. For example, the literature on frugal innovation within emerging market suggests the lack of infrastructure causes accessibility issues, thereby resulting in unreceptive conditions for distribution and logistics (Anderson & Markides, 2007; Prahalad, 2010, 2012) and creating the need for strategic decision making that overcomes such distribution and logistics barriers. For many large firms, consumers within emerging markets are key to long term growth and profitability (Ananthram & Chan, 2019; Anderson & Markides, 2007; Asakawa et al., 2019; Cai et al., 2019). The final A is for awareness and refers to modes and methods for communicating the product to consumer. Hence, firms practising frugal innovation within emerging markets take various strategic decisions in order to address the awareness and availability gaps, thereby maximising the value of the product with minimised cost.

In sum, Anderson Markides (2007), and Prahalad (2010, 2012) suggest that managers who intend to do frugal innovation must pay attention to all the 4As in their strategic managerial decision making as they potentially facilitate cost minimisation and value maximisation. Aligning with the 4As framework, a recent study by Cai et al., (2019) also suggests that managers need to focus on leveraging institutions that enable capability in emerging market firms to fill the gap left by institutional voids. For the present research, such managerial decisions could serve as a starting guiding step to explore strategic decisions making for frugal innovation within developed market firms.

The literature on frugal innovation capability building within emerging markets also suggests that emerging market firms doing frugal innovation need to strictly enforce their strategic decisions regarding price control (Cai et al., 2019; Kim & Mauborgne, 2000; Lim et

al., 2013). Some scholars argue that it is the strategic decision making around adopting a “clean slate design” approach with no benchmark, coupled with strict cost constraints, that enables the out of the box thinking and imaginative problem solving that result in frugal innovation (Lim et al., 2013; Prahalad, 2012). This can be illustrated by the example of the Tata Nano car, where the project began with three criteria: first, setting the strategic price at the beginning of product development; second, providing value to customers; and third, meeting safety and environmental requirements (Palepu, Anand, & Tahilyani, 2010). Subsequently, the low-cost and price control objective was not only practised in the innovation process, but remained a key strategic decision followed by top management. As a result, every purchased item or design that did not reduce the cost or exceeded it was rejected by top management (Lim et al., 2013). Similarly, Cai et al. (2019) suggest a cost-leadership strategy not only promotes frugal innovation, but also increases the innovation performance as dysfunctional competition increases. Other scholars within the literature of frugal innovation have also considered dramatic changes in price performance (value) as a cost minimisation and value maximisation strategy (Govindarajan & Ramamurti, 2011; Prahalad, 2012). Hence, with regard to the present research, price control strategic decisions could also be relevant for developed market firms doing frugal innovation.

Another approach for capability building identified in the literature on frugal innovation within emerging markets are strategic decisions relating to integration of internal and external knowledge sources for frugal innovation through alliances, partnership and collaboration in order to access local and global knowledge, in particular technological knowledge and capabilities (Agarwal et al., 2019; Dost, Pahi, Magsi, & Umrani, 2019; Lim et al., 2013; S. Ray & Ray, 2011; Shankar & Hanson, n.d.). For instance, Dost et al. (2019) suggest that knowledge integration both internal and external to the firm’s boundaries facilitates frugal innovation. They also suggest that while technological turbulence strengthens the effects of internal and external knowledge sources on frugal innovation, market turbulence, on the other hand, only strengthens the effects of external sources of knowledge. In some instances, a financially stable firm within an emerging market will target a foreign firm possessing the necessary capabilities for acquisition, considering this decision crucial to minimising the cost of building those capabilities from scratch (Lim et al., 2013; Srivastava, 2015). For instance, Malik (2017) suggests acquisition capability along with relational learning capability, market sensing capability, political capability and overall frugal innovation capability are necessary for emerging market firms to enter and be successful in a developed market. Other firms operating in emerging markets take advantage of collaboration between headquarters and subsidiaries

and the supporting role of senior management (Agarwal et al., 2019). Similarly, involving suppliers, distributors and vendors as collaborative partners and including them in the product innovation process from the very early stages of concept development is also considered a critical strategic decision that enables cost minimisation and value maximisation (Lim et al., 2013; S. Ray & Ray, 2011; Tiwari & Herstatt, 2012c; Tiwari et al., 2014; Viswanathan & Sridharan, 2012). Belkadi et al. (2018), for instance, suggest that modular-based frugal product design supports supplier selection and evaluation and the overall network of the supplier. In addition to formal collaboration approaches, Bianchi et al. (2017) suggest that in some contexts such as healthcare, where promoting the relationship between the users and producers of technology is limited to only a few formal mechanisms, a strategic decision towards informal relationships is more effective in generating knowledge that is mostly accidental, and leads to the successful utilisation of users as co-designers. Similar to these collaborations, Prahalad (2012) recommends the strategic decision of collaborating with academic and research institutions, a third party with similar manufacturing experience, non-governmental organisations (NGOs) and the public sector in order to develop successful frugal innovation. Thus, the present research could use similar alliance and collaborative partnership related strategic decisions as a starting point to explore such decisions within developed market firms doing frugal innovation.

Creating a new business model and capabilities or altering an existing business model and capabilities are also considered crucial strategic decisions in the literature of frugal innovation within the emerging markets. For instance, Govindarajan and Trimble (2012a, 2012c) suggest incorporating strategic decisions that encourage an environment of learning, such as providing opportunities for practising new things, as in the clean slate approach. The clean slate approach can be achieved through managerial decisions such as deep immersion into consumer living to get unique insights, distribution and logistics in hostile conditions, use of hybrid technologies, lean management, and deskilling of work that contributes to overall cost minimisation efforts in the new product development process (Prahalad, 2012).

A recent study on business model transformation in a digital enablement context suggests frugal innovation is a good tool for achieving consumer-to-business transformation, particularly in a mass customising business (Lan & Liu, 2017). It is also suggested that the managerial decision around a frugal innovation-based internet strategy can facilitate commercial links for becoming more efficient in the frugal and inclusive dimensions. In sum “frugal innovation is a strategy in which firms are being compelled by cost-conscious and eco-aware consumers, employees, and governments to create offerings that are simultaneously

affordable, sustainable, and of high quality” (Rodríguez & Cunha, 2017, p. 389). For the present research, such decisions provide a potential guideline for exploring similar decisions within developed market firms doing frugal innovation.

In sum, firm-level cost minimisation and value maximisation objectives are achieved through the underlying strategic decision-making activities that enable capabilities for frugal innovation in firms within emerging markets. These strategic decision-making activities relate to managerial approaches such as the “4As” framework, price control, acquisition of firms, the formation of alliances and collaborative partnership, early involvement of suppliers, distributors and vendors, lean management approaches, use of hybrid technologies, and clean slate business models. All these strategic decisions could thus serve as a starting point for exploring strategic decision for frugal innovation in developed market firms.

2.3.3. Process-level cost minimisation and value maximisation

This section uses the dynamic capability perspective to review and interpret the frugal innovation literature on capability building at the process level. Studies of the process level mainly focus on the project level, such as new product development projects, to explore and understand the underlying activities that enable capabilities for frugal innovation in emerging market firms.

The literature on frugal innovation in emerging markets reveals various underlying cost minimisation and value maximisation related activities in the new product development process. These activities are: (1) product design approaches; (2) the developer’s approach towards problem-solving; and (3) knowledge integration and collaborative approaches within the new product development process. The following sub-categories have been identified within knowledge integration and collaboration approaches: (a) integrating knowledge through collaborative partnership; (b) integrating existing technology knowledge; and (c) integrating customer’s knowledge. Following is a detailed discussion of activities underlying the cost minimisation and value maximisation occurring at the process level of frugal innovation in the emerging markets.

1. Product design approaches

Prominent product design approaches identified in the literature of frugal innovation within emerging markets are: modular design or innovation, architectural innovation, design for manufacturability, out of the box design thinking, clean slate design, and combinations of these approaches.

According to Viswanathan and Sridharan (2012), the focus within emerging market firms when designing a frugal innovation product remains on customisation, making it less complicated, easy to use, sustainable, and a design component that can easily be added on to existing products. In that respect, the product design has to be modular to facilitate easy and speedy customisation as per customer needs, incur less maintenance cost, and make components easy to use in other further products (Belkadi et al., 2018; Juntiwassarakij & Petrick, 2011; Niroumand et al., 2020; S. Ray & Ray, 2011). Belkadi et al. (2018) suggest three module categories that can co exist in the same product, and which are accessible from the local product system or from external suppliers. These module categories are: 1) standard modules that can be used without any modification; 2) adaptable modules where some features can be modified to fulfil local requirements; and 3) specific modules that are developed from scratch.

Similarly, architectural innovation is often achieved through changing an existing component, such as by resizing, or changing its material composition or other design parameters in a way that creates a new combination with other components in existing products (S. Ray & Ray, 2011). The innovator often opts for architectural innovation to make different use of existing technologies or to target non-mainstream markets. Architectural innovation therefore becomes a logical low-cost choice for product innovation within firms in emerging markets (S. Ray & Ray, 2011). Consequently, modularity and architectural innovation both enable the capability for frugal product design and cost minimisation. Additionally, design for manufacturing or manufacturability is another design approach that contributes to cost minimisation because it focuses on the material and the design of the products in a way that cuts the cost of manufacturing (Lim et al., 2013).

Incorporating environmental factors (such as the lack of institutions and infrastructure within emerging markets) in the product design approach also facilitates the achievement of value maximisation and contributes in building capability for frugal innovation (Ananthram & Chan, 2019; Bhatti & Ventresca, 2012; Cai et al., 2019; Prahalad, 2012). For example, Viswanathan and Sridharan (2012) suggest that looking beyond infrastructural deficiencies and taking advantage of scarce alternative resources during the product development process contributes to capabilities for frugal innovation. Consequently, the lack of infrastructure can motivate innovators to design a portable, durable, simple and easy to use solution that requires minimum maintenance and distribution cost. Such designs thus reduce the cost of ownership and price, leading to high value for the customer and saving much time and cost in the testing phase of product development.

In sum, product design approaches that enable capabilities for frugal innovation are often achieved through extensive collaboration and integration of knowledge related to technologies, market needs, product design and materials. These collaborative efforts, which are discussed in more detail later within this section, are a possible starting point for conducting the project-level exploration for the present research.

2. Developer approaches towards problem-solving

The developer's approaches towards problem-solving, such as developing a frugal solution, is another key aspect for enabling firms within emerging markets to build their capability for frugal innovation. Some prominent approaches identified in the literature on frugal innovation are: the use of inventive analogies, the developer's attitude towards learning from a completely unfamiliar setting, and holding first-hand experience of customer's need. Explanations of each of the approaches follow.

Tiwari et al. (2014) suggest that some emerging market firms make use of inventive analogies. Inventive analogical transfer refers to the transfer of knowledge gained from experience within one industry domain to another, knowledge transfer within the same industry domain, or knowledge transfer through acquiring a solution from nature—called bionic analogies (Kalogerakis, Lüthje, & Herstatt, 2010). Tiwari et al. (2014) explain inventive analogies using the example of a solution for hernia repairs in which sterilised mosquito netting was used as a substantially lower-cost substitute for expensive commercial meshes. Their findings further suggest that firms doing frugal innovation in emerging markets systematically search for analogies and are open to external knowledge and solutions. One of the main advantages of using inventive analogies is not only to apply existing solutions to new or similar problems, but also the cost minimisation perspective. Benefits arise from making use of already patented technology or an existing design component in a novel way. Thus, the use of inventive analogies not only lowers development costs, but also increases process efficiency, which in turn reduces development time and enables further cost minimisation.

An extremely open orientation to learning from a completely unfamiliar setting is considered another developer approach that enables building capability for doing frugal innovation in emerging markets (Prahalad, 2012; Viswanathan & Sridharan, 2012). Some developers also possess an empathetic orientation that helps in identifying customers' transformational needs and aspiration (Viswanathan & Sridharan, 2012). Additionally, cultural sensitivity is also considered crucial to the approach of the developer team to facilitate in-depth

exploration of contexts outside their own cultural comfort zone (Prahalad, 2012; Viswanathan & Sridharan, 2012).

On the other hand, Tiwari and Herstatt (2014) argue that developers with first-hand experience of customer needs and mindsets in resource-constrained environments are in a better position to design a product that meets the aspirations of potential consumers. They further suggest that frugal innovation developer team members who are living with the same needs and aspirations as their consumers are capable of getting to the roots of their customers' needs, and this is potentially one of the driving forces for building capabilities for doing frugal innovation (Tiwari & Herstatt, 2014a).

In sum, the developer approaches identified in the frugal innovation literature are: the use of inventive analogies, attitudes towards learning from completely unfamiliar settings; and having first-hand experience of customers' needs. For the present research, such developer approaches are considered a crucial starting point for exploring frugal innovation developed market firms.

3. Knowledge integration and collaboration

a. Integrating knowledge through collaborative partners

Collaborative partnerships with suppliers, vendors, and foreign partners, as well as being engaged in global innovation networks are considered another critical approach through which capabilities for frugal innovations are built within emerging market firms (S. Ray & Ray, 2011; Tiwari & Herstatt, 2012c; Viswanathan & Sridharan, 2012).

Studies on Tata Motors, an emerging market automotive, highlight that in their collaborative partnerships with suppliers, they adopted a similar approach to the Japanese tiered supplier system (see for example Clark and Fujimoto (1991)). Tata Motors collaborated with suppliers in close proximity, building strong communication and ties and inviting them to co-create innovation from the early stages based on an approach prioritising “design to cost yet meeting the critically required quality for target customers” (Lim et al., 2013; S. Ray & Ray, 2011). For example, Tata Motors organised early integration of suppliers in the concept design phase and outsourced 85% of component design and manufacturing, 70% of which went to local firms and 30% to foreign firms (Lim et al., 2013; Palepu et al., 2010; S. Ray & Ray, 2011). The bigger supplier firms collaborating with Tata Motors then managed second- and third-level suppliers to reduce component costs (Lim et al., 2013; Palepu et al., 2010). This collaborative network between Tata Motors and its suppliers gave engineers at the supplier end the chance to go beyond their routine work, try new designs and prove their ingenuity. Instead of giving

precise specifications for the components, Tata Motors merely shared the low-cost objective and main design components, such as the two-cylinder engine s (Lim et al., 2013; Palepu et al., 2010; Ray & Kanta Ray, 2011). This approach created a win-win situation for both Tata Motors and its suppliers. Tata Motors achieved a low-cost yet high-value car and new knowledge integrating capabilities, whereas the suppliers gained the opportunity to build new capabilities through the opportunity to design and manufacture new components (Lim et al., 2013). Tata Motors, along with their suppliers, went through several iterations and built several detailed designs before arriving at the final design prototype. Their motives were to facilitate knowledge sharing and integration of suppliers' knowledge relating to design and materials, creating ideas and solving problems together with suppliers, and achieving a high-value product for customers featuring substantial cost reduction and simplicity through eliminating unnecessary frills (Lim et al., 2013; S. Ray & Ray, 2011). Similarly to the above mentioned studies, Šoltés et al. (2018) reports that approaches such as providing full autonomy for design, development and decisions to the development team, establishing a culture of failure and multiple iterations, and strong partnerships and collaboration with stakeholders are crucial to achieving cost minimisation and value maximisation.

Emerging market firms doing frugal innovation also incorporate vendors in the early design phase. This approach can be explicated by going back to the example of Tata Motors. According to Ray and Ray (2011) and Snyder (2008) Tata Motors initiated an early vendor integration program for identifying customer demands, and to collect ideas for lowering the design and manufacturing cost by leveraging, exchanging and sharing knowledge within the network. Ray and Ray (2011) further explain that the early vendor involvement also benefited the suppliers, as some suppliers considered this the main reason for the reduced cost. In addition, early vendor integration enabled a reduction in total product development time through reducing the time for decision making (S. Ray & Ray, 2011; Snyder, 2008). As well as the supplier and vendor involvement in the design phase, ideas imparted through other knowledge sharing activities such as a small group for mechanics on serviceability and an accessibility workshop enabled the lowering of maintenance costs for the Tata Nano car (S. Ray & Ray, 2011).

Apart from supplier and vendor knowledge, firms doing frugal innovation acquire complementary knowledge and human resources from foreign partners to further build on existing technological capabilities and apply innovative technologies within the innovation process (Lim et al., 2013). In addition, emerging market firms also make use of the design and manufacturing knowledge of their foreign partners (S. Ray & Ray, 2011). This is seen in the

example of Bosch Automotive, as described in S. Ray and Ray (2011). Bosch Automotive has strong capability for reengineering, adapting and redesigning mature technologies for new products with less complexity, size and weight. Because Bosch Automotive was a foreign partner of Tata Motors (the example mentioned earlier in this chapter), these capabilities were used in making the Tata Nano car lighter, smaller and simpler. In terms of value maximisation, the knowledge of distributors and vendors about customer needs and demand also enables developers to achieve high value through dramatic changes in price performance, ease of use, accessibility and sustainability (Prahalad, 2012).

For the present research, the above-mentioned knowledge integration and collaboration activities can be used as a starting point to explore these aspects in developed market firms doing frugal innovation.

b. Integrating existing technological knowledge

Combining existing technologies through ingenious reuse of available resources is another approach through which firms within emerging markets are building capability for doing frugal innovation (Prahalad, 2012; Viswanathan & Sridharan, 2012). This approach enables them to solve the problem in hand by creating breakthrough innovations (Prahalad, 2012). Also, re-use of existing technologies or being a technology follower saves on initial costs (J. Wu, 2013; L. Y. Wu, 2010). Prominent ways by which emerging markets firms doing frugal innovation integrate the knowledge from existing technologies are: a new combination of existing technology, a new application of existing technology, and the use of innovation technologies.

The integration of existing technological knowledge is achieved through a new combination of existing technologies to create a new modular product design (Belkadi et al., 2018; S. Ray & Ray, 2011), or through a different application of existing technologies after modifying them in an appropriate manner (Tiwari & Herstatt, 2012b). Such approaches using new combinations and applications of existing technologies imply that frugal innovation often takes advantage of existing ideas, knowledge and experiences, and technologies in various fields (Tiwari & Herstatt, 2014a). To access existing technology and technological knowledge, firms doing frugal innovation in emerging markets collaborate outside the firm to integrate external knowledge and capabilities with firm's internal knowledge and capabilities relating to technology (Lim et al., 2013). As suggested by Tiwari & Herstatt, (2012a, 2012b), frugal innovation is particularly successful when firms are involved in open global innovation networks (OGIN) for collaborative development. The concept of OGIN was introduced by scholars in the field of frugal innovation, who looked into combining the open innovation

paradigm suggested by H. Chesbrough (2003) with global innovation to understand the practices of frugal innovation in emerging market (Prahalad & M. S Krishnan, 2008). “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” (Chesbrough, Vanhaverbeke, & West, 2006, p. vii). Thus, capabilities for doing frugal innovation in emerging markets are best developed through OGINs as the technologies are easily tradable across the globe. Moreover, accessing existing technological knowledge from around the globe saves firms doing frugal innovation from having to reinvent the wheels at a low cost. (Tiwari & Herstatt, 2014a). While integrating existing technology knowledge is considered useful in achieving cost minimisation and value maximisation, of course it needs to be an appropriate technology. Appropriate technology is defined as “technology that is suitable for the socio-economic and geographical context, is environmentally sound and promotes user self-sufficiency” (Molina-Maturano et al., 2020, p. 7). The use of appropriate technology is identified as a crucial factor in the success or failure of frugal product development (Molina-Maturano et al., 2020), and therefore must be considered when integrating existing technological knowledge.

Lim et al. (2013) describe the use of innovation technologies within the new product development process as a means for building capabilities for frugal innovation within emerging markets firms. These innovation technologies are often acquired from foreign partners, through both complementary knowledge and human resources. The term “innovation technology” was introduced by Dodgson et al. (2005), comprising software technology that supports the innovation process of designing, testing and prototyping. Lim et al. (2013) further argue that such innovation technologies have a significant impact on the innovation process as they enable substantial cost reduction in the design and manufacturing process. Once again, the example of the Tata Nano car confirms the truth of this argument in the context of frugal innovation in emerging markets, where substantial cost reduction and good-enough quality is achieved through a continuous cycle of design-build and prototype (Lim et al., 2013). Through innovation technologies, emerging market firms have been able to remove subcomponents that are deemed unnecessary and reduce assembly or machining activities, which minimises manufacturability, in turn minimising material resources and lead time (Lim et al., 2013).

In sum, the activities identified in the frugal innovation literature relating to integrating existing technology knowledge include a new combination of existing technology, a new application of existing technology, and the use of innovation technologies. For the present

research, existing technology knowledge integration and collaboration activities can be used as a starting point to explore similar activities in developed market firms doing frugal innovation.

c. Integrating customer knowledge

Understanding unfamiliar customer needs and aspirations demonstrates good market sensing capability in the innovators of firms within emerging markets, and enables them to design multi-purpose with user-friendliness, flexibility and sustainability (Ansari et al., 2012; Lim et al., 2013; Viswanathan & Sridharan, 2012). Thereby integrating customer knowledge through market sensing includes envisioning unfamiliar usage situations, and consumer or lead user involvement in product design to facilitate value maximisation, both for the developers and consumers of frugal innovation within emerging market (Ansari et al., 2012; Lim et al., 2013; Ramdorai & Herstatt, 2015; Viswanathan & Sridharan, 2012).

Frugal innovation scholars argue that understanding customer needs and envisioning unfamiliar usage situations builds capability within emerging market firms to design a product for multiple purposes (Nakata & Weidner, 2012; Tiwari & Herstatt, 2012a; Viswanathan & Sridharan, 2012). It is easy to identify customer needs. The challenge lies in exploring and designing a product that performs well for alternative usages for which it was not originally designed (Viswanathan & Sridharan, 2012). For instance, the Haier group of China introduced a low-cost, user-friendly and durable washing machine that was originally designed to wash clothes, but was later found being used for washing vegetables and fruit in rural areas (Anderson & Markides, 2007; Nakata & Weidner, 2012). Instead of disapproving such usage, Haier considered it as an opportunity to modify the original washing machine with pipes that would not clog with vegetable peels, and also provided instructions for such usage. Later, Haier also developed a washing machine to make cheese from goat's milk (Anderson & Markides, 2007). Such multi-purpose product design and envisioning of unfamiliar usage within emerging markets is achieved by involving creative and inspiring lead users, and through the imaginative problem-solving ability of developers who are experiencing the same needs as their customers (Tiwari & Herstatt, 2012a; Viswanathan & Sridharan, 2012). Thus, emerging market firms are building capability to do frugal innovation by exploring unexpected customer needs.

According to Viswanathan and Sridharan (2012), consumer involvement within the new product development process occurs to a greater extent in emerging market firms doing frugal innovation as compared to developed market firms. They justify their argument by referring to lead user's feedback in emerging market firms doing frugal innovation, pointing out that within

emerging market firms, some consumers acquire lead user capability through their ability to draw practical insights from an unfamiliar domain through their creativity and imaginative problem-solving approach. Consequently, lead users within emerging market firms (which appreciate user involvement in the new product development process) are not entirely the same as in developed market firms, where lead users typically enjoy greater privilege and access to technology as compared to other consumers (Von Hippel, 1986). Hence, identifying lead users and involving them in market research and the new product development process is identified as a critical new product development capability for doing frugal innovation in emerging markets (Viswanathan & Sridharan, 2012). Additionally, with regard to cost minimisation and value maximisation, the user participation approach is argued as incurring minimal cost and offering greater accuracy of information about customer needs, not only due to lead user feedback, but also through the firm embracing user-created concepts or products (Gassmann, 2006; Hippel, 2001). Šoltés et al. (2018) also suggest that a deep understanding of users and the local market is crucial to achieving cost minimisation and value maximisation. According to Viswanathan and Sridharan (2012), the above mentioned approach of lowering cost through acquiring accurate information about customer needs also holds true for firms within emerging markets doing frugal innovation, suggesting that user participation contributes to building capability for doing frugal innovation within emerging markets

Hence, integrating customer knowledge involves understanding unfamiliar customer needs and aspirations, market sensing, envisioning unfamiliar usage situations, and facilitating consumer or lead user involvement in product design. For the present research, similar customer knowledge integration activities can be used as a starting point to explore market knowledge integrating activities in developed market firms doing frugal innovation.

In sum, process-level cost minimisation and value maximisation objectives substantially contribute to activities that enable capabilities for frugal innovation in firms within emerging markets. In particular, these activities are incorporated in the new product development process as product design approaches, developer approaches towards problem-solving, and approaches to integrating knowledge from collaborative partners, technology knowledge and customer knowledge. This includes knowledge related to the source of materials, modular design, manufacturability and architectural innovation, and suppliers and their tier system. Moreover, knowledge relating to core customer needs and aspirations is sourced from vendors, or through the direct involvement of customers such as lead users. Furthermore, knowledge relating to existing technology that can be reused, or knowledge of innovation technologies that can assist in the innovation process may come from either foreign partners in developed markets, or

through the acquisition of developed market firms. Thus, throughout the innovation process, the main focus remains on the identification of knowledge resources outside the firm and integrating them with the firm's in-house knowledge. The present research will therefore explore these project-level activities as a starting point for exploring the knowledge integration process for frugal innovation in developed market firms.

2.3.4. Implications from Frugal Innovation capability building in emerging markets

The literature on capability building for frugal innovation within emerging market firms shows that capabilities for frugal innovation are manifested in strategic decision making and the integration of knowledge resources to achieve cost minimisation and value maximisation within the new product development process. These implications provide initial guidelines for exploring similar activities for achieving cost minimisation and value maximisation within developed market firms involved in frugal innovation. The findings and conclusions from the literature of frugal innovation in emerging market firms could also hold true in the context of developed market firms, where, even though the infrastructure and institutions are established, resource scarcity is an emerging issue due to various reasons—for example, (1) environmental changes (Radjou & Prabhu, 2015b); (2) managers who may not be fully aware of potential moderate or extreme constraints, such as disaster relief (Viswanathan & Sridharan, 2012); and (3) the growing segment of value for money customers due to economic crisis (Radjou & Prabhu, 2015b). Therefore, it is critical for managers in developed market firms to develop a more in-depth understanding of unpredictable product usage scenarios, focus on local sustainability, and be able to leverage any available infrastructure (Viswanathan & Sridharan, 2012). Firms within developed markets also need to focus on activities that contribute to minimising the use of resources (e.g., financial, natural and time) to minimise cost and maximise value (e.g., customer, shareholder and society) in their normal innovation activities to develop frugal innovation (Radjou & Prabhu, 2015a). Thus, exploring innovation activities that are similar to those utilised by emerging market firms, with a focus on cost minimisation and value maximisation, would provide the grounds for identifying the capabilities required by developed market firms to do frugal innovation.

2.4. Initial theoretical model

Based on the developed theoretical framework, which draws on the dynamic capability perspective, and after using the dynamic capability perspective to review the frugal innovation literature on capability building, the initial theoretical model is illustrated below in Figure 1.

As shown in the illustration, the initial theoretical model includes firm-level strategic decision-making activities and project-level knowledge integration activities as per the dynamic capability perspective. More specifically, the firm-level strategic decision-making activities include entrepreneurial, administrative, and leadership decisions. The project-level knowledge integration activities comprise internal knowledge and external knowledge, whereas external knowledge is further categorised into market knowledge, technology knowledge and stakeholder knowledge.

The initial theoretical model also illustrates the activities that enable frugal innovation within emerging market firms. These activities have been identified by applying the dynamic capability perspective to interpret the literature on capability building for frugal innovation in emerging markets. Consequently, the activities are identified at the firm-level as strategic decisions, and at the project-level as knowledge integration.

Both the activities underpinning dynamic capabilities and the activities enabling frugal innovation within the emerging market are collectively illustrated within the one context, which is the drivers of frugal innovation within emerging markets such as cost minimisation and value maximisation. Finally, all the activities within the aforementioned context are linked to the distinct capabilities built for doing frugal innovation within developed market firms, to use as a guiding point for exploring developed market firms' capabilities for doing frugal innovation.

2.5. Chapter summary

This chapter has developed the theoretical framework to address the main research question for the present research. The dynamic capability perspective has been used to develop the theoretical framework, and also applied to interpreting the literature on capability building for frugal innovation in emerging markets. These theoretical lenses provide guidelines for conducting the data collection and analysis for this research. The theoretical framework implies that an empirical investigation of strategic decision-related activities at the firm level and knowledge integration-related activities at the project level within new product development projects could potentially identify the distinct capabilities for doing frugal innovation within developed market firms, and the underlying activities enabling those capabilities. The

theoretical framework developed to answer the research question also contains the initial theoretical model.

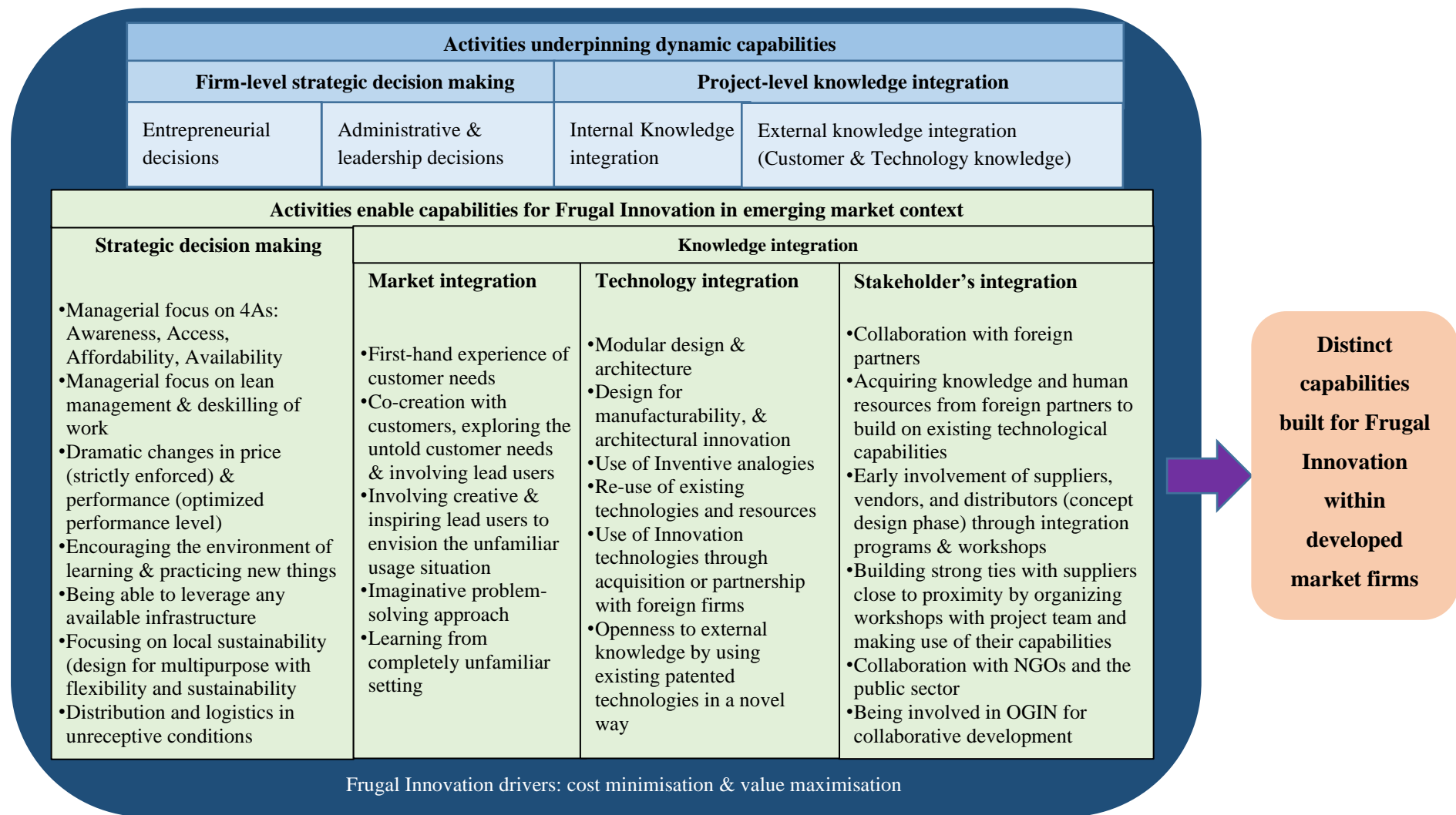


Figure 1 Initial theoretical model

3. Research Methods

The objective of this chapter is to describe the research methods used to answer the articulated research question through the lenses described in the previous chapter. It also aims to present and justify the appropriateness of the chosen approaches for this research.

This chapter is organised as follows. Section 3.1 presents the interpretivist paradigm that informs this research. The study takes the form of a multi-level analysis at the firm level and the project-level. Section 3.2 describes the unit and level of analysis. The unit of analysis is new product development projects within developed market firms (based in a developed market context, in particular the Asia-Pacific Region) with the aim of cost minimisation and value maximisation from the perspective of customers based in an emerging market context (in particular in the Asia-Pacific Region). Section 3.3 explicates the qualitative case study approach as the methodological approach, and section 3.4 details case studies as an appropriate research method. Drawing on four in-depth purposive case studies, section 3.5 presents the criteria for selecting the cases. Section 3.6 details the methods of data collection, which were semi-structured interviews using both current and retrospective approaches triangulated with relevant reports and archival data. The collected data was analysed using thematic analysis, which is explained in section 3.7. Section 3.8 describes how the quality of the research was assessed. Section 3.9 outlines the ethical considerations for the research, followed by section 3.10, which presents a summary of the research.

3.1. Research paradigm

The research is informed by the interpretivist paradigm due to the subjective nature of the phenomenon under inquiry. The interpretivist paradigm is concerned with understanding the nature of the social world at the level of subjective experience and seeks explanations within the research participants' frames of reference (Burrell & Morgan, 1979). Primary in any research design is the fit between the design and the underpinning philosophical paradigm. The reasons justify using an interpretivist paradigm: (1) The nature of the frugal innovation literature, which is nascent and mostly consists of qualitative case studies that are concerned with understanding experiences; (2) A subjective approach is considered the most appropriate in terms of the dynamic capability theoretical lens applied in this research because it captures the nature of competitive advantage in a dynamic context (Ambrosini & Bowman, 2009; Ambrosini et al., 2009; Barney, 2001; Barney, Wright, & Ketchen, 2001); (3) The research

question for the present research addresses the subjective experience of the participants and seeks an explanation of frugal innovation as the phenomenon under inquiry from the participants' perspective. The interpretivist philosophical approach relies on a dialogue with participants to explore and uncover the subjective meaning of their experiences (Creswell, 2014; Rynes & Jr., 2004). Hence, using the interpretivist approach establishes coherence between the phenomenon under inquiry, the theoretical lens used to look into the phenomenon, the research question, and the researcher's worldview.

3.2. Unit and level of analysis

The unit of analysis for the present research is the new product development project, which is an established unit of analysis for understanding the activities that enable capability building (Eisenhardt & Martin, 2000; Iansiti & Clark, 1994; Kashan & Mohannak, 2015; Teece, 2012). More specifically, this research is based the new product development projects of developed market firms that are incorporating frugal innovation-related activities in their normal innovation activities to achieve frugal innovation outcomes.

The present research is conducted at multiple levels of analysis, the firm level and the project level, with the understanding that studying organisational capability mostly involves firm-level analysis, but the analysis of capabilities is performed at the level of project teams (Annique Un, 2001). Scholars in the dynamic capability literature also emphasise the importance and need for multi-level empirical examinations (Salvato & Rerup, 2011; Teece, 2014). The present research therefore considers the multi-level analysis approach appropriate as aligns with the level of theory and facilitates avoiding erroneous conclusions (Klein, Dansereau, & Hall, 1994; Pfeffer, 1982).

3.3. Methodological approach

This research adopts a qualitative research approach. Further to the previous discussion on research paradigms, Burrell and Morgan (1979) highlight the link between the researcher's worldview, the type of research question and the research technique adopted. Additionally, Edmondson and McManus, (2007, p. 1155) emphasise the importance of "methodological fit", defined as the "internal consistency among the elements of the research project", such as the research question, prior work, research design, and contribution to the literature. Based on these scholarly suggestions, a qualitative research approach is considered the most appropriate methodological approach for the present research for various reasons. First, the nascent nature of prior research on frugal innovation, which is mostly made up of exploratory qualitative case

studies, justifies adopting an exploratory qualitative research approach for this research. Second, through the qualitative research approach, this research intends to produce “rich” and “thick” detail that helps in building in-depth understandings around the area of inquiry (Doz, 2011; Dyer & Wilkins, 1991; Eisenhardt & Graebner, 2007; Geertz, 1973). Third, the articulated research question is highly subjective and seeks to understand the participants’ experiences, which can be best addressed through qualitative research (Edmondson & McManus, 2007; Lee, 1999). Fourth, the theoretical framework used to answer the research question also supports the application of a qualitative research approach to explore capability building (Grant & Verona, 2015). The objective of the present research objective is to explain how things happen by connecting abstract ideas to human experience, which is a common goal of the qualitative research approach (Huff, 2009).

3.4. Research method

Within the qualitative research approach, the case study research method is adopted. It is considered the best means of accommodating an interpretivist perspective with its emphasis on interpretation, description, and understanding of subjective experiences (Dyer & Wilkins, 1991; Fitzgerald & Dopson, 2009; Yin, 2014). While case study research has been defined by several scholars (e.g., Creswell, 2014; Eisenhardt, 1989a; Eisenhardt & Graebner, 2007; Yin, 2014), this research follows the definition presented by Creswell (2007, p. 73) which describes the case study as

...a qualitative approach in which the investigator explores a bounded system (a case) or multiple bounded systems (cases) over time, through detailed, in-depth data collection involving multiple sources of information.

Within case study research, a “case” is a bounded entity that could be people, organisations, behavioural conditions, events or other social phenomena (Patton, 2015). In this research, the cases are the new product development projects/products within developed market firms that are incorporating frugal innovation activities into their normal innovation activities.

Using the case studies, this research aims to extend existing theory through in-depth analysis of the nascent phenomenon of frugal innovation from a holistic perspective. There is both a generic reason and specific reason relating to the innovation literature for adopting an in-depth case study approach. In generic terms, the case study method is considered appropriate because it is best applied for describing a process in a real-world context, illustrating a topic descriptively, and enlightening a situation in which intervention has no clear or single outcomes

(Yin, 2014), in this instance new product development practices within developed market firms. More specifically, observing the unobservable, such as the firm activities that enable capability building through which sustainable competitive advantage is acquired, is best explored qualitatively through multiple case studies (Godfrey & Hill, 1995). As discussed earlier, the second reason for adopting the case study method is the research question's orientation towards "how". The case study method will help provide a comprehensive explanation of how (Eisenhardt & Graebner, 2007; Huff, 2009, p. 184; Yin, 2014). Thirdly, the case study research method is considered highly persuasive, thus providing a means to validate the quality of this research (Eisenhardt, 1989a; Eisenhardt & Graebner, 2007). Fourth, the case study method helps understand important contextual conditions (Yin, 2014), which is particularly relevant to this research.

Innovation scholars have long considered the case study research method appropriate for innovation studies (S. L. Brown & Eisenhardt, 1995; Goffin & Mitchell, 2016; Van de Ven & Poole, 1990), and therefore the case study research methods for innovation related studies is considered legitimate by the present research. Further, the phenomenon under enquiry, which is capabilities, has repeatedly been explored by innovation scholars using the qualitative case study method (Danneels, 2011; Godfrey & Hill, 1995; Grant & Verona, 2015; Verona & Ravasi, 2003). For instance, Grant and Verona, (2015, p. 67) argue the "tremendous potential for qualitative case-based research to validate and extend existing theories concerning the development and deployment of organisational capabilities". They further suggest two main benefits of case-based research of organisational capabilities: 1) To gain in-depth insight into the origins and development of capabilities and their relationship to strategy; 2) It allows the exploration of idiosyncratic capabilities, which are, from the RBV perspective, considered very important for conferring sustainable competitive advantage.

Yin (2014) describes three types of case study, namely exploratory, descriptive, and explanatory. This research adopts the exploratory case study approach as it aims to explore new situations. On the other hand, descriptive case studies focus on explaining real-life contexts, whereas explanatory case studies include effects and implementation, therefore neither align with the interests of the present research. Further, a multiple case study design is used in the present research with the aim of allowing an in-depth and comparative case analysis (Yin, 2014). A multiple case study allows the researcher to derive findings and develop themes by comparing and contrasting the cases to identify unique aspects and commonalities across the cases, thus promoting theoretical reflection on the findings (Bryman & Bell, 2011; Eisenhardt, 1989a).

Scholars vary in the number of case studies used in their empirical research. There is the single case study (Siggelkow, 2007), single or multiple cases depending upon the nature of the enquiry (Dyer & Wilkins, 1991), and multiple case studies (Eisenhardt, 1989a). The present research follows Eisenhardt (1989a) to conduct a multiple case study. She suggests that anything less than four cases is unconvincing in terms of developing an in-depth and thick understanding of the field of inquiry. Therefore, a minimum of four cases is considered necessary to achieve the objective of deeper understanding. Consequently, the present research conducts an in-depth analysis of four cases followed by a cross-case analysis, which not only develops a better understanding of the activities that enable capability building for frugal innovation within developed market firms, but also increases the external validity of the case study findings.

3.4.1. Criteria for selecting the cases

This present research adopts “purposive” sampling, which means selecting information-rich cases to study in order to provide maximum illumination on the phenomena under inquiry (Patton, 2015, p. 264). As suggested by Miles and Huberman (1994), sample identification follows the theoretical framework and research question. In particular, extreme cases are identified and selected with the ambition of revealing clear patterns for constructs, variables, and their relationships (Eisenhardt & Graebner, 2007). The case selection is made as per the following criteria:

- The firm has to be within a developed country in the Asia-Pacific region, in particular Australia or New Zealand;
- The firm has to be at least three years old at the time of data collection;
- The innovation has to be a tangible product that may count on services, but is not primarily a service;
- The innovation needs to be addressing an issue and meeting an existing need in one of the less privileged populations of the emerging markets of the Asia-Pacific region, in particular Papua New Guinea, Vanuatu, or Fiji, but not limited to them;
- The innovation has to represent significant cost reduction as compared to an immediate competitor/product substitute (reduction in the price tag, maintenance cost);
- The innovation must focus on core functionalities such as reducing complexity to make it easy to use, yet provide essential functions and benefits that afford high value to the customers;

- The innovation must have an optimised performance level so that it is fit for purpose in the particular socio-economic-cultural environment.

3.4.2. Identifying and approaching firms

As frugal innovation is still rare within the developed market context, identifying firms and convincing them to participate in this research was the most challenging and time-consuming phase of this research. The techniques used to identify and approach firms with potential case projects were:

- Exploring the Internet to identify firms with potential cases;
- Word of mouth approach to identify firms with potential cases;
- Attending industry and scholarly social events, conferences, and seminars;
- The snowballing approach through friends, family members, professional networking events and co-workers;
- Contacting personnel from governmental organisations such as the New Zealand Medical Association (NZMA), Ministry of Business, Innovation and Employment (MBIE), Ministry of Social Development (DSW), and Callaghan Innovation;
- Contacting non-governmental organisations both within New Zealand and Australia and attending their social events;
- Advertising this research and promoting participation through the University of Auckland website and Alumni Newsletter;
- Distributing marketing brochures in conferences; and
- Identifying and contacting researchers at other universities with a similar research interest.

After identifying firms with a potential case project, emails and an access pack were sent out. The access pack included the research information sheet, consent forms for both firm and individual participants, prompting interview questions, the researcher's CV, and a cover letter written particularly for each contacted firm (See Appendix I). The first point of contact in all firms remained the CEO or the managing director (MD). Once the firms with potential case projects were identified, the firms were formally contacted to gauge their willingness to participate. In total, seven firms with potential case projects were identified, of which one firm expressed reluctance to participate in the research without giving any reason. Two firms did not meet the criteria for case selection. The remaining four firms with potential cases met the criteria for case selection and accepted the invitation to participate in the research.

All four selected firms expressed good intentions towards contributing to worthy research work for the benefit of both the developing and developed world, and with potential benefits through publicity for their firm and product. Upon indicating willingness to participate in the research, the CEO/MD of each of the selected firms was asked to sign the organisation consent form. They were then asked a few basic questions to further clarify the identification and appropriateness of the selected case projects and later interviewed for the firm-level study. At this time, they were asked to identify other potential participants within their firm who were currently actively involved in decision making and innovation-related activities and asked to make referrals.

As all four firms are based in the Asia Pacific region, in particular Australia and New Zealand, this facilitated data collection within budget and time limitations. Two of the four firms ('Company C' and 'Company B') are New Zealand based and operate in the medical devices industry. The other two firms are based in Australia, where one operates in the agriculture and solar power industry ('Company D'), and the other in the housing industry ('Company A'). For an overview of the firms, see Table 4. All the selected firms agreed to refer to their innovation product/project directly and reveal the product name as well as the firm name, however, confidentiality is maintained as per ethics document.

Table 4 Overview of developed market firm cases

Selected Firms doing Frugal Innovation in Developed Markets	'Company A'	'Company B'	'Company C'	'Company D'
Foundation	2013	2006	2013	2015
Industry	Housing/ building construction	Medical devices	Medical devices	Agricultural machines & solar power system
Size of frugal innovation product portfolio	4-5 projects/ products	3 projects/ products	1 project/ product	2 projects/ products with solar power systems
Case project	The 'Project A': low-cost houses/buildings made of recyclable plastic waste	The 'Project B': infant incubator	The 'Project C': Anaesthesia Machine	'Project D': agricultural machine with a solar power solution
Number of core team members	<10	>10	<10	<10

Headquarters' location	Brisbane, Australia	Auckland, New Zealand	Christchurch, New Zealand	Sydney, Australia, & Hong Kong
Idea-design-prototype activities location	Australia	New Zealand	New Zealand	Australia
Manufacturing location	Australia & China	India	New Zealand	China

3.4.3. Retrospective approach

The present research incorporated both current (ongoing) and retrospective projects. The retrospective approach was considered appropriate for the present research because it informs the interpretivist philosophical paradigm where the aim is to understand the present through the construction of past reality (Cox & Hassard, 2007). Additionally, as events are rare and occur infrequently, it would be time-consuming to consider only current projects. The retrospective approach has both pros and cons as a qualitative research approach. As suggested by Eisenhardt and Graebner (2007), one pro is that the numbers and depth of the cases can be acquired efficiently, as such an approach mainly relies on interviews and archival data. On the other hand, the associated cons could be forgetting the information or being biased and reporting only successful events for one reason or another (Cox & Hassard, 2007; Eisenhardt & Graebner, 2007; Golden, 1992). However, these disadvantages of the retrospective approach can be converted into advantages by approaching multiple knowledgeable informants per case, ensuring confidentiality, keeping focused on concrete events, and minimising inconvenience (Cox & Hassard, 2007; Eisenhardt & Graebner, 2007; Miller, Cardinal, & Glick, 1997). Additionally, Golden (1997, p. 1215) suggests that “if significant efforts are made to minimise retrospective biases and error, and these data can be validated, retrospective data may well provide unique access to past organisational events”. Following these suggestions, this research conducted interviews with multiple knowledgeable informants from each case by assuring confidentiality where necessary and concentrating on critical issues related to the research question. Moreover, as the topic of the present research was associated with recent frugal innovation activities, the issues around memory lapses may not be a factor. As described, the research selected projects carried out within the preceding last three years.

3.4.4. Methods of data collection

Both primary and secondary data collection techniques were used. According to Eisenhardt (1989a, p. 534), “case studies typically combine data collection methods such as archives,

interviews, questionnaires, and observations”, enabling triangulation that references “multiple observers, theoretical perspectives, sources of data and methodologies” (Bryman & Bell, 2011, p. 412). Data triangulation is highly recommended in the case study research method as it increases the robustness of the research findings (Berg, 2009; Dubois & Gadde, 2002; Miles & Huberman, 1994; Yin, 2014). It also overcomes the critique of qualitative research (that it involves biased values and judgements of the researcher) by building coherence of data, and assisting data trustworthiness, dependability, and credibility through convergence between different sources of data, participant counter checking and having rich and thick descriptions (Creswell, 1994; 2003). Moreover, data from multiple sources supplements and extends the richness of information (Collis & Hussey, 2003; Jick, 1979), and therefore increases the external validity of data collected about the phenomenon under inquiry. In the present research, “data triangulation” was achieved through having multiple sources and the techniques for data collection, which are discussed later in this subsection. A description of the primary and secondary data collection follows.

Data collection occurred in two rounds. The first round was for the purpose of primary data collection, whereas the intention of the second round was to collect fresh data after analysis of the first-round findings for the purpose of cross-validation, and to increase robustness and rigour. The primary data collection was through semi-structured interviews because they are useful for generating information about lived experience and its meanings (Denzin & Lincoln, 2003). Semi-structured interviews are also known as in-depth interviews because they are less rigid than structured interviews and the interviewee has a great deal of leeway in terms of how to reply and express their opinion (Bryman, 2012; Esterberg, 2002). Such an approach helps the researcher in understanding the interviewee’s opinions and views about a particular process. Thus, for the present research, an interview guide containing a list of a few questions for both current and retrospective projects was prepared for the semi-structured interviews. The preparation of the interview guide involved using the theoretical framework developed in the previous chapter to assist the researcher in asking questions specific to the topic, but not limited to it. The semi-structured interview guide was adapted and revised as necessary to gain a better understanding. This approach is flexible yet helpful in getting maximum output within a short time and assisted in identifying patterns (Bryman, 2012).

Data collection was carried out using both a current and retrospective project approach and triangulated with relevant firm reports and archival data. In total, 17 semi-structured interviews were conducted. The interviews were 90–120 minutes in duration. Thirteen interviews were audio recorded and transcribed, and notes taken for the remaining four interviews. All the

interview recordings apart from one were transcribed by an official transcriber provided by the university body. The remaining interview was transcribed by the researcher. After the transcripts were received, they were sent back to participants (who had requested this) for final approval, thus contributing to the internal validity of the data (Yin, 2014). The researcher double checked all the transcripts against the audio recordings for correctness and completeness. The metadata for all the interviews, such as interview date, time, duration, location, interviewee name, and position within the firm, were recorded in an Excel spreadsheet as a part of data collection.

The interview material was complemented with secondary data including from the respective company's website, reports, the company's internal and external documents such as the minutes of meetings, project reports, memos and presentations, published project descriptions, material related to filing IP applications, press releases, press interviews and other relevant videos (Bryman, 2012; Myers, 2013). Additionally, other physical artefacts such as devices, tools, and a system were also considered as useful sources of information, as suggested by Myers (2013).

Data triangulation was used at two specific stages of the data collection. In the first stage, publicly available information about the chosen firm and the case project was gathered to contextualise and triangulate with the data collected via interviews. In the second stage, the interview data was triangulated with other interview related publicly available data, with the firm's internal documents, and with interviews with multiple employees within each firm to verify information gained from participants against multiple sources (Berg, 2009; Bryman and Bell, 2011; Dubois and Gadde, 2002; Miles and Huberman, 1994; Yin, 2014). Data collection was stopped after interviewing everyone who needed to be interviewed, and the revelations obtained from cases became minimal (Eisenhardt, 1989a).

3.4.5. Methods of data analysis

The data analysis for the present research was carried out in an iterative manner, moving to and fro between the literature and associated initial theoretical framework, data, emerging themes, and findings (Eisenhardt, 1989a; Miles & Huberman, 1994). For the data analysis, the primary focus was the framework suggested by Eisenhardt (1989a), which she maintains is a nearly complete roadmap, compared to previous frameworks, for executing qualitative case study research. As such, this approach was considered most effective for analysis of the current case study research. As per Eisenhardt's (1989a) framework, the steps followed for the analysis were: identifying prior constructs, case selection through theoretical sampling, using multiple

data collection methods and sources for triangulation, being flexible and opportunistic in data collection, within-case analysis, cross-case analysis for pattern searching, iterative tabulation and replication, comparison with the literature, and theoretical saturation when possible.

Eisenhardt's (1989a) framework has been further simplified by Miles and Huberman (1994) as a three stages process in the form of: 1) Within-case analysis; 2) Data reduction; and 3) Cross-case analysis. The present research followed this three-stage process and further, conducted a thematic analysis within each of the three stages as suggested by Blanche, Durrheim and Painter (2006), which they describe as a six-phase process: 1) familiarising oneself with the data; 2) generating initial codes; 3) searching for themes; 4) reviewing the themes; 5) defining the naming themes; and 6) producing the report. Other scholars also consider thematic analysis as the foundation of qualitative analysis, describing it as a method for identifying, analysing, and reporting themes within data (Braun & Clarke, 2006). Consequently, the thematic data analysis for the present research was conducted by repeatedly reading through the data to engage in thematising and categorising activities, and to elaborate and interpret data in order to theorise it in novel ways.

During the thematic analyses for this research, the data was thematised using coding, which means “breaking up the data in analytically relevant ways” (Blanche et al., 2006, p. 324). Coding has been described by multiple scholars as an interpretive act. For instance, Miles and Huberman (1994, p. 56) define codes as “tags or labels for assigning meaning to the descriptive or inferential information compiled during a study”. Saldana (2015) also argues that coding is an interpretive act and not a precise science. Similarly, Richards (2005) suggests that analytical coding is central to qualitative inquiry and a first step to opening up meaning. Interpretation and reflection is required to identify emerging themes, or to code existing themes. Thus, for the present research, the coding process was initiated after repeatedly listening to all the interviews and reading the transcripts several times to gain rich familiarity with data. The initial codes in the present research are either taken directly from the text and therefore descriptive (Saldana, 2015), or they are interpretive (Miles & Huberman, 1994).

In the present research, the raw data for each case was coded, organised, and categorised using NVIVO software. NVIVO software facilitated the analysis process in various ways, such as labelling nodes for each case and providing various formats of data storage in nodes, which could then be easily organised and reorganised. Nodes within NVIVO software allow for the organisation and storage of related material or codes in one place and thereby enable categories and subcategories, which facilitates the identification of emerging themes and ideas. In the

present research, nodes were named as per the initial theoretical framework and, where necessary, the themes emerged from the empirical data, both at the firm-level and project-level.

As described earlier in Chapter Two, the present research applies the dynamic capability perspective in developing the theoretical framework. The construct of dynamic capability has been widely used and further developed under the influence of two seminal works, namely Teece and Pisano (1997), and Eisenhardt and Martin (2000). According to Teece (2014) and Teece and Pisano (1997), building capabilities requires abilities such as sensing, seizing and reconfiguring/transforming. On the other hand, Eisenhardt and Martin (2000) consider dynamic capability as a specific and identifiable organisational and strategic process that aims to integrate resources such as strategic decision making, product development routines and alliances, and where managers combine their varied skills and functional background to create profit-generating products or services. While Teece (2014) and Teece and Pisano (1997) have been the subject of critiques for their lack of specificity and precision (Grant & Verona, 2015) and lack of measurables for empirical work (Arend & Bromiley, 2009; Grant & Verona, 2015; Newbert, 2007), the present research has addressed these perceived shortcomings by using Eisenhardt and Martin's (2000) definition of dynamic capability as an identifiable and specific process, a definition that has significantly expanded the applicability of dynamic capability perspective (Peteraf et al., 2013), and which is widely referenced in the literature on product development and innovation (e.g., S. L. Brown & Eisenhardt, 1995; Hisham Hamid Hawass, 2010; Kashan & Mohannak, 2015; Maniak et al., 2014; Marsh & Stock, 2003, 2006; Verona & Ravasi, 2003).

The present research therefore incorporated Eisenhardt and Martin's (2000) definition in building the theoretical framework and applied it in the data analysis to overcome valid critiques of the sensing, seizing and transforming processes suggested by Teece (2007) on the grounds of a lack of measurables, specificity and precision. Additionally, consistency in construct identifiers, and face validity and discriminant validity for this empirical research was achieved through triangulating multiple sources of case data, as suggested by Grant & Verona (2015). Moreover, from the analysis perspective, the present research complements the views of dynamic capability scholars who consider capability building a multi-level process (Eisenhardt & Martin, 2000; Grant & Verona, 2015; Salvato & Rerup, 2011; Teece, 2014; Teece & Pisano, 1997). Hence, the focus of the present research is the firm-level strategic decision making and the underlying project-level knowledge integration related activities that enable capability building.

The nodes for the present research, named as per the initial theoretical framework, are 1) Strategic decision making, and 2) Knowledge integration. The firm-level analysis was conducted by investigating the strategic decision making carried out by the managers, R&D directors, and other similar managerial positions. More specifically, applying the dynamic capability framework, this research analyses decision-making mechanisms and approaches throughout new product development projects in the dimensions of entrepreneurial, administrative, and leadership decisions. Therefore, the strategic decision-making node is further subcategorised as (a) entrepreneurial decisions, and (b) administrative decisions and leadership decisions, as per the initial theoretical framework. Within each of these subcategories, further subcategories were identified from the empirical data and analysis. For instance, entrepreneurial decisions were further subcategorised as (i) prior entrepreneurial experience and capabilities, and (ii) entrepreneurial intent. Similarly, the administrative and leadership decisions are further subcategorised as (i) R&D structure and management decisions, (ii) regulatory & quality decisions, and (iii) IP decisions.

At the project-level, the analysis shifts towards micro processes of knowledge integration within the new product development projects. By applying the dynamic capability framework, the knowledge integration node is subcategorised into (a) external knowledge, and (b) internal knowledge. External knowledge is further subcategorised as (i) market knowledge, (ii) technology knowledge, using the dynamic capability perspective, and (iii) stakeholder knowledge using the literature of frugal innovation within the emerging market context. Based on the empirical data and analysis, the internal knowledge has been further categorised into prior knowledge of innovators along with internal knowledge from previous projects. All the subcategories were analysed according to the pre-identified measures grounded within the dynamic capability perspective, the existing literature on frugal innovation within emerging markets and other potential measures that emerged during the inquiry.

The node-labelling exercise facilitated the coding process by categorising and subcategorising the raw data into nodes. Subsequently, the coding process facilitated the within-case analysis, which involves a “detailed case write-up for each case” (Eisenhardt, 1989a, p. 540). During this process, data from interviews were compared and coupled with data from secondary sources. The within-case analysis allowed intimate and rich familiarity with each case as a separate entity and enabled pattern emergence specific to each case, which ultimately accelerated the cross-case analysis.

The cross-case analysis for the present research was used to identify pattern and themes across the cases (Eisenhardt, 1989a). For this purpose, as suggested by Miles and Huberman

(1994), 13 tactics for generating meaning out of data were applied, such as noting patterns and themes, clustering, making metaphors, and making a comparison, all of which were considered while analysing the data for this research. Eisenhardt (1989a) suggests looking at the data in several divergent ways during cross-case analysis in order to avoid information-processing biases. This research implemented Eisenhardt's (1989a) approach by choosing a category or dimension, either from the existing literature and/or self-selection, and looking for similarities and differences among cases with respect to this category. An iterative tabulation approach was also used to identify similarities and differences across all four cases, which led to reducing and re-naming themes. Once the themes were finalised, final themes were compared with the literature. The objective of cross-case analysis is to go beyond initial impressions and identify results that facilitate theory expansion. Hence, this research used the inductive, interpretivist, theory-driven approach, in which theory provided initial guidelines to conduct the empirical research and predicted a model, which was then validated and modified through the empirical work (Eisenhardt, 1989a; Miles & Huberman, 1994). The aim was to contribute to theory expansion rather than generating new theory.

3.5. Quality of research

To assess the quality of this research, Riege's (2003) techniques for assessing the case study method were applied; specifically, evaluating construct validity through confirmability, internal validity through credibility, external validity through transferability, and reliability through dependability. The present research achieved confirmability using multiple sources of evidence and having the case study reports reviewed by a key informant. Credibility was achieved through the within-case analysis and cross-case pattern matching. The second round of data collection to confirm the first-round findings increased robustness, rigour, and, accordingly, credibility. Additionally, transferability was achieved by using replication logic through multiple case studies. Finally, the dependability of the present research was established through a dependability audit, which involved documenting the process of inquiry and then examining whether the process was understandable, well documented, and unbiased.

3.5.1. Ethical considerations

As the main object of inquiry for this present research is human beings, ethical considerations were therefore of crucial importance (Denzin & Lincoln, 2003). The present research, therefore, incorporates the main elements of ethical concern suggested by Denzin and Lincoln (2003), which are informed consent, the right to privacy, and protection from harm. Extreme

care was taken to avoid violation of any of these ethical concerns. Consequently, all the interviewees signed a consent form for participating in this research, the interviews were recorded only where permission was granted, and all the data collected for this research has been kept secure as per ethics requirements. Apart from these standard ethical concerns, there were no other foreseeable ethical issues, and the ethical application for the present research was duly approved. There were no changes to the study after the approval that needed to be communicated to the ethics committee. All the ethics documents can be found in Appendix I.

3.6. Chapter summary

In summary, the present research adopted the interpretivist qualitative case study approach. By using four purposively selected case studies and the new product development project is the unit of analysis, this study conducted multi-level research at both the firm-level and the project-level. The data collection was carried out in two rounds through semi-structured interviews with both a current and retrospective approach, and the interview data triangulated with relevant reports and archival data. The collected data was analysed through thematic analysis. Overall, the intention of the research is to expand the existing literature and theory on frugal innovation. The next chapter details the within-case analysis.

4. Within-Case Analysis and Findings

This chapter presents the within-case analysis of four in-depth case studies, which provide insight into the frugal innovation activities of developed market firms through their new product development projects. As mentioned in previous chapters, the main objective of the present research is a systematic and in-depth empirical investigation of activities that enable capabilities for frugal innovation in developed market firms, particularly those based in the Asia Pacific region. More specifically, the present research studied purposively sampled case projects within developed market firms based in the Asia Pacific region to explore their strategic decision making at the firm-level and knowledge integration at the project-level. The data collection was carried out based on the initial theoretical framework, which set the groundwork for the case studies and provided the theoretical and empirical bases for the subsequent cross-case analysis.

The case studies as presented here follow a guiding structure to increase comparability and consistency and avoid repetition. However, firm-specific language and characteristics are used to present the participants' experiences and provide reliability and validity for the case findings. Specifically, the cases are presented according to the following structure:

- Company profile
- Frugal innovation project
 - Market research and problem identification
 - Solution and product description
- Activities enabling capabilities for doing Frugal Innovation
 - Firm-level strategic decision making to develop frugal innovation
 - Project-level knowledge integration to develop frugal innovation

Sections 4.1 to 4.4 present each of the four cases and the chapter is summarised in section 4.5. Table 5 summarises the key attributes of the cases.

Table 5 Key attributes of the cases

Selected firms doing Frugal Innovation in developed markets	‘Company A’	‘Company B’	‘Company C’	‘Company D’
Foundation	2013	2006	2013	2015
Industry	Housing/ building construction	Medical devices	Medical devices	Agricultural machines & solar power system
Size of frugal innovation product portfolio	4-5 projects/ products	3 projects/ products	1 project/ product	2 projects/ products with solar power systems
Case project	‘Project A’: Low-cost houses/ buildings made of recyclable plastic waste	The ‘Project B’: Infant incubator	The ‘Project C’: Anaesthesia Machine	‘Project D’: agricultural machine with a solar power solution
Number of core team members	<10	>10	<10	<10
Headquarters location	Brisbane, Australia	Auckland, New Zealand	Christchurch, New Zealand	Sydney, Australia, & Hong Kong
Idea-design-prototype activities location	Australia	New Zealand	New Zealand	Australia
Manufacturing location	Australia & China	India	New Zealand	China

4.1.Case 1: The ‘Project A’

4.1.1. Company profile: ‘Company A’

‘Company A’ is a sustainable social enterprise keen to earn a profit through constructing innovative low-cost houses, schools, medical clinics, and other structures from recyclable plastic waste. Based in Brisbane, Australia, it was founded in 2013, and registered as an Australian company in 2016. The founder is an experienced entrepreneur, innovator, surfer, surfboard shaper, and philanthropist. He is internationally recognised as a member of the surfing community and founder of the world-renowned and successful surfboard brands. As a surfer, the founder had observed the increase in plastic waste in the ocean. Wanting to do something about it, in 2002 he invested in a plastic recycling company, which operated out of Europe. He remained a passive investor until 2009 when the CEO of the company developed cancer and passed away. At the time the founder took over, the company was just about

recycling waste into pallets that were yet to be turned into a product, and therefore lacked positive impact for him. Consequently, he began turning the recycled plastic waste into low-cost deployable houses. In his words:

Every time I tell the story about what we could do, people go wow, that is a social, economic and environmental solution to affordable housing. And, then you start talking about the community and what does that mean to the community.

The founder follows a Philanthro-Capitalist approach, which he describes as “doing well by doing good”; that is, earning profits by offering a solution that makes the world a better place to live. The company therefore seeks to generate a profit by doing good for emerging markets, with any profit then reinvested in R&D activities to make the business sustainable.

The founder said that he had been in marketing all his life and had operated a surfboard company for 30 years. Because he already owned the trademark and the dot com, the founder’s son suggested the using similar name. The name of the company is thus derived from the name of the founder.

The primary objective of ‘Company A’ is to provide a holistic, innovative solution with social, economic, and environmental impact by recycling plastic waste into low cost, yet high value and good quality shelters/buildings for underprivileged populations around the world. The company’s approach is to provide a solution to emerging markets that is fit for purpose and their environment, as outlined on the company’s website:

[name of the company] adopts a grassroots approach to ensure that the needs of individuals and communities are met. This means developing tailor-made solutions based on careful research and assessment. (‘Company A’, n.d.)

‘Company A’’s core team consists of five individuals, all of whom contributed to refining the final product. The formal roles of the core team are the founder, director and head of operations, the lead architect, a marketing person, and a communications person. In addition to the core team, the company has a consortium of experts and enterprises from various sectors and industries. The company has several shareholders, the largest being the founder of the company, followed by the director of ‘Company A’.

‘Company A’ offers an innovative solution for low-cost houses and other structures made from recyclable plastic waste. This solution addresses one of the world’s biggest problems and has received multiple awards (Wright, 2016).

4.1.2. Frugal Innovation case project: The 'Project A'

Market research & problem identification: The problem identification arose from the founder being a surfer, surfing on the best beaches around the world and feeling dismayed at the increase in plastic waste he observed in the ocean. Upon identifying the problem of inadequate and unreliable shelter for emerging markets, especially relevant in cyclone-prone regions such as the Pacific Islands, he came up with the idea of constructing a building out of planks made from recycled plastic waste.

His market research for the idea showed that population growth in emerging markets presented a multi-trillion dollars market for low-cost housing ['Company A' presentation]. At the time a McKinsey housing report estimated that by 2025, around 440 million urban households would occupy inadequate and unsafe housing and estimated the global cost of meeting that demand at USD12 Trillion (The McKinsey Housing Report, 2014). After further market research, the founder discovered that governments in emerging markets were unable to provide adequate safe shelter, particularly in the case of natural disasters, because of scarce public resources and a lack of overall infrastructure. Hence, there was an intense need and demand for providing affordable yet quality shelters to the disadvantaged population of these emerging markets as per their needs and environment.

Later in 2015, the founder witnessed inappropriate solutions to the shelter problem when visiting Vanuatu only three weeks after category five cyclone Pam. According to the founder, "No one had a solution for permanence, for short, mid and long-term permanent housing. The only solution was tents, and those tents are still there". Similarly, the operational director of 'Company A' described the inappropriateness of existing solutions in the following words:

Just about every company out there that supplies low-cost housing to developing markets says here is your western box, go and live in it. And most of the time, people do not want to live in them. They are rubbish houses; they do not sit well within the environment, they do not meet the local people's needs, how they interact as a tribe, a family, a network, a community.

Beyond identifying the limitations of existing solutions, the 'Company A' also identified political challenges. It was difficult to agree deals between the users and the funders. For example, after completing their first project (a school building in Vanuatu), the government wanted to use 'Company A' as their provider of housing. However, the High Commissioner for Australia, the country which funded the project, refused to give the contract to 'Company A' as the company was new. The founder reported that 'Company A' also experienced political barriers in two other countries, describing this as very challenging and disappointing.

The third problem identified by the ‘Company A’ was securing plastic waste to use in the product manufacturing. Initially, the founder was unaware that access to plastic waste was an issue until informed by one of his team—a polymer chemist:

I was told by the polymer chemist, ‘[name of founder], gets your waste streams sorted before you start planning a business’. I said ‘oh, there is plenty of waste in the environment, what are you talking about?’ ‘No [name of the founder], actually a lot of it has already been recycled, and a lot of it goes to landfill, and a lot of it has been controlled by the Mafia, and there is all this stuff, and you will not be able to get the waste you think you can get’.

Moreover, the pickers and scavengers who would sort through rubbish piles for recyclable materials to sell did not pick up that waste because it had no value. Therefore, plastic waste stayed in the landfill or in the ocean.

Despite the issues relating to existing solutions in the market and handling the politics, the ‘Company A’ began their market research, keeping the needs and environment of the target market in mind. According to the lead architect of the ‘Company A’ project, the design process for the ‘Project A’ started with a brief from the founder, which was to make houses for underprivileged populations out of recycled plastic waste. The architect also mentioned that he helped the founder build the brief. He further mentioned that for any ‘Company A’ shelter project, cultural observation and understanding were foremost in developing the brief. He stated, “we will go to the country, and we will think about the landscape and what can we use from the local vernacular, the local skills, have these prefabs, highly sophisticated buildings, belong in the context.”

The lead architect mentioned that as a student he was exposed to different ways of living when he spent six weeks in Bali and Java on a university study tour. He acknowledged this early experience as a key influence when developing a brief for the design. He added:

And as a surfer, and as an architect, I have continued to when I travel places, I try and understand the people, and understand how they live, and I observe things. That is what I do as an architect; it is my interest, to study people and culture.

The second important factor mentioned by the lead architect as helpful in developing a design brief was “cultural observation or understanding”. According to him, cultural observation is more than market research; it is about understanding the needs, environment, and ways of living of different cultures. The third important thing in the brief was that ‘Company A’ wanted housing that felt like it belonged to the place for which it was designed,

in this case Indonesia. Further, the house should be able to be assembled by the local community with limited trade skills and conventional tools, meaning it could be built in the same way as locals built their regular houses. The participant further explained the fourth part of the brief as follows:

The other thing we wanted to do is that it would be obviously contemporary design but not. So, we are not pretending to be a Kampong village home, we are a contemporary modern house, but it has sensitivities to local vernacular, okay. So, we are not copying, but we want to belong.

Finally, the fifth significant part of the brief was to design the house in such a way that it is acceptable and appeals to bureaucrats, government official, or superannuation fund managers, etc. This is because, according to the participant, it would not be the local people in the village who buy the house or choose it. Rather, a governmental official would decide whether or not a 'Project A' would be built in a village. The lead architect explained it in the following words: "A home that would appeal to the corporate decision-makers, and it would look culturally consistent, or let us say it looked like it belongs in the context of a village into which it is going." Similarly, when the founder was asked about how he identified the shelter problem and how he identified the needs of the community and the environment, he gave the example of their Vanuatu project:

We did our initial research, we took our architect with us, and one architect said I will not design you a house unless I live with the people unless I understand the people. So that is our mandate that is what we do.

The founder further explained that in another project, they were designing for an indigenous community up in the Northern Territory of Australia. The 'Company A' team went to the community and sat with the elders, had a conversation with them, and proposed the 'Project A' to which the response was— "it is fantastic". The community admired the 'Project A', saying it was not like the typical house that the Australian Government wanted to give them, which is a "Donga" (the white man's house). The community still wanted a white man's house, but with the flavour of their own culture. 'Company A' took a similar approach for a project in Mexico, the founder said:

In Mexico, we had to understand what they wanted, and now we are talking flat roof, box, side by side housing. That is what they want; they do not want a community of individual little buildings, houses.

Solution and product description: In 2013, while the founder was on a surfing trip to Bali, Indonesia, friends there told him the Indonesian government was planning to handle the shelter crises in the Island of Lombok in Indonesia. It was then the idea of making low-cost, reliable, and good quality shelters sparked in his mind. As he mentioned in his interview, he had never been involved in the housing industry before this thought came to him. However, being a visionary, he could see much potential in it, both from the perspective of cleaning the environment and providing good quality, affordable shelter to the disadvantaged populations of the world. As he put it:

The fact that I was involved in the environment all of my life, and I was so upset by what I'd seen, and realised that if we could find a solution that every house would take a very large volume of plastic waste, so two to three ton of plastic waste per house, then I went whoa, hang on, how much waste is there in the environment globally? Would it be possible if we used all waste and turned it into the shelter? And if we were able to do that would there be enough plastic waste on the planet to build enough houses, and in fact, there is not (laugh). There is not enough, so it made me think, that was a very macro picture, a very grandiose, altruistic perspective. Sometimes you have to go to the top of the pyramid and go hang on, what could happen if we pulled this off.

Being unfamiliar with the housing industry, he hired the best architects and engineers in Sydney to come up with a model of a house that met the needs of the government of Indonesia, the community that was supposed to live in it, and the environment in which the house would be built. The founder and his team also did extensive market research and came to the realisation that the house needed to be tailor-made for a given region and community.

Consequently, the 'Project A' was constructed with planks made from recyclable plastic. They also designed the structure to be affordable, modular and customisable, and to be risk-free with no health issues, have no or very low maintenance costs, to burn very slow as compared to hardwood, to survive a category five cyclone, and to be easy and quick to deploy (such as within three to five days). Their planning also incorporated solar power, sanitation, and freshwater solutions for remote communities.

Involving the community gave them a feeling of pride and ownership, and 'Project A' achieved acceptance from the government, landowners, and the community as a result. 'Project A', hence, possessed all the attributes of an ingenious frugal innovation solution as an affordable, holistic, innovative solution with social, economic, and environmental impact through turning recyclable plastic waste into low-cost yet high-value and good enough quality shelters/buildings for underprivileged populations around the world. When asked about the

specification for the design, the director of the ‘Company A’ said:

So I guess what we’re really big on here as a ‘Company A’nd our end vision is we want to, and which is where [named the leading architect] comes in very handy, is actually designing a house that suits the local requirements, cultural needs, religious beliefs, sits well within the topography of the area, and actually sits in the environment like it’s meant to be there.

Following the broad specifications given by the founder, within six months of the birth of the ‘Project A’ idea, the ‘Project A’ team of architects and engineers came up with a design and 3D-printed model of a house. Similarly, to the founder, when the lead architect was asked how he came up with the idea of the house, and in particular the design for the plastic panels with which the house would be built, he said his ideas often come from places in between work and play. He recalled a workshop in Sydney where they were brainstorming ideas for the house and facing many problems. Feeling overwhelmed, he suggested taking a break and going for a surf. According to the lead architect:

Most people involved in the [‘Project A’] are surfers. [...] And so, I said how about we take a break and go for a surf? And we did, and we had a lovely time. [...]. Getting ready to go back to work having just played, in between work and play, I cracked the idea that we could design a profile from one die that could probably interlock and be a wall. It could be a louvre, and it could also be a roof, and it could also be a floor. And that’s what the F1 panel is.

Hence, the first ‘Project A’ panel, named the F1 panel, was designed. Other participants from the ‘Company A’ confirmed this story. While explaining the design process for the F1 panel, the lead architect said that first he tried to understand the key elements common to vernacular Indonesian houses. He explained that as per his cultural observation and understanding of such houses in Lombok Island, Indonesia (mentioned previously), there are posts and beams. The infill panel between the posts of a vernacular Indonesian home is woven bamboo. There is a hierarchy of elements. First come the posts, followed by a frame to hold the panels, and then there are sub-frames. The final element is weaving. Subsequently, the F1 has four layers that play with light and shade, and all of this is just about the walls. The F1 was thus designed to be an infill panel between posts, which are placed at a distance of around 2.5 metres in a common Indonesian house. As the lead architect said:

It does not really matter the dimension, it's the principle. You look at the essence of the beauty of a vernacular house, and you seek to resonate with that. Now where does that beauty come from, it comes from light and shade, that tonality.

The lead architect also explained that the F1 panel is designed in such a way that it contains hollows. The reason for the hollows is to stiffen and lighten the panel, and to reduce material usage. Other key design elements considered in the design process were making the house category five cyclone resistant. To add that level of strength, they made ribs on the F1 panel, which also cast shadows to keep the inside of the house cool. The lines also create a visual indentation, whose primary function is to play with light and shade. However, they are also used to help hide the joints, such that the joints between panels will look tidy whether open or shut. This aspect of design was incorporated in an attempt to make the house look modern, clean, and contemporary. The lines in the panels were designed so they could be cut accurately and attached easily, thereby facilitating manufacturing and making modification easier. Additionally, the founder explained that there are no health issues associated with the material. Further, it is even more fire retardant than hardwood.

4.1.3. Activities enabling capabilities for doing Frugal Innovation

4.1.3.1. Firm-level strategic decision-making to develop Frugal Innovation

The strategic decision of forming a virtual and flat R&D structure: 'Company A' operates as a virtual social enterprise and does not have onsite working arrangements. Its organisational structure is composed of distributed team members based in various locations who have multiple roles. The company collaborates virtually with experts and other companies on fixed-term bases to acquire particular knowledge and expertise; therefore, it does not need to recruit its employees for the long term. The objective of virtual fixed, and virtual ad hoc R&D is twofold: (1) Hiring the best people in their field whose values and beliefs align with the objectives of 'Company A'; (2) Avoiding the higher cost of recruitment and high salaries.

The founder of 'Company A' mentioned that all these experts and consortium partners play a critical role in R&D as integrating their knowledge has enabled the development of 'Project A' as a holistic plug-and-play solution. Similarly, the director of 'Company A' explained the virtual R&D activities as follows:

The design activities are happening all over the world. I mean [name of the architect] is in Sydney, all of the new R&D is in Kentucky in the US, you know, so there's a lot of different places.

As indicated earlier by the example of the Sydney workshop, 'Company A' members conduct meetings and workshops if trying to solve a particular design, material or other 'Project A' related issue. The lead architect also mentioned that such activities are rarely done well over Skype, and therefore he saw conducting face-to-face workshops and meetings as crucial to solving problems by bringing various experts altogether. However, he acknowledged that because the consortium members and foreign partners involved in R&D were located in various locations, they do have Skype meetings, but getting to know each other first face-to-face helped deal with the challenges of virtual collaboration. On the other hand, the director of 'Company A' mentioned communication by video, Skype call, or email as good means of communication. He also added that he does most of the communication through Skype and considered it his preferred mode of communication. For him, the only challenge was trying to fit in with the time zones of collaborative partners in other parts of the world.

The strategic decision around quality control by approaching a manufacturer with ISO 13485/FDA approval/CE Mark accreditation & in-house capability: One critical strategic decision that has led to the success of 'Project A' is complying with the quality standards for buildings at the lowest cost and time. When the founder was asked about complying with quality standards, he said:

We finalised the Australian building codes, but the frame of the house, the construction of the house already meets Australian building codes. The builds themselves just have a bit more testing to do with category five wind impact and things like that.

The founder further mentioned that because 'Project A' is a demountable house, it does not have to meet more stringent building codes around the world, but it still has to meet other types of quality and sustainability standard, and for that 'Project A' has an expert whose main focus is this task. To cope with the cost and time needed for complying with quality and design standards, 'Company A' also took the strategic decision of identifying and approaching architects and manufacturers who already possessed certification for such standards. For example, they approached a company in the US for R&D work and involved architects who had prior experience in low-cost house design and who possessed the in-house capability to design similar projects.

The director of 'Company A' mentioned another strategic decision to maintain absolute integrity, quality and sustainability. They chose to have a special advisor on the Board of Directors who was also a member of an ethics and sustainability committee. Explaining the pivotal role of the ethics and sustainability committee from the perspective of quality assurance, the director said:

So, their roles will be to make sure that companies we are dealing with the fit, basically abide within our mantra, our business model that they are not operating in a negative manner as a business, they are not employing slave labour or miners or things like that.

The strategic decision around acquiring intellectual property: A strategic decision that, according to the founder, could potentially be beneficial for 'Company A' in the long run is to acquire a patent for the F1 panel. The lead architect further explained that anything he draws has copyright, which is the nature of the architectural business. However, the 'Project A' design is about more than just copyright. He further explained that in the building and design industry, having a patent is unusual, adding:

The design IP is not really that relevant because in my industry someone is just got to change the design a little bit and we cannot do anything, okay? They can copy it by just changing it a little bit, yeah, so protection has limited value unless you plan to defend it in court. The best protection is to keep developing your ideas, so you are ahead of those who copy.

However, the lead architect mentioned that the material for 'Project A' does have an IP. The operational director also said, "we do have IP in that panel. It is quite hard to prove, and it is costly to maintain patents or to register for patents." He further mentioned that even if they consider a patent, at the end of the day, countries like China will copy and produce whatever they want to produce regardless of patents. Therefore, 'Company A' is looking for ways through which the design can be physically defined and protected from imitations and copies. When the founder of 'Company A' was asked if he had any patents on 'Project A', he responded:

Yes and no, the panels for ['Project A'] are wood plastic composite panels. They are a particular design that is unique to ['Project A'] but it is not patented, and we are not worried about that. Let me make something very clear, I'm not worried at all about competition. [...] the size of the market is 250 million houses, you know, so it does not

matter if people copy what we are doing. Without investors, because it is a full profit company, keep in mind what we are doing is Philanthro-Capitalism.

He further mentioned that it does make sense to have patents for being sustainable in business as they are not into charity. However, he also said that if they can provide a solution that is competitive in certain markets, and they then make houses within those markets and clean up the environment while making a profit from doing that, then they are going to be a sustainable business.

Strategic decision of keeping control over project: The strategic decision around keeping control of ‘Company A’ was achieved by creating a shareholder base with similar interests. According to the director of ‘Company A’,

And we have even tried to maintain that through our whole shareholder base too, making sure that people that had invested in the company, probably 90 to 95 per cent of our investors are all family, network and friends, and people that have an interest in what we are trying to achieve. Not investing in it because they expect a return, investing in it because they believe in the concept and the project, and they want to help in doing something good.

Therefore, regarding shares, the founder of the ‘Company A’ has the highest shareholding, followed by the operational director. So, counting the fund managers’ shares, the ‘Company A’ hold a controlling vote. The operational director mentioned that one the biggest concern of setting up the funds for ‘Company A’ was maintaining control. He further emphasised the importance of owning management shares to them to override decisions they are not happy with and to make sure things go the way they need them to go. To him all of this means keeping control of ‘Company A’ and its decisions:

[...] and that has been I guess our number one thing is a) it’s always protected investor’s interests, people that have funded the [‘Company A’] and helped us get where we are, and b) always making sure that we have not sold out and we have maintained control.

The founder of ‘Company A’ also commented that for him to grow his company organically requires a massive balance sheet to make it work and for that he would need to sell his company to a venture capital group. However, he does not want to do because he does not want to lose control.

Strategic decision for developing an innovative business model and holistic solution:

Developing an innovative business model and a holistic solution instead of just a house remained the most important strategic decision for the success of ‘Company A’. This decision has also served as a key and inspirational marketing approach that has made funding acquisition, and convincing the public, and private intermediaries a lot easier.

While speaking further about ‘Project A’ as a holistic solution, the founder said that ‘Project A’ is all about their overall approach to the community. First, the community should produce things such as agriculture that can be packaged by ‘Company A’ marketing and media sold around the world. The second aspect is that globally industry is shrinking back and becoming smaller and more local. He further said that everything within ‘Project A’ should be what he termed a plug-and-play solution. He explained this with several examples, such as providing a solar solution for minimal electricity needs like lighting or charging mobile phones, and on a larger scale, such as for a medical clinic, refrigeration and air conditioning. He explained that their solutions can scale up to the needs and wants of the community. He exemplified the holistic solution through their sanitation system:

We can provide a solution that will just go, you know, straight out of the house into a bio-digestive system, and then from that straight out into the garden. [...] So they are all simple solutions that are cost-effective. People are doing this all over the world; we are not doing anything different to what other people are doing. And that is what I said before about [‘Project A’] being one solution which attracts all of these great solutions.

He mentioned that to make ‘Project A’ a holistic solution with social, economic, and environmental impact, the ‘Company A’ has involved consortium partners from all over the world. He gave the example of a chemical company that is making a product with anti-mosquito (which carry malaria) and other insect properties to be added to the molecular structure of the F1 panel. Putting it all together the founder said, “So, the master plan will include the whole facility which will be; I think I said earlier, waste management, manufacturing, energy display, education, micro-economies etc.”

The operational director of ‘Company A’ also explained that the holistic nature of the ‘Project A’ solution is towards cleaning up the planet and using as much recycled material as possible, while providing a house that is suitable both for its environment and its people. He further said,

[‘Company A’] has a vision of like this whole closed loop community where we are not just going in providing a house, we are going in providing water, sanitation, jobs, the whole lot, and everything can be totally off the grid.

Regarding the business model for ‘Company A’, the founder said, “[...] that is one of the micro-economies that we want to introduce”. He further said that the ‘Company A’ is focusing on developing an innovative business model and does not want to continue using third-party manufacturing, third-party manufacturing had served as a good starting point for ‘Company A’. Similarly, the operational director mentioned that in the near future, ‘Company A’ was going to set up its own manufacturing facility in the Gold Coast, Australia. It will serve as a physical model for duplication in other countries, thus stimulating employment at the same time as people are cleaning up their own country and environment. The lead architect summed up the holistic solution perspective of ‘Company A’ and its business model as follows:

Our vision is to collect all our waste, have our own factories, make our own panels from way more than one or two polymers, that is why we are talking to CET. And have our own factories, and also for those factories, they will be containerised so that we can send them to countries and they can clean up their waste, put it in that factory and make their houses.

Strategic decision of developing a customisable and scalable solution: Making the solution modular, customisable, and subsequently scalable is another important strategic decision that has enabled ‘Project A’ to be marketed both in emerging and developed markets. As the founder put it:

We as a company, our main focus is to keep everything simple and make it scalable up in volume, but not in size, just in volume. So, we can scale our manufacturing facilities; we can scale our energy and micro-economy type scenarios. We can just scale up all these little things, and that is where there’s going to be major impacts in developing nations for people, and bring them out of poverty, because they can stay in their village.

The operational director of ‘Company A’ also noted that customisability is crucial to meeting the diverse needs of emerging markets. As an example, he said that a timber structure for South Pacific markets would be well received within their communities, even though a little more expensive. However, these timber structures could not be sold to the very bottom-end markets such as within Indonesia and the Philippines. He added that the technology they were

using allowed them to build customised houses, as they had recently built houses in Mexico which were entirely different in design from the ones they build Vanuatu.

The lead architect also emphasised the importance of the customisable design of the ‘Project A’, with options for both single-layer cladding and double layer cladding depending upon the climate. The design also incorporates an exterior that matches with the cultural aspects and local vernacular, whereas the inside layer can be any insulating layer. Moreover, in other local vernacular houses, they might need an insulated layer both inside and out. He continued, saying “that is the systems we are developing with [name of the architect]. You can put two different layers together, and they clip together, they do not screw, they clip.” He also explained that customisability is not only important to make the house fit well with the local vernacular and culture, but also to win the contracts from the bureaucrats by making the house fit their expectations:

So, there are two different things (emphasis). So, they are the things that we agreed to do, 1. to make a home that would appeal to the bureaucrats, and I do not mean that in a negative way. A home that would appeal to the corporate decision-makers, and 2. It would look culturally consistent, or let’s say it looked like it belongs in the context of a village into which it is going.

All the participants from the ‘Company A’ said they foresee plenty of opportunities and huge market potential for ‘Project A’, both in developed markets and emerging markets.

Strategic decision of adopting the Philanthro-Capitalist approach: Adopting an approach called philanthro-capitalism has been one of the most critical strategic decisions for ‘Company A’. The founder’s vision is based on the Philanthro-Capitalist approach, which he describes as “doing well by doing good” to earn profits by offering a solution that makes the world a better place to live. The term philanthro-capitalist is derived from two words: 1) philanthropy, which is the humanitarian act of helping other people or the environment; and 2) capitalism, which is about adding value and making profit. ‘Company A’ has a vision of working hand-in-hand with both capitalism and philanthropy. The company therefore seeks to generate profit by doing good for emerging markets, with any profit reinvested in R&D activities to make the business sustainable. According to the founder,

It is a very profitable company. Now people would say oh but you are making houses for the poor; you should not be making a profit. That’s not true. [name of a person] said to me, “I am sick of writing cheques to unsustainable companies providing an unsustainable

solution. Well done [‘Company A’], this is a fantastic solution because it solves our problem.”

The operational director of ‘Company A’ explained that he previously had a very successful business of his own, but there was no inner satisfaction. He said, “I wanted to get involved in something where I could make a difference, improve people’s lives. And then [‘Company A’] came along, and it was just like wow, this is it.” He also mentioned that while he had invested money in ‘Company A’, he did not join ‘Company A’ for the money, but to ‘make a difference’ as he put it:

[...] it is all in the aim of doing something so good that is so needed. And I mean I got involved in it to do something good, not to make money. [...] I got involved because I wanted to make a difference.

The operational director further illustrated the philanthro-capitalist and sustainable nature of ‘Project A’ through the example of the [name of the fund] fund. He explained that one of the reasons for setting up [name of the fund] fund was to acquire a charitable fund where 10% of the profit from investments would go toward deliver projects that do not require any paid donor money. This strategy fits with the company’s Philanthro-Capitalist approach. As the operational director said, “It [name of the fund] is a big part of our business plan, you know, it is the whole doing well by doing good is I guess why they call it philanthro-capitalism, you know”. He further explained,

I mean our end goal isn’t to be, you know, be multi-billion-dollar company rolling in profits. Our end goal is to provide housing for those who need it. So, if we can do that and make a profit, and put some money back or some profits back into doing more good, then it is a win-win for everybody. And obviously cleaning up the Earth while we are doing it.

The lead architect also explained that for him, being a part of ‘Project A’ was entirely to achieve his aspirations for helping people in need and cleaning up the environment. He further said that his contribution to ‘Project A’ and its overarching objective was not just about being involved in design and architecture activities, but also to educate and raise awareness among people. He acknowledged that his lifelong experience of working in remote and indigenous communities had given him an education about the importance of understanding the people for whom ‘Company A’ wants to build houses, including their culture, context and climate.

Strategic decision of adopting a “Moral Strategy”: Adopting a moral strategy has been important in terms of acquiring skills and services or convincing others to work with ‘Company A’ for free or at a reduced cost. As explained by the participants, a moral strategy is a strategy to convince other to become involved in a project like ‘Project A’ to be seen good. Participants used the terms “inspired networking” and “inspired publicity”. Using his experience as an entrepreneur with a vast network, the founder said inspired networking made it easier to get on board movie stars such as Jane Smith, Will Smith, Margaret Covey, and Adam Scott. For him, their involvement had two benefits. On one hand, they got to be involved in a good cause, and on the other, ‘Project A’ got massive publicity because of their involvement. He further commented that ‘Project A’ itself is a very inspiring story, and whoever hears of it becomes enamoured.

The founder also explained that it was this aspirational attraction to the story that inspired people from Luxemburg to get involved in ‘Company A’. They then invited the founder to speak in London at the Aleze event, an annual event for fund managers around the world. As a result, the whole financial vehicle for ‘Company A’ was established. Similarly, many of the consortium partners, including firms and expert individuals, offered free or discounted services to ‘Company A’ because of the inspiring publicity. According to the operational director of ‘Company A’:

A lot of people have helped out, and either haven’t charged or haven’t charged a lot for their time. You know, everybody believes in the project. When you speak to [name of the founder] or anybody about the project, everybody is like wow that is amazing, and people just fall in love with it. Moreover, I guess our overall vision of what we want to achieve is such an amazing thing, so you do find a lot of people that are getting involved or have been involved in the past.

The operational director of the ‘Company A’ also gave some examples, such as the Australian supplier and R&D collaborator, who got involved in the ‘Project A’ purely for philanthropic reasons. He mentioned that collaborators also help financially by funding part of the R&D work, which minimises time and finances compared to ‘Company A’ being involved in long-term commercial relationship. Additionally, he stated that some good friends of the founder also contributed to the ‘Project A’ because they wanted to help achieve their friend’s vision and believed in what he was doing. Apart from free and discounted services, the operational director mentioned that some people still charge an exorbitant fee, but they wanted to be involved to be seen to be doing good. On the other hand, there were a few people that committed time and were gifted equity in the company instead of money. The operational

director explained that the objective of the inspired networking and publicity is not just to expand ‘Company A’, but to build a brand:

We have been trying to build a brand, not just a product or a company. We want anyone to think, as soon as they think of disaster relief or low-cost housing or anything, we want to be the [‘Project A’] that everybody thinks about immediately. We want to be the sort to market that actually makes a difference globally.

Another crucial aspect of the moral strategy and inspired publicity mentioned by all the participants is to identify and involve people with a similar mind-set. For instance, the operational director commented that while employing people and building a team, it is crucial to make sure that the people engaging with and working in the ‘Company A’ are the right cultural fit and share the same values and beliefs. He said:

So I think from that a huge lesson is really researching and doing your due diligence, and making sure that the people that are aligning with you or even working with you, and that goes down to even engaging consultants and other people that you’re engaging to get to where you need to be, really make sure that their values align with yours and what you’re trying to achieve, what your end goal is, and what your objective is.

Entrepreneurial capabilities: Some of the most critical capabilities essential to coming up with a holistic solution like ‘Project A’ are the entrepreneurial capabilities of the founder and managers. The ‘Company A’ founder’s entrepreneurial capabilities are evident in his decision to become involved in both recycling waste and low-cost housing, as both these activities were entirely new to him and he had no prior knowledge or experience in these areas. However, his philanthropic drive, and openness to external knowledge and ideas outside of his domain enabled him to achieve ‘Project A’. As he said, “I did not know anything about the set of codes of plastic. I had to learn all of that.”

The founder acknowledged his own instinctive entrepreneurial capabilities, but also admired his team, saying he had a team of very passionate people and considered team capabilities to be as crucial as those of the founder. He further said that it is important for an entrepreneur to not only be optimistic and passionate about his/her venture, but also aware of their limitations to avoid disappointments. He said, “I am the optimist, and I need that. So, when you are an entrepreneur, you really must understand your limitations, and I know what my limitations and risks are.”

The founder further explained that one of the essential factors leading to the success of 'Company A' has been the social and environmental drive behind the company. According to him, the more he became involved in the 'Project A' and understood its impact on the environment and the provision of affordable housing and structures, the more he grew passionate about it. Similarly, all the participant mentioned that perseverance is crucial in projects like 'Project A'.

The operational director of 'Company A' explicitly mentioned that the founder's prior experience in the surf industry and vast exposure and global network enabled them to connect with experts around the world and was a critical factor in the success of 'Company A'. He also admired the founder's entrepreneurial capabilities. Further, all the participants agreed the founder having a pre-established brand name brought success, growth, and quick market exposure to the 'Company A'. The operational director highlighted persistence and not quitting very quickly as essential. He added this is only possible if not only the founder but the team as a whole are willing to make a difference. He further said that people often quit when they are very close to success. However, having a founder with a vision and a team with a similar passion for making a difference can lead to success, but this is easier said than done:

With us as a company, we have cost ourselves a lot of grief, and loss of time and money due to having people involved in the business that, although they portrayed to be the right type of people, they were not. And they were sort of greedy, self-centred, were more interested in themselves than actually making a difference.

The lead architect also explained that in virtually distributed projects like 'Project A', where people from diverse areas and expertise are involved and do not know each other, it is essential to have people management skills. He appreciated these skills in the founder and admitted that he had learned such skills by being involved in 'Project A'.

In sum, 'Company A's firm-level strategic decisions to achieve cost minimisation and value maximisation and to develop frugal innovation included forming virtual-fixed rather than long-term relationships with experts and other companies, virtual adhoc R&D management, a flat R&D structure, quality control by approaching manufacturers that were already complying to first-world quality standards and possessed similar project manufacturing capability, acquiring intellectual property for profitability, keeping control over the project by holding maximum shares, developing an innovative business model through holistic solutions, developing customisable and scalable solutions, adopting inspired publicity for onboarding stakeholders, adopting a Philanthro-Capitalist approach, and possessing vast entrepreneurial experience and capabilities.

4.1.3.2. Project-level knowledge integration to develop Frugal Innovation

Integrating the developer's existing knowledge and experiences: 'Company A's core team knowledge was one major contributing factor in the successful development of 'Project A'. 'Company A's founder, operational director, and other core team members had many years prior experience, which enabled them to achieve a high quality and low-cost innovation for emerging markets.

The founder of 'Company A' emphasised the importance of the background of team members in the success of any project, and in particular the relevance of the prior knowledge and experience of the team members to a specific project. He further said that although he has spent his whole life in business and remained a successful entrepreneur, he still needs people with the expertise he lacks:

Well it started off obviously with me with a vision, and I am not a detail person, I am a big thinker. That does not mean I'm not smart, that is just my personality. And because I'm not a detail person I know my limitations, so I need to get detail people around me to handball the idea to other people.

Further, admired his team's potential, including that of his brother who played a crucial role in the success of the 'Company A'. For him, the most important thing for an entrepreneur is to understand his/her weaknesses and limitations and overcome that by having a team member with complementary capabilities the entrepreneur does not possess.

The operational director of 'Company A' had previously owned and ran a metal roofing company in Australia for 11 years. Therefore, he already held extensive knowledge and relevant experience which he brought with him to 'Company A'. The founder appreciated his presence in 'Company A', saying:

He[operational director] is a young guy, he is in his mid-30s and he's doing incredibly well, he owns a company called Queensland Roof Works, and he's a practical guy. He's the guy that's on the coalface, he's the guy that goes we cannot build that [name of the founder], and by the way we can't use that for the roof because we're not 100 percent sure it's going to last 50 years, so we need to use colour bond.

The operational director mentioned that core team members were all involved in multiple tasks apart from the specific role assigned to them. He mentioned that when he first joined 'Company A', he was given the task of developing a prototype. After delivering two

prototypes, he became more and more involved to the point that he became ‘Company A’'s operational director. He also mentioned that his prior experience and involvement substantially contributed to lowering the cost of the house, a primary objective of the company. According to him, when he joined ‘Company A’, there was some design and engineering work that had been done and a lot of money had already been spent on it. However, the end design and selection of materials did not align with the objective of low-cost housing. Hence, he redesigned and re-engineered the design, and built two physical prototypes. As he said:

And then the end product which they had come up with, yes it may have engineered and physically worked, but the time to manufacture, the cost to manufacture, it didn't stack up economically whatsoever.[...] and it's taken me to come along and tear it all up and say this is no good, none of it works, and it's far too expensive, let's do this and make that happen. And that's what led to getting the prototypes built, and then obviously getting that first project secured in Vanuatu.

The operational director also added that knowing his potential and capability, he asked for full authority and control over the design and material decisions. According to him, building these prototypes would not have been possible if he had not been leading the projects. When asked what he brought to ‘Company A’ in terms of past knowledge and experience that have contributed to building the capabilities of ‘Company A’ as a firm, he said:

I guess just having a really, really practical outlook on things, and in my head being able to visualise how things are going to go, what's functional and what's not, what may work, what may not. And having I guess that exposure to, so the modular projects that we did previously, so they were like high volume, production line style manufacturing. So, trying to implement that into what we were designing, so having knowledge of how to design things that will go together very quickly and easily, and then obviously having to consider all the logistical side of things. [...]. I guess all of that, having that capability I guess certainly helps when you're looking at the design aspects.

The lead architect of ‘Company A’ was highly qualified in the field of architecture and had several years of experience in architecture, prefabrication and low-cost housing. He also had an empathic drive towards the underprivileged population of the world, and shared ‘Company A’'s intent to provide a solution for them. The founder also appreciated his prior knowledge and skill and believed that his involvement had a very positive impact on the success of ‘Project A’. The founder said,

He trained for ten years under Renzo Piano, the famous Italian architect. He is an expert in modular housing; he's an expert in timber, he built the big timber thing that goes around D1 in Dubai, the hundred story building, just beautiful architecture. He has written a chapter of a book called *The Settlements in Australia*, about aboriginal housing, indigenous housing, so he understands it.

When the lead architect was asked about how he became a part of 'Company A', he also emphasised his prior experience with low-cost housing, his travel experiences, and, most importantly, his drive to develop housing for the underprivileged populations of emerging market. He commented, "I had the sensitivities that [name of the founder] needed to develop housing for the poor, or housing for emerging markets. And it is a wonderful thing to be doing." When asked about what he brought to the 'Project A', he mentioned several things and emphasised the importance of his prior experience in similar and related projects, where he learnt new stuff, all of it applicable to 'Project A'. He further described his experience in developing low-cost housing in Nepal, where he had designed a house that cost double the budget they had and then had to decide which half to build. He mentioned that he used that experience in the Vanuatu project, saying:

And so that is another thing I borrowed, when we had the same question, when we did housing in Vanuatu, that we said okay that is great, but how can you make it even cheaper? So, this is what we did, this half of the house is category five cyclone resistant, and this half is low-fab.

He also mentioned his deep sensitivities and understanding developed through close cultural observation. He illustrated this with an example of his work with the indigenous Australian community:

When you first go there, most white people would see a slum, and so you have to wait and build up trust and learn. And you start realising that what you are seeing is very, very carefully thought out. Generations of knowledge, and generations of experience, technical, social, sustainability, everything, was imbedded in those self-built homes. So it's that level of sensitivity and awareness that I bring to the ['Project A'].

Further to acknowledging all the prior experience that helped in the 'Project A', the lead architect particularly emphasised the importance of not generalising the learning from one domain to another. As he said:

You cannot think that because one community in indigenous Australia, is applicable to anywhere else, no. But what you learn is the ability to look and listen, and what you learn

and what you bring to the project, to answer your question is to not assume. And you learn to try to reduce as much as possible your arrogance, to start from zero.

Another core member of the ‘Company A’ is the person responsible for all the marketing and personal relationship building. His prior experience and having friends in PR agencies in common with the founder of ‘Company A’ substantially helped in PR related matters and media releases.

Identifying and approaching the right skillset: In order to develop ‘Project A’, the ‘Company A’ acquired different types of knowledge from experts from diverse but relevant areas. To identify and access those suppliers, vendors, foreign partners and experts, the founder and his core team first contacted their friends, relatives and professional network to find people with the right skillsets. The operational director of ‘Company A’ placed particular emphasis on the key role of the founder’s professional network, surfing activities and general networking capability in the success of ‘Project A’. He said,

And [name of the founder], because of his past businesses and who he is, has a really broad reach and is very well connected in so many parts around the world. And I think because of that, that’s really, really helped us get this brand I guess established.

When the founder was asked about key strategic decisions he made that brought success to ‘Project A’, he immediately answered ‘hiring the best people’. According to him,

The first one is to hire the best people, and that’s an itchy thing to say because people say that every week. But in my case, I needed to hire the best architects and the best engineers that was the first cab off the rank. Then I had to consider the financial aspects of it all, so I had to involve myself with key people who knew about that.

Another approach through which people with the right skills for ‘Project A’ were identified and approached was snowball networking. According to the founder, the snowball networking approach was useful in identifying the right people with relevant prior knowledge and experience, and with similar intentions. The founder further mentioned that informal conversations and serendipity also contributed. For instance, getting the lead architect on board resulted from an utterly informal conversation between the architect and a project manager in his current firm. Both were surfers, and during a surfing trip to Indonesia the project manager introduced the soon-to-be lead architect to the founder of ‘Company A’. When interviewed, the lead architect said:

[...] and I heard what [name of the founder] wanted to do, and [name of the founder] learnt what I had been doing on and off all my career. And we agreed on the spot to work together to find a solution to his dream to clean up plastics from the environment and make housing for the poor.

The lead architect also had useful links that he introduced to ‘Company A’. For instance, one of the key people he introduced is [name of another architect], a builder, inventor and architect who was playing a key role in redesigning the F1 panel in a plug-and-play manner. The lead architect also mentioned that bringing together people with a variety of personalities and skillsets is difficult, but more than that, it is difficult to make them work together as each are expert in their own fields. His contribution in bringing right skilled people to ‘Company A’ was very rewarding yet challenging, as he describes:

And they [people from different professions] bring very different skill sets, extremely different behaviours and different ways of working, and we could not achieve what we are going to achieve unless we work out how to work together. I just spent nearly all day yesterday trying to bring parties together because of the value one party brings and the value the other party brings. But they, and I can see the value of both, and I try to help both parties see the value of each other.

The operational director of ‘Company A’ commented that his involvement in ‘Project A’ was more serendipitous as he and the founder had a mutual friend. According to the operational director, his friend who was also his business partner at the time said to him:

I want to introduce you to [name of the founder], you know, he has got this fantastic idea. Told me about it and he said with your experience with what you’ve done with modular construction and stuff I think you would add a lot of value to it.

Additionally, the founder also identified and approached people with the right skills through relevant events and platforms.

Integrating knowledge through collaborative partnerships: The next crucial step was integrating the knowledge and skills of identified experts. Because ‘Project A’ is a holistic solution, experts from a variety of areas were involved in the project. Some of these experts were also consortium partners of ‘Company A’. These experts included polymer chemists, water sanitation partners, agroecology partners, and energy partners. Involving these experts and the resulting integration of knowledge from various disciplines not only contributed in developing the design and choosing a material that fits well with the purpose and gives high

value, but also helped in reducing the cost. Emphasising the importance of input from experts, the founder gave the example of polymer chemists who cleared away plenty of doubts and made things much more understandable and manageable considering the founder's limited knowledge about recyclable plastic waste and making panels out of it. Similarly, the lead architect described learning things from the polymer chemists, such as they could make a stick 2.5 metres length among other similar factors that became part of the brief for the panel design and led to reducing the overall cost. As he explained:

It's not a one-man job, it's basically a combination of knowledge of experts from different industries. so somebody would have said that okay, so for instance you propose the diagram and then those, making it hollow was proposed by someone else to make it like maybe good for insulation as well? you know the beauty of this.

Another example given by the lead architect was the manufacturing expert telling them the cost of the die was going to be the most significant challenge to making low-cost housing out of recycled plastic. As the participant said:

So, if we wanted to make walls, roofs, floors, windows, posts, beams, everything, then wow how many dyes is that? So, we've already got a big problem because we have too many different components and too many different dyes. So that becomes part of the brief, how do reduce the number of dies.

The 'Company A' also sought individual expert advice from the fund industry to help in setting up the Luxemburg fund. Similarly, the team appointed some special advisers to the board of directors who were experienced investors. An anthropologist was added to the team and suggested making a portion of the house with cyclone-resistant 'Project A' panels and allowing the rest of the house to be built using local materials so that the future owners could take pride and ownership in building it. This approach not only enabled further cost reduction, but also maximised the value of the house.

The founder mentioned companies who had become consortium partners and played a vital role in making a 'Project A' a holistic solution. For instance, the founder named an Australian company in Indonesia involved in activities such as re-bed gardens. This company offered 'Project A' re-bed gardens to grow local crops and provide better yield from the water flowing out of homes in the rural community. In terms of integrating supplier knowledge, the operational director of 'Company A' mentioned a third-tier Australian laminated veneer supplier who supplied wholesalers in Australia. He explained their involvement in redesigning and re-engineering alongside the architect, which not only contributed to winning a design

award in 2016, but also led to the first two prototypes and the completion of the Vanuatu project. Moreover, the 'Project A' team was recently working on their advanced version by collaborating their R&D activities with local and foreign partners. For instance, the lead architect explained, they were working with a local firm with a machine, which shreds the plastic material and will be used to build the 'Project A' in the future. Another example given by the operational director is a US-based foreign partner using technology to make big curved barge covers from recycled plastic. They are involved in 'Company A' R&D activities to develop the latest prototype for the panel using the PIM (powder impression moulding) process, which uses a lot more plastic than the product has at the moment. They are also looking into mixing in some the organic fibres or agricultural waste. As the operational director said, once they have PIM panelling, they will be getting rid of the wood plastic composite (WPC). Explaining the benefits compared to WPC, he explained:

So as soon as that is done the WPC will be gone. Wood plastic composite uses about 33 per cent I think from memory recycled plastic, and then there's some wood fibres and polymers and things in it as well. Whereas this other technology will be utilising a lot more recycled waste in it.

With regard to the modes and means of collaboration and communication, the lead architect maintained they would keep on running workshops whenever it felt necessary, and in particular if they got stuck with some design or material problem or other related issue. As he said:

So, the process for innovation will always include a series of experts from different disciplines who bring different knowledge and different motivations to the table. And these projects are very rarely done by Skype, from my experience they are done face to face, so that's what we committed. We organised, I think it was a two day, or maybe a three-day workshop session on the Gold Coast with polymer chemists, structural engineers, logistics people. builders, myself, and [name of the founder], the visionary at least, there were other people there too, businessmen and stuff like that.

The lead architect also explained how problematic it was at times when they were working with people from different disciplines who did not know each other. He explained how the different aims and objectives of people working together could lead to conflict and problems in the design activity. He also mentioned that such issues could be improved through face-to-face collaboration and meeting in person. According to him:

And let's say new people coming into the team who don't know each other very well and therefore don't necessarily respect each other's skills and may not necessarily respect

each other's opinion. So, they're the issues around collaboration and around team building, and challenging projects that have to be overcome.

Integrating knowledge to achieve alternative material, alternative design and design for manufacturability: Integrating the knowledge of various consortium partners and other individual experts increased 'Company A's' capability for building in simplicity that not only reduced the total number of parts, but also enabled easy and quicker deployment of the house. It also enabled a modular design that adds portability, whereas the customisable nature of the design made it adaptable to different socio-economic environments, which created colossal market potential. Most importantly, through integration of consortium knowledge, the design became fail-proof, cyclone-resistant, and risk-free, with added value through the material, which enabled a clean environment through waste utilisation. To achieve all of this, the 'Company A' decided to adopt a clean slate approach where they wanted to start from scratch without building on any existing ideas. The lead architect mentioned that all of the team was involved in the design process, so that as he was drawing, someone would make a comment on the drawing, and then he would make the alteration. As he said, "It was a live drawing exercise in scale one to one."

The founder also explained the designing of the F1 panel occurred in a similar way, with a focus on the benefits of ribs concerning light and shadow or making the house cool. He also mentioned that since the design was as a rural house, whose louvre windows typically have a stick to operate them, 'Project A' instead made a louvre in the internal wall that gets locked in the event of a cyclone and does not require cross-bracing or lining. The founder explained the modularity and multi-use functionality of the F1 panel, saying:

It is ready to go, that is going to be the roof of the house, and that can also be the floor. One panel can do everything. So, when we need to do a house that needs normal windows or fly screens, we can do all that too. We can do a flat roof, we can do pitched rooves, that's just architecture. As long as the modularity of the house remains the same, it is just change it by moving it out this way, and everything is fine.

The lead architect further explained the F1 panel as one die that could carry out multiple functions, thus playing a vital role in overall cost reduction. He mentioned that it was the polymer chemist in the team who emphasised the expense of having multiple dies for the house's many components. He provided many examples of how design, materials, and manufacturability enabled cost minimisation and value maximisation, again highlighting the F1 panel:

F1 panel is one example. Another example is reducing labour and time by using fabricated portal frames. Yet another example is we are now looking at alternative materials to timber, we're looking at all recycled materials including aluminium, which is way cheaper than timber.

The lead architect explained that the hollowed design of the F1 panel reduced costs in terms of materials, portability, and strength. Concerning the materials, the founder said no concrete is used. Instead, the footings for the house are screw piles, which makes it cyclone resistant. The founder also commented that everything grew from his vision of cleaning the environment of plastic waste in a way that would have a positive impact on the underprivileged populations of the world. However, initially the individual experts and consortium partners explained that it was not possible and therefore 'Project A' started with galvanised steel, wood plastic composite and sustainable timber. That decision bought time for 'Company A' R&D work and finding R&D partners who could help in developing a material that utilises 100% recyclable waste. The founder added, "I am getting close now to saying that we can take nearly all of the plastic waste out of the environment." Currently, 'Company A' was collaborating with their R&D partners to develop panels out of 98% recyclable material using PIM techniques that are considered a lot cheaper and better compared to WPC extrusion. Similarly, the operational director said the PIM process would have a very positive impact on the overall objectives of 'Project A':

I guess the benefits are its [PIM] going to be cheaper, it is going to be quicker to manufacture. It is going to use more recycled waste like the whole thing is built from recycled material. It is a lot lighter, so manual handling, shipping logistics, everything becomes a lot easier. Because it is lighter, you can ship more of it in containers.

The design process also incorporated the manufacturability concern to make manufacturing and modification easier. Therefore, the lines in the panels are designed so they can be cut straight and efficiently, and can also be screwed so they will also be attached straight.

Integrating knowledge of prior projects/prototypes & continuous innovation: All the team members emphasised iteration and reiteration to make the 'Project A' simpler, sustainable, efficient, and cost-effective. This process has resulted in four prototypes, while the fifth prototype is still in the R&D stage. The operational director of 'Company A' explained that when he joined 'Company A', he was given the first panel design, which was far too expensive due to material selection. Later with the help of an architect and supplier who provided design

and engineering assistance, he came up with his initial two prototypes, which he built in his backyard. The founder of 'Company A' mentioned how well designed, and well developed the first two prototypes were—both from the perspective of material and architecture. He said:

So, we built two prototypes on the Gold Coast in March 2015, and they were there for two summers on the Gold Coast in Australia, very hot and without anybody touching them. So before we pulled them down, coz they were version one of ['Project A'], I just arrived there one day and looked at them and went oh there's a bit of grime on them, rubbed my finger on it, and it just came off. And then I got a brush, a hose and I just washed. It was brand new, the house was brand new, and it had not been touched for two years.

The operational director further explained that the first two prototypes were used as the basis for building 14 community structures in Vanuatu, which could keep the whole village safe in a category five cyclone, however they required tradesman to do the installation. Therefore, the 'Project A' team was keen to improve the design further so that the design could be assembled and deployed by an unskilled local villager, which would consequently eliminate the margin for human error.

From a material perspective, the operational director explained that the initial project in Vanuatu involved a wood-plastic composite, whereas the new, improved version would be a much longer-term solution, with 98% recyclable plastic waste. Moreover, he said the Vanuatu project was significant in the sense of learning key lessons:

Since the Vanuatu project was delivered we've sort of been a) setting up the finance vehicle for the business, dealing with lawyers and protecting all the shareholders and their interests in the company, and also working on new technology and new designs so that we can take lessons from the project we delivered in Vanuatu, improve the product.

The lead architect also praised the two prototypes and explained that they were now working on version three of 'Project A'. According to him, the third version was in the final stages of design and will be built in Queensland, Australia. He added that while using the same materials, the design has been improved with the help of a new team member who is an expert architect and considered among the best in his field. He further explained that this version would not only be one third the cost of the existing model, but also requires no tools whatsoever to put the house together and the material used would be 98% recycled, including recycled aluminium for structural components, recycled plastics, glass, and rubber:

Once your footings and your first portal column's set up you do not need a tape measure to put it together, everything clicks and locks into place. Everything's pre-drilled marked plug and play kind of thing.

Regarding their current R&D, the operational director further explained that their R&D is not stopping here as in parallel to version four, the 'Project A' team is also working on version five through conducting collaborative R&D virtually with foreign partners based in the US. This R&D work is focusing on replacing the WPC with PIM panelling as explained earlier. Switching to the PIM process seemed to be causing excitement at 'Company A', as almost every team member participant was talking about it and looking forward to it. As the founder said, "The other material we are starting to use now, which is the really exciting thing, is the powder impression moulding."

Integrating existing technological knowledge: The 'Project A' team used existing technological knowledge to cut down the cost of their product. The lead architect explicitly mentioned that 'Project A' is using existing sophisticated technology to develop a simple and low-cost solution with high value, which is very different from the process by which low-cost houses were currently being built in emerging markets. According to him:

I would say that what you are seeing with ['Project A'] is the technology that we bring from a developed market perspective. And the very high levels of sophistication will deliver something that's very, very simple with low cost, without the need for skilled labour on site of remote areas. Now that's a very different process, or a very different product to low-cost, that is done in an emerging market.

The lead architect further said that for low-cost housing, 'Company A' is in competition with the emerging market, which the benefit of low wages or free workers as the villager themselves build homes for their community. However, these houses are mainly built with low fab building methodology and take a long time to be built, but it's beautiful work. However, 'Company A' is not trying to do that. Instead, 'Company A' is trying to use sophisticated technology and tools to deliver simple and affordable housing:

We are trying to use the most sophisticated tools we can get a hold of, the most sophisticated technology we can possibly bring to bear on the challenge. And deliver the simplest cheapest thing we can.

The initial technology used by 'Company A' for recycling waste was from a UK based company that no longer exist. The new licensee of the technology is a company in Kentucky,

from whom ‘Company A’ has obtained the licence to use the technology. This ‘Company A’ also provides finite element analysis testing of the product. Another technology used by ‘Project A’ is a system called ATM for sanitation of water. ‘Project A’ also uses CET, which stands for clean emission technology. According to the founder, this Australian government certified technology takes all the waste from biohazard waste in the form of tyres, plastic, animal waste, and landfill. It then incinerates it once at 1500 to 2000 degrees, and then using gas combustion incinerates a second time at 2500 to 3000 degrees. After the second incineration it is completely clean and all the material is fully recycled. At the molecular level, the only thing left is nano-carbon and clean emissions. He further explained that the steam turbine connected to the CET system can generate a megawatt of power, which is sufficient for approximately 750 to 1000 homes, and which is very economical compared to generating a megawatt from solar energy:

The cost of doing a megawatt of solar is between 1.5 and 2 million dollars. This system (CET) will be less than a million dollars. You can put it in the middle of the community, have an underground grid with hot air, hot water, electricity, everything going to the house, desalinated water, all from the one system. So, this system, in fact, will ultimately replace solar, and wind farms, because it will take all the waste, organic, everything, and also remove landfills. So, it is amazing technology.

The operational director also mentioned the ‘amazing’ CET technology in his interview felt it aligned with what ‘Company A’ is trying to achieve, i.e. cleaning the environment. Hence, instead of investing in developing new cleaning technology, ‘Company A’ has reduced the overall cost by utilising existing sophisticated technology. Use of existing manufacturing technologies such as the PIM process has contributed substantially in not only achieving cost reductions, but also in improving the quality of the F1 panel.

Integrating customer knowledge: All the participants considered the involvement of the lead customer in the development process and co-creating with customers in general as crucial to ‘Project A’'s success. The participants considered customers critical players and believed it necessary to involve them in building process. As the lead architect said, “It is very important that the village, the people who are receiving the houses, feel some sort of ownership and feel part of the process.” From a design perspective, not only were the customers observed to understand their lifestyle and socio-economic living conditions, they were also involved in the deployment process for the house. The founder explained they wanted to deliver a house that blended well with the culture and norms of villages in Vanuatu. They also had to achieve

maximum affordability. Therefore, they decided to build half the house and make it cyclone resistant, leaving the rest of the house for the villagers to build using local material, as well as have an outdoor place to cook and socialise as they would typically do. This insight came not only from the anthropologist and lead architect in the 'Project A' team, but also from the customers. The lead architect said that building a half-house in their first project enabled them to achieve low cost and facilitated the blending of the house design with the existing houses and living pattern of the villagers.

In sum, to develop frugal innovation, 'Company A' project-level knowledge integration activities focused on cost minimisation and value maximisation from the consumer's perspective. The knowledge integration activities included both internal and external knowledge integration. The internal knowledge integration included the prior knowledge of the developers and knowledge gained from previous prototypes. The external knowledge integration included identifying and approaching people with the right skillsets; achieving alternative designs and materials, and manufacturability; and integrating the knowledge of collaborative partners, technology knowledge, and customer knowledge.

4.2.Case 2: The 'Project B'

4.2.1. Company profile: 'Company B'

'Company B', founded in 2006 and based in Auckland, New Zealand, is the result of the philanthropic drive of its founder to help disadvantaged populations around the globe, and also seeks to generate profit for reinvesting in R&D activities and become a self-sustaining social enterprise.

It was founded by a remarkable individual who is a philanthropist, pharmaceutical scientist, innovator, entrepreneur, and humanitarian. He has won multiple awards for his humanitarian efforts through 'Company B'.

'Company B' was founded as a result of the founder's philanthropic drive and inspiration to help disadvantaged population around the globe. Their website identifies that 90% of the life-threatening illness are suffered by those living in developing countries. The aim of the founder is therefore not only to identify primary health care problems through first-hand experience, but also to work industriously to research and develop healthcare solutions and make them accessible and affordable to those in need. Thus, the solutions offered by 'Company B' in the form of ingenious products and technologies are frugal innovations. They are

affordable to disadvantaged population, and also provide high value by being fit for purpose and the operating environment.

‘Company B’'s main commitment is to make good quality and high value healthcare accessible through affordable products and technologies on a global scale. It is also committed to creating an international network that promotes the development of sustainable enterprises, products, and technologies. Apart from frugal innovation activities, the founder explained that ‘Company B’ monitors the quality, safety and efficacy of cost-effective global healthcare initiatives offered by multinational businesses, and government and non-government organisations. Thus, ‘Company B’'s significant product portfolio ranges from medical devices to nutritional products, for which the company has applied and acquired worldwide patents.

The founder sits at the top the firm's hierarchy, followed by the board members. Next are four teams: the technology team, marketing and fundraising team, media and communication team, and legal and financial team. The firm also has sponsors, schools, and patrons who help in raising funds for the overall operation of the organisation, including the R&D activities.

The primary emphasis regarding product innovation at ‘Company B’ is product realisation rather than simply product development. Therefore, it concentrates on aspects such as meeting customer needs, product design and function that is fit for purpose, the potential benefits for customers, quality assurance, health and safety assurance, and marketing approach. They are also focusing on quality risk analysis and ensuring that their products comply with first-world standards. Their approach to achieving all of the above is through a combination of lean manufacturing, integrating knowledge from various sources, and out of the box thinking throughout the innovation process, from the birth of an idea to its commercialisation.

4.2.2. Frugal Innovation case project: The ‘Project B’

Market research & problem identification: ‘Company B’ is conducting several projects where the focus is to identify critical issues in the developing the world and provide solutions. One problem identified by ‘Company B’'s team through their first-hand market research is a lack of appropriate infant incubators. Infant Incubators are used in neonatal intensive care units (ICUs) specialising in the care of ill or premature newborn infants. After several months of hospital visits and first-hand observations of recurring problems and mishaps within ICUs in emerging countries, ‘Company B’'s team identified some critical problems with existing infant incubators. These problems required urgent solutions as more casualties were being caused by the incubators than the actual neonatal illnesses. Hence, ‘Company B’ aimed to provide a solution to those problems that is not only fit of for purpose and the operating environment, but

also meets first-world quality standards at substantially lower cost. To achieve this objective, ‘Company B’ initiated thorough market research and conducted a failure mode effects analysis (FMEA). FMEA is a step-by-step approach for identifying all possible failures in design, and the manufacturing and assembly process or product/service (“Failure Mode Effects Analysis (FMEA) - ASQ,” n.d.).

‘Company B’ identified a considerable number of issues with the existing incubators being used in the hospitals in emerging markets. For instance, the existing incubators were mostly made of expensive and bulky materials and required regular maintenance. Consequently, these incubators were less affordable and accessible for the hospitals due to high maintenance costs and lack of technical expertise necessary to perform even routine maintenance tasks. Accordingly, once the incubators malfunctioned and became unusable due to routine faults and a lack of scheduled maintenance, they were dumped in storage and never repaired. As a result, hospitals in emerging markets faced a shortage of incubators to meet their requirements. According to the founder every hospital that he visited in developing country, he observed non-functioning incubators in.

‘Company B’'s team observed that some existing incubators had an expensive system to clean the air coming into main chambers of the incubator, which should ideally be free from any particulates and microbial contaminants. In hospital environments in developed countries, the air is already sufficiently clean due to the air conditioning system, and therefore incubators do not require specialised air treatment equipment. In contrast, air will have undergone minimal conditioning within the hospital environment of emerging markets, and therefore incubators in these hospitals require special equipment for air treatment.

‘Company B’'s team also realised that the existing incubators are designed to provide a suitably humidified environment inside the main chamber of the incubator. Therefore, the water used for humidification needs to be free from all contamination. The lead innovator explained that unlike developed market hospitals, in emerging markets, a clean water source is often not available and therefore is it important to have a specialised water treatment equipment within the incubator.

Explaining further, the founder said ‘Company B’'s team also realised that the conventional sensors used in the incubators to maintain humidity and temperature didn't work particularly well in emerging markets where the power supply would go off due to condensation. The condensation leads to measurement errors and causes the system to shut down. ‘Company B’'s team, therefore, realised that they need to go back to basics and design their own humidity temperature sensor.

According to the founder only a few firms have developed low-cost incubators for emerging markets with the intention of addressing the problem of unaffordability and inaccessibility. Nevertheless, due to insufficient FMEA, these incubators suffer from serious technical issues and have proven to be more harmful than helpful. The many design, manufacturing, operability, and functionality issues with these low-cost incubators are mostly due to the lack of comprehensive preliminary research about how the product will operate, and the environment in which it will operate.

Part of 'Company B's' market research involved investigating all the existing incubators that were designed and developed for emerging markets at low cost but had several failure modes. For instance, James Dyson's award-winning incubator named MOM is a low-cost, electronically controlled, inflatable incubator that cost \$400 USD ("MOM Wins 2014 James Dyson Award," 2014). It is compact, lightweight, and robust and runs on mains electricity with backup batteries. The incubator's infection control system is claimed to be easy to clean and has a replaceable body ("Home," n.d.). However, as the 'Company B' founder mentioned in his interview, it is made up of flexible plastic utilising plasticisers, which if released into the air could harm the infant. Similarly, the Design that Matters (DtM) company introduced a low-cost incubator for emerging markets named "NeoNurture". They took a different approach to make it low cost. Instead of finding ways to build an incubator that does not break, they explored ways through which maintenance can be done easily and cost-effectively in emerging countries. Thus, they decided to take advantage of an abundant local resource in emerging countries and made the incubator out of Toyota car parts, based on the premise that any local garages have mechanics who can service and repair Toyota cars ("Past Projects," n.d.):

The incubator uses sealed-beam headlights as a heating element, a dashboard fan for convective heat circulation, signal lights and a door chime serve as alarms, and a motorcycle battery and car cigarette lighter provide backup power during incubator transport and power outages.

According the founder the cost of this incubator was \$1,000 as compared to the traditional \$40,000. However, the 'Company B' founder explained that this incubator also has serious air contamination issues due to the materials and is not safe enough for neonates. Thus, as part of their market research, 'Company B's' team not only conducted FMEA on incubators designed for emerging markets where issues arise mostly in the attempt to make the incubators low cost, they also conducted FMEA of the incubators used in developed countries, such as the ones used in Auckland Hospital. According to the founder, the model of incubator used in Auckland Hospital costs around \$45,000 and is very heavy due to its size and the materials used.

However, the inside technology is very simple. It consists of a fan and a heater but is designed in such a way that it could potentially spread bacteria into the air from the baby's faeces. Also, there is no proper way to measure the level of humidity inside the incubator, which could potentially result in the baby overheating. Additionally, the founder explained that the overall design is not user-friendly, as the holes intended for medical staff to put their hands into to place cannulas into babies or change their diapers make these procedures more challenging rather than easier.

Consequently, after identifying all these potentially fatal flaws within existing incubators, 'Company B's team felt inspired to design and develop an incubator that was different from traditional approaches and to provide a solution to all the safety issues. Not only did the incubator need to not cause harm, it also needed to be fit for the environment in which it would be operating so that it would not break down easily. Further, it needed to be substantially lower cost to make it affordable and accessible for emerging markets. However, in attempting to make it low cost, there should be no compromise on quality; rather the intent was to make it first-world quality so that it could be used both in developing and developed markets.

Solution and product description: After extensive market research, problem identification and a resulting commitment to solving the identified problems by developing a low-cost and high-quality neonatal incubator, 'Company B's team initiated their project with innovative and creative design thinking. They wanted to design a product that is simple, consists of fewer of parts, light in weight, easy to handle and a shape that can regulate the air properly and thoroughly to avoid any potential air contamination inside the incubator.

The resulting 'Project B' infant incubator is an ingenious innovation, solving all the problems associated with the hospitals in emerging markets, as detailed above. It complies with all the pre-set needs and standards, and costs only \$2000, which is substantially less compared to the cost of a traditional incubator at \$45,000. It has been designed around customer needs and their environment within emerging markets and is therefore fit for purpose. 'Company B's team conducted an extensive quality risk analysis to bring this incubator to the first world standards. Therefore, it has the potential to be used in developed markets. Also, rigorous health and safety risk analysis has been carried out to ensure that it is safe for babies and users. The founder further mentioned that each incubator has the potential to save up to 500 lives across their lifespan, guaranteed at a minimum of 10 years.

The founder further explained that the most innovative component of the 'Company B's incubator is the humidification and sterilisation system. According to their patent documents,

this innovation was internationally patented initially in 2011, and later improved, modified and internationally patented in 2015. The founder explained in his interview that the patent had initially been filed in the USA and China and was still going through the patent process in India and other PCT countries. The humidification and sterilisation system includes a heating chamber, filter and humidification chamber. In the heating chamber, the gas (air) is heated to a certain temperature to sterilise it. The chamber includes a heating element mounted in a conducting bulk material where heat is generated through the power supply. A filter is used for filtering liquid (water). In the humidification chamber, the filtered liquid is allowed to evaporate into the sterilised gas. In doing so, the sterilised gas cools and the output is humidified gas at the required temperature. For evaporation, the humidification chamber contains an evaporative surface in the form of an exposed surface made up of a wicking membrane (a porous ceramic material with a maximum pore diameter of 0.2 microns), which allows the liquid from a source to move to the humidification chamber using capillary action and therefore forms part of the first filtering process for the liquid. The wicking chamber is also impregnated with Nanoparticulate silvered quartz pieces. The second filter for filtering the gas is composed of two filter media and is readily replaceable.

Other components of the humidification and sterilisation apparatus explained in patent documents are: a flow device that allows the gas to flow through the sterilisation and humidification system; a sensor for sensing; and controller for controlling the temperature of the gas in the heating chamber, the temperature of the heating element, and the temperature and humidity of the humidified gas. The humidity is monitored through a glass attached to a microchip. This has proved an effective way of monitoring the humidity level and is unique to this incubator. The incubator also includes a bypass chamber, which allows the sterilised gas to bypass the humidification chamber. Moreover, it has a mechanism for distribution adjustment to allow the proportion of sterilised gas that passes through the bypass chamber to be adjusted. Finally, the incubator includes an occupancy chamber, and a curved internal surface to facilitate the flow of fluid from inlets (receiving gas and liquid input) to the outlet flow opening.

In the most recent model, 'Company B' has incorporated noise cancelling technology to counteract the external noise created by the machines, which will help in saving more lives. It is a useful application of a very simple technology, similar to that used in noise-cancelling headphones.

4.2.3. Activities enabling capabilities for doing Frugal Innovation

4.2.3.1. Firm-level strategic decision-making to develop Frugal Innovation

Strategic decision of forming a virtual and flat R&D structure: Since ‘Company B’ is a charitable trust, it operates as a virtual social enterprise and does not have an onsite working arrangement. Instead, ‘Company B’ formed a flat and virtual R&D structure. Therefore, their R&D arrangements differ from the R&D carried out a traditional company where everything happens under one roof. Instead, the organisational structure of ‘Company B’ is composed of distributed teams for each of their projects. Each team consists of members based at various locations and working on different parts of the product. This decision, therefore, significantly contributes to coping with limited resources and achieving substantial cost reduction. The founder mentioned that their team members worked in isolation, and explained it using the example of an expert engineer who works from home:

He’s got the luxury of doing that, and he picks his kids up at a certain time of the day. And I know that, so I do not call him at those times. [...]. And they are the people that are involved in making the key decisions about say the power supply or the software.

Based on the founder’s past experiences within the pharmaceutical industry, he decided not to have an R&D department that consists of permanent long-term employees. Instead, he acquired skillsets and expertise as per the requirements of a particular project, and the tasks within it. According to the founder, different projects need different people with different skillsets. So once the project finishes, their contracts with ‘Company B’ also finish. As a result, ‘Company B’ does not have to pay continuous salaries or provide space for employees. The founder exemplified this practice through ‘Company B’'s engagement with Stanford University students for a short period to conduct some R&D activities, including initial market research to identify customer needs around a lifting mechanism for hospital beds. He summed up the reason behind this strategic decision as follows:

So, what we learnt was it is better to make a virtual organisation and getting the skills that you know you need to do a particular raft of work. And then once the project is finished, they get a pat on the back because they have been part of something that’s very successful. But we have not had to, you know pay their salary or, you know look after them as a career path guarantee.

Strategic decision around quality control by approaching a manufacturer with ISO13485/FDA approval/CE Mark accreditation and in-house capability: Identifying and approaching a manufacturer who not only had a good relationship with the FDA and had already been FDA approved for neonatal equipment, but also possessed the in-house capabilities for manufacturing neonatal devices, and at low cost, was a strategic decision that enabled ‘Company B’ to substantially reduce their manufacturing costs. This decision saved ‘Company B’ a substantial amount of time and expense in meeting regulatory requirements and obtaining approval by the FDA.

The founder explained that manufacturing medical devices, and particularly Class II medical devices (present a moderate to high risk to the patient), requires a standard called ISO13485. This standard requires a lot of front-end stuff, and all aspects of the planning process must be documented. The documents must explain the objectives of the device and how it will be manufactured in order to meet end user requirements. A thorough risk analysis is also required in the documentation that details what could go wrong with the design process, and how it could be ameliorated with different design elements. Keeping all these things in mind, ‘Company B’ decided to collaborate with a manufacturer in India. The founder explained ‘Company B’'s decision as follows:

The single decision was to go with India` was two-fold. It was not because just the low cost of manufacture, it was because the manufacturer in India, as well as being low cost, has in-house capabilities to manufacture incubators. They are already manufacturing incubators, and they have FDA approval.

He further explained his strategic decision in terms of minimising cost using the example of the process for getting FDA approval. He said all the equipment used to test the incubator and its functioning needed to be certified by third-party suppliers in order to gain FDA approval, which is very time-consuming. However, if the components/parts are already certified for other products, then such certification is not needed. Therefore, ‘Company B’ looked for a manufacturer with experience in manufacturing neonatal equipment, and who already had certification for the equipment they needed. As the founder said, “So we ameliorated the cost of FDA approval by going to a company that already is FDA approved.”

Strategic decision of acquiring intellectual property and achieving self-sustainability: Acquiring the patent to achieve self-sustainability was another critical strategic decision that contributed to the value maximisation of the firm. Based on previous experiences, the founder decided to patent the technology as a way of making some profit from its products so that

‘Company B’ could become self-sustainable. The main idea was to become a Philanthro-Capitalist organisation that earns a profit by doing good. According to the CEO:

What we learnt when we set up [‘Company B’] is to make some profit out of the products that we have made so that we can become self-sustainable. And we do not have to go back asking people for money to do these things, so hopefully, that is what our exit strategy is. In the next five years, we want to be totally self-sustainable and have enough money to research, do a lot of other products or other versions of the incubator, or even extend the nutritional product range.

In patenting the technology, ‘Company B’'s reasoning was that if a firm obtained a license the sterilisation and humidification system, then it was very likely they would also decide to license the technology for the sensors relating to these things, which would eventually add extra benefit.

Strategic decision of adopting a “Moral Strategy”: Convincing others to work with ‘Company B’ for free (which the founder referred to as their “Moral Strategy”), was identified as an important ‘Company B’ strategy. According to the founder,

What’s happening in society is that in commerce it is becoming more and more important not only to be good in the way that you run your business in terms of ethics, but it is also important to be seen good.”

He explained his point of view through the example of a firm, who supplied the primary filter for bacteria in the ‘Company B’ incubator. The founder explained that the firm was very pleased to be associated with ‘Company B’'s incubator and offered to wash the filters. They wanted to be seen to be good, so they blogged about it internationally, saying they were helping the founder of ‘Company B’ to clean up the water in the ‘Project B’. The founder further said that such blogs not only added value to it’s own business, but also provided publicity for ‘Company B’.

‘Company B’'s moral strategy also enabled it to acquire free services from experts in their area by emphasising the philanthropic aspect of their activities. Moreover, people with a philanthropic drive were happy to contribute to the good cause. For instance, the New Zealand based company are donating coils to be used within the power supply. However, the founder commented that such free offerings could only be for a certain time as the donor company may not always be able to afford to keep providing a product or service for free. He further said, “It sounds a bit ad hoc, but it actually works in terms of spinning speed to market.” Hence, it was

‘Company B’'s moral strategy provided capability to get people to buy into a project that is doing good for the world. He also mentioned that several individual experts and firms were donating their time for free to help them, for example, with building a website, media communication and digital media adverts. He further explained his way of onboarding people:

[I told them] And you are not going to go to heaven, but if you work for us you just might, and if you work for us for free you might. And, so we do that sort of social marketing ourselves and get people to buy-in, and they really want to do it.

‘Company B’'s moral strategy enabled them to engage media communication companies to work for them for free.

Strategic decision of getting into a commercial relationship with flexibility: Apart from their “moral strategy”, another approach taken by ‘Company B’ was to acquire free skills and services, but only until they proved workable and then convert this arrangement into a commercial relationship. According to the founder, this approach proved very helpful in terms of avoiding wasting money and time on trial and error methodology. However, again as another major benefit of their “moral strategy”, ‘Company B’ are quite flexible in the decision-making around getting into a commercial relationship. So, for instance, if the Auckland based company who builds their printed circuit boards cannot keep up production due to an increase in production volume, then the production can shift to India. According to the founder:

[...] that is the beauty of what we are doing. If it were a commercial relationship with an agreement, we would have had to sign away manufacturing with one supplier forever for them to do the R&D. But because they are donating their time and services, they are quite flexible.

The founder also gave the example of another firm who after knowing ‘Company B’'s intent to make the whole incubator, offered their help for free to see whether or not it was going to work technically. Thus, ‘Company B’ paid for the manufacturer's dies while this firm did all the manufacturing and used the scrap material for free. The product, in the end, was strange looking and of different colours, but they had proved it could work. Later after visiting this firm, ‘Company B’ realised they had some very sophisticated machinery for back-end forming, which was better than the machinery they had offered for free. Therefore, ‘Company B’ decided to get into a commercial relationship with them for pilot manufacturing. The founder told this firm that ‘Company B’ would pay them the going rate because at this stage they were paying for something which was already tested—and worked.

Entrepreneurial capabilities: The entrepreneurial capabilities of the top management at ‘Company B’, such as their passion for the purpose, perseverance, and in particular, ability to cope with anxiety if things go wrong, is another key contributing factor in the success of its low-cost high-value project. The founder particularly emphasised coping with feelings of panic and described once receiving a complaint about a ventilator that had no air coming out of the vent. Everyone was very anxious until they figured out someone had put the fan on the wrong way around. The founder, therefore, sent a message through his interview to anyone who wished to be involved in a similar project, saying:

If I could give somebody any advice about these things it is to have a panic because what happens inevitably when you are doing these things, as you will have what I call good days and bad days. [...] you have to, you know not to worry about. There’s always a solution to a problem that you discover. It is just that it is going to be a time and a cost issue at worst.

In sum, ‘Company B’'s firm-level strategic decisions to achieve cost minimisation and value maximisation and to develop frugal innovation included forming virtual-fixed and adhoc R&D and a flat R&D and management structure, quality control by approaching manufacturers that already complied with first-world quality standards and possessed similar project manufacturing capability, acquiring intellectual property for self-sustainability, adopting a moral strategy to onboard stakeholders and to acquire free or low-cost services, getting into commercial relationships with flexibility, keeping control over the project by holding maximum shares, adopting the Philanthro-Capitalist approach, and having vast entrepreneurial experience and capabilities.

4.2.3.2. Project-level knowledge integration to develop Frugal Innovation

Integrating developer’s existing knowledge and experiences: The integration of the existing knowledge and prior experience of ‘Company B’'s core team was one major contributing factor to the successful development of the incubator. Some of the developers had prior knowledge of developing low-cost innovation for emerging markets, including the founder himself who had 20 years’ experience. According to him, he knew that communication and, in particular, feedback is very important in delivering instruction, especially using clear language in the “standard operating procedures” (SOP). He further said it is important to learn and understand everything about your distributed team, and then communicate the SOP to them in a very understandable manner. For instance, by managing the information sent to them, such as

sharing specific drawings that include scales, colours etc. so there is very little wriggle room when something goes wrong. Such preparation and communication around the SOP are crucial for projects like the ‘Project B’, where cost and time are the biggest constraint. According to the founder:

Because we have not got a lot of money, so we need to make sure that everything that we do is communicated really really well. So that nobody misunderstands, [...] so we actually have documents that we actually do sign off as we go through saying yes that drawing was approved for that part to be manufactured.

Other core team members were also experts in their fields with several years’ experience in a related area of product development and management. As such, they were made part of the team due to their philanthropic drive for the cause and expert knowledge, irrespective of their geographical location.

Identifying and approaching the right skillset: To develop the ‘Project B’, ‘Company B’ acquired different types of knowledge from experts from diverse but relevant areas. To identify and access those suppliers, vendors, foreign partners, and experts, ‘Company B’’s approach was very clear. According to the founder:

Well you need obviously the people who have the skills and acumen to deliver, and so what we do is we find the best of the best to help us with the project. Again it starts at that planning stage [...]. So we do a shopping list, and then we go out and source those resources and get the necessary support to deliver a project on time.

He further explained that their foremost approach is to identify their stakeholders, such as suppliers, over the internet, choose the ones they think would be the best for their project with the help of their technical expert team, who know what sort of technology the ‘Company B’ team want get in, and then contact the prospective stakeholder via phone call. As the founder said:

What we do is we go, you know really on the internet and find suppliers that we think we are looking for, [...]. And then we go and do some cold calls to a number of different people and the ones that respond in the best way, you know that’s the important thing. That once that it responds accurately in the best way are probably the ones that are gonna deliver.

The founder mentioned that identifying and accessing the right people sometimes occurs serendipitously, giving the following example. The founder explained that while the ‘Company B’ team was working on the power supply for the incubator, a chief design engineer

from [name of the company] who was building their battery power supplies learned about their good work and wanted to contribute. According to the founder, “And he called me up and said I want to help, it was like a supernova because he was far, far more knowledgeable than anybody else.”

Other instances of serendipitous networking are detailed in later sections. The founder added that identifying people with the right skills and approaching them is more like osmosis, and in most cases people approach them because they have heard about ‘Company B’'s good work. ‘Company B’ then filter them and group certain skillsets together. The founder further explained that such relationships could be difficult on occasion due to language differences and communication difficulties. Nevertheless the relationships are crucial, and as he remarked:

But then it all goes back to knowing pretty much what you want to achieve. And then you go and find that partner who has the skills to do that. And not only that but also acquiring those skills for nothing is another overlay that goes into this whole process.

Integrating knowledge through collaborative partnerships: After identifying and acquiring the right-skilled experts for a particular task, acquiring their knowledge and skills without bringing them under the roof of ‘Company B’'s lab was one of the most significant factors in achieving low-cost yet good-quality innovation. For instance, ‘Company B’ wanted to develop their own custom-built power supply. This was because they had identified power outages as the main issue in hospitals in the emerging market environment. Since the existing incubators were all running on electricity, they would stop working in the event of an electricity breakdown, or any malfunction leading to a sudden increase or decrease in the power voltage. Therefore, to cope with such situations, ‘Company B’ decided to incorporate a power supply system that protects the ‘Project B’ against power surges and keeps the incubator operating throughout significant power outages. Thus, a search for experts to build the power supply was initiated by the founder in a talk he gave about incubator at an innovation-focused event. Consequently, a CEO of [name of the company] offered the experience he had in the design of electronic manufacturing technologies that are easy to use yet powerful to provide a customer-centric user experience.

Later ‘Company B’ collaborated with the owner and mastermind behind another firm, which is a private commercial research company based in Australia. ‘Company B’ realised the owner knew much more about MR battery charging and could fast-track the design process. Thus, the owner of that firm worked as a power electronics design engineer for ‘Company B’ and

developed the required power supply system. For the manufacture of the power supply units, 'Company B' then went back to the CEO who offered the experience he had in the design of electronic manufacturing technologies, they made printed circuit boards for commercial and semi-commercial production. However, in the future, 'Company B' might yet shift their manufacturing to India. The founder said, "It is a question of again looking at the cost, once you get the product done, and you get it in pilot scale manufacture, you can still go back and have a look at ways to reduce the cost".

The electronic coil for the power supply was custom manufactured by a New Zealand company based in Auckland. The coil ensured the power supply continued to operate even in the most challenging environments. Also, to ensure that the incubator works continuously even in an extended power outage, 'Company B' contracted the services of a team a company in China, who are experts in designing and manufacturing Lithium Ion batteries that last longer.

Likewise, the humidification and sterilisation system are also the result of collaborative efforts, where the skills and knowledge from multiple experts located in various locations have been integrated. For instance, 'Company B' conducted collaborative technical work with the team a company in China, who are one of the top ten manufacturers of air filters in China. As a result of this collaboration, 'Company B' developed a novel lifetime HEPA filter, which ensures that any fresh air entering the incubator is free from bacterial contamination. These filters are washable and guarantee long-term reusability, therefore resulting in cost minimisation from a maintenance perspective. Similarly, 'Company B' chose the Katadyn filters provided a firm in Singapore, which ensure that the water used for humidification in the incubator is 99.99% bacteria free. The core technology used in the Katadyn filtration system is manufactured by the Swiss-based Group, the market leader for portable, personal water treatment systems and products. Further, through a technical collaboration with a company based in Taiwan, 'Company B' developed a low-cost and reliable PTC Thermistor heater element. As a consequence of this collaboration, the 'Project B' became the first of its kind to operate continuously on a 12 Volt DC supply. The PTC Thermistor heater element is the "engine room" and therefore essential component of the 'Project B'. Finally, the ceramic heating system was designed by an engineer who works for well know automotive company.

To fast track the development and commercialisation of innovative healthcare technologies, 'Company B' has facilitated strategic alliances with national and international academic and research-based organisations. For instance, an important partner is with New Zealand's largest institute of technology. The objective of this partnership is to harness creative minds to develop novel technologies and improve global healthcare outcomes. For instance, a senior lecturer at

that institute has developed a noise cancelling technology for the latest version of ‘Company B’'s incubator. Further, the institute students helped ‘Company B’ by creating all the engineering drawings required throughout innovation and development process for by the FDA. Similarly, a biomedical technician team at Christchurch Hospital’s Biomedical Engineering Department in New Zealand provided their research expertise on medical devices to help in the development of this novel low-cost medical solution.

Integrating knowledge to achieve alternative materials, alternative design and design for manufacturability: After rigorous thought and design effort, ‘Company B’ decided to develop an alternative design for an incubator to minimise the cost and maximise the value for customers. The alternative design approach began with a new oval shape for the incubator. ‘Company B’ realised that the traditional rectangular shape does not allow the proper flow of air. Consequently, if the child vomits or suffers from diarrhoea, the air becomes contaminated and gets trapped in the corners due to the rectangular shape, which does not allow proper circulation of air. This results in the accumulation of contaminated air inside the incubator, and despite the air purifier unit, this can harm the infant. Further, but the new design has also lowered the cost due to less material being required for the oval shape compared to the usual rectangular shaped incubator.

Another reason for seeking an alternative design was to keep things very simple. For example, ‘Company B’ needed a part that enables the opening of the main chamber and connects the lower base with the canopy. The first suggestion was a hinge that cost \$480, designed by students at Stanford University. Considering it too expensive, ‘Company B’ approached a New Zealand based engineer to see if he could find a less costly solution. The engineer was very experienced and had designed a smart washing machine-drier in the past. He subsequently came up with elliptical spring design that cost \$17.50 USD. Later, by chance, one of the service people for the manufacturing site in India was talking to an ‘Company B’ technicians and suggested hinges he had recently repaired in the hotel which stops a door swinging when somebody pushes it. These hinges have spring mechanisms that allow the door to move only at certain speed, exactly what was required for ‘Project B’. So in the end, as the founder explained, ‘Company B’ did not have to design or manufacture the hinge. Instead, they just sourced it, put it in the incubator, and it did the job for around \$10.

The seal design for the canopy, which has been iterated and reiterated to make the incubator simpler and more cost effective through applying the lean manufacturing concept, is another example of achieving an alternative design and material. ‘Company B’ had been talking to

several companies about the seals for the canopy, yet there remained plenty of issues around the sealing. Notably, it was too wobbly. After looking into various options such as putting a metal frame around the bottom or attaching a handle in front to lift the lid, which meant drilling two holes to attach the handle, the ‘Company B’ design team redesigned the lid of the incubator to be the same thickness as the plastic of the body. This then formed a seal, and a “T” seal was added that clipped on the end and made two flat surfaces on top of each other. However, later they reiterated that design completely. Instead, they made a double-walled canopy, which made it very strong, and put a right-angled turn on the canopy with a very flat 15ml surface, which can then mate with another flat surface. By doing this they were able to get rid of the seal. Also, the canopy could just be vacuum formed out of a flat piece of material using a lean manufacturing technique with a 15ml backward cut that makes it nicely flat and which extends to provide a natural handle. According to the founder:

We get rid of all those parts for the handle, every single part has to have an FDA approval. So, the more parts you get rid of, the easier it is to have lean manufacturing and a very slick fast FDA approval.

Cost minimisation has also been achieved through the use of the alternative materials. For instance, the material used to develop the incubator is a superior quality, but inexpensive plastic called plyometric plastic. It means the incubator is sturdy but very light weight for ease of handling.

From the perspective of manufacturability, this plastic has a reasonably low melting point and therefore can be vacuum formed, which is a low-cost manufacturing technology. Vacuum forming of plastic has proven an excellent approach for achieving flexibility, cost-effectiveness and speed of production, all needed in the particular case of the ‘Project B’. For vacuum forming the plastic material, ‘Company B’ collaborated with a firm based in Auckland, New Zealand, who are experts in this area and they produced the high-tech plastic components for the incubator. Similarly, the design of the canopy for the incubator required high-quality, clear glass or plastic material through which a baby can be seen clearly. For this purpose, ‘Company B’ collaborated with another firm based in Christchurch, New Zealand, who, by using novel technology, manufactured the required clear glass canopy for the ‘Project B’. Moreover, low-cost manufacturability has been a constant focus of ‘Company B’. As the founder said, “Everything that we did was predicated upon doing low-cost manufacturing, what we call lean manufacturing.”

In terms of value maximisation, the most innovative component of this incubator is the humidification and sterilisation system previously described in the product description section.

This humidification system is 50% more accurate than a traditional humidification system, and it does not wear out and become blocked up, therefore substantially maximising the value of the product. The system has solved the problems around contaminated air and water within the main chamber of the incubator. For instance, the ceramic material used for filtration has an absorptive capacity that stops the build-up that causes contamination in the incubator. The design and materials used for the system have contributed substantially to reducing the cost of the incubator.

Once the final prototype for the ‘Project B’ had been developed, ‘Company B’ decided to manufacture it in low-cost labour countries. Hence while aiming to achieve cost minimisation through having the incubator manufactured in India, ‘Company B’ also looked for a manufacturer who already had ISO, CE, and FDA approval for neonatal equipment. To identify and access such a manufacturer, the approach was even more focused. According to the founder, “[‘Company B’] wanted to have a manufacturer, who has in-house capabilities to manufacture incubators.” Thus, ‘Company B’ contacted internationally recognised manufacturer in India that similar to ‘Company B’, also aimed to make quality medical equipment available to everyone. Thus, through this collaboration, ‘Company B’ acquired the in-house manufacturing capabilities of their manufacturer, which substantially contributed to minimising the cost and maximising the value of their product.

Integrating existing technological knowledge: ‘Company B’ also cut down the costs for the ‘Project B’ through rapid prototyping. The founder described how this was achieved through the help of an engineering professor from Auckland, New Zealand, with expertise in the creation of inventive technologies. This rapid prototyping (use of innovation technologies) enabled them to incorporate lean manufacturing concepts throughout their innovation process. The founder further explained that the main idea was to make a prototype and have something physical and tangible in front of them, and then start to analyse it again to achieve further cost reduction by questioning their prototype. As he said, “You can only do that when you have got it working and saying well what else we can do to, you know make it cheaper?”

To monitor the performance of the incubator and observe how the incubator was being handled by users within the hospital environment of emerging markets, ‘Company B’ contracted the services of an internationally recognised software entrepreneur, who developed a cloud-based healthcare data system. This cloud system can perform biometrics, and monitors, records and communicates user handling and performance information, such as: the number of

times the incubator has been opened and closed, how long it is kept open, and even the beep if it has been kept open for too long.

‘Company B’ also made use of inventive analogy, as demonstrated through the example of the canopy for the ‘Project B’. The canopy originally incorporated a cavity sandwiched between two layers of material to offer double glazing insulation. It was strong but very expensive because the dome had twice the surface area of material and was thus also very heavy. So, an alternative option was explored to make it cheaper, lighter, and more efficient in terms of keeping the temperature constant. An ingenious solution was found (through the use of inventive analogy) where heating elements (e.g., very thin heater wires used in the back-car window) used in the automobile industry were used to provide heating at low ambient temperature within a single-layer canopy.

The founder further illustrated inventive analogy with the example of how the ‘Company B’ team have been able to make the air chambers serviceable. He mentioned that initially the incubator had three chambers. However, through the help of a friend working in a company that develops commercial washing technology, and they used an inventive analogy from the washing machine industry that enabled them to put three separate modules in one box, thus making these easily removed for service and repair. As the founder reported, his friend said:

“And what you do is, you just take that big box out and service the whole big box, you know we do not even bother about whether it is the fan or whatever. You just put that whole big box in a DHL box and send it off and bring it back to the factory.”

The founder added, “And that is what we ended up doing, you know, and we would not have thought of doing that if we had not had a third party come in from outside.”

Integrating customer knowledge: Regarding integrating customer knowledge, ‘Company B’’s plan was to involve users in the testing phase. Thus, the ‘Project B’ was first tested on an artificial baby to identify any potential problems. The founder said, “Obviously it is much better to solve problems in the factory, rather than when it is out into the hospital”.

To ensure the incubator’s functionality and as a precautionary measure, ‘Company B’’s next step will be a soft release into hospitals in Chennai, India. As the founder described, “The next stage is a soft release into hospitals in Chennai, with real babies and we have got data loggers in the machines to show us what’s going on with the incubator”. The founder further explained that they have wireless set up to communicate any glitches, because he wants to ensure no glitches affect the functionality of incubator. Yet the glitches are crucial. As he put it, “Those

are the kinds of things that you find out by running it over a long period of time in different circumstances.”

In sum, to develop frugal innovation, ‘Company B’'s project-level knowledge integration activities have focused on cost minimisation and value maximisation from the consumer’s perspective. The knowledge integration activities include both internal and external knowledge integration. The internal knowledge integration is based on the prior knowledge of developers and knowledge from prior prototypes. The external knowledge integration includes identifying and approaching people and other companies with the right skillsets; achieving alternative design, materials, as well as manufacturability; and integrating the knowledge of collaborative partners, technology knowledge, and customer knowledge.

4.3.Case 3: The ‘Project C’

4.3.1. Company profile: ‘Company C’

‘Company C’ is an innovative medical equipment manufacturing company based in Dunedin, New Zealand. According to the founder, it was established in 2003 and was registered as a company on July 24, 2013. It is a social enterprise seeking to generate profit, which is planned for reinvestment in the R&D activities of the company. The co-founders of ‘Company C’ are a New Zealand anaesthetist and inventor and his friend who is a medical engineer and inventor. Both the founders are innovators, entrepreneurs, and humanitarians. The pair have won multiple awards for their innovative anaesthesia machine. To date, the company has 1200 shares owned by the founder with 51% shares, and the co-founder with 49% shares.

‘Company C’ is a vehicle for the philanthropic drive of its founders, and their aim to create innovative medical devices for underprivileged populations around the globe. Their company’s first product, the ‘Project C’: the compact anaesthesia machine, is especially designed for hospitals within emerging markets. It is affordable, reliable, portable, simple, easy to use, and low maintenance. Thus, it possesses all the attributes of an ingenious frugal innovation as it is not only affordable for disadvantaged populations, but also offers high value by being fit for purpose and the operating environment. As the founder said:

Our intention is not to make money but rather to provide a cheap, ultra-reliable anaesthetic machine.” (Founder, ‘Company C’)

The basic hierarchy of ‘Company C’ comprises the founder and co-founder who are supported by three main team members who all contribute in refining the final product, carrying out specific tasks such as preparing documentation for CE mark and patents, manufacturing and production activities, and software development. The company’s main objective explained by the founder is to develop a machine that is seen as an affordable, dependable, compact anaesthetic machine and that provide years of trouble-free service to satisfied customers.

4.3.2. Frugal Innovation case project: The ‘Project C’

Market research & problem identification: The problem identification around the anaesthesia machines being used in emerging markets started with the personal experiences of the founders of ‘Company C’. During volunteer work in Asia and Pacific region, they observed second-hand anaesthetic machines that were donated by developed countries. Since those machines were very sophisticated and had been made for the developed world, they could not tolerate the hot, humid, and salty climate. They used to break down within weeks and were then abandoned in hospital storerooms because of a lack of knowledge and skills to repair them. Moreover, the parts needed for repair work were also unavailable. Recalling his experiences, the founder explained it as a graveyard of machines, unsafe to use, yet he had to repair and use them.

The founder made similar remarks while being interviewed by [name of the magazine] in 2016. Additionally, the co-founder said in his interview for this research:

The thing with these modern machines is, over the years they have had problems that arise and what they have done is put an alarm in for that. But all they have done is put in a system to warn you something has gone wrong. I thought, ‘Let’s do away with the stupid design, so the problem does not arise in the first place.

The founder has been doing volunteer work for around 25 years, mainly in the Pacific islands and Vietnam. He has therefore lived the experience of being a doctor working in those resource-scarce countries and has the first-hand knowledge of the frustrations and limitations faced by doctors who work there fulltime. He explained his experience, giving an example of his work in Fiji:

I went to the [name of the hospital] in Fiji, which is probably the best hospital in Fiji, and the anaesthetic equipment was just terrible, it was dangerous, and I did not like using it. Every operating theatre had different machines; they’d been inherited from other parts of the world; the Americans donated some, the Japanese donated some, the Australians,

New Zealand, all a mish-mash of gear, none of it worked, you know. They had cobbled it all together, and it was really dangerous, and I used to have using it.

Further reflecting on his experience of using anaesthesia machines in these emerging markets, he described how unfit the second-hand anaesthesia machines are for the environmental conditions, skill sets and reality of resource scarcity:

[...] What I am saying is, this [the machines used in New Zealand], the technology is very sophisticated, and that does not work in emerging markets. Why? Because if you take a developing country, 1: they can't afford to buy a \$500,000 machine for a start, 2: if they do buy it, or if somebody gives it to them, within a few weeks it breaks down, they can't fix it, they haven't got the expertise, they can't afford the spare parts.

The high technology and sophisticated equipment used in the developed world was inappropriate for the purpose and the environment of the emerging markets. Those resource-scarce environments needed simple, robust, reliable, high quality yet affordable anaesthesia machines that could easily be serviced in their hospital workshops. Moreover, the co-founder also observed the frustration in hospital staff with regard to the large size of the existing machines in the hospital, which he described as follows:

And some hospitals I go to, they have like a CT scanner downstairs, and they have a patient, some patients are still on anaesthesia, and it is very simple, they just need to be asleep while they do a CT. Well, I know, speaking to the girls, they hate it because they have to go there every day, check over this huge, big machine, or wheel it down. If they had something like this that is all they need for down there.

Thus, the founder's frustration of observing and using these inappropriate anaesthesia machines while volunteering as a doctor in overseas ignited a passion with purpose and led to his philanthropic drive towards doing something for the disadvantaged populations of emerging markets. Moreover, he was determined that one day he would come up with a solution that would target all the problems associated with the second-hand, fancy, sophisticated and expensive anaesthesia machines being used in hospitals of such countries. As he recalled:

And I decided, about 30 years ago, what I would like to do is make a simple, cheap anaesthetic machine, which would be really reliable, never break down, or if it did break down, they could fix it up easily in the hospital workshop. That is the important thing, easy to use, simple, safe, and reliable; those are the key things. And so, I started thinking about that.

Solution and product description: To solve the problem of complex, expensive, and inappropriate anaesthesia machines within emerging markets, the founders came up with an idea based on the previously invented a small, trouble-free and incredibly reliable ventilator was invented by the co-founder in 1994. The founder knew about this ventilator because he had used one himself. He therefor proposed the idea of expanding the concept of previously invented ventilator to the co-founder. According to the founder:

And I said, why don't we expand this concept, why don't we take your ventilator, that will the heart of the machine, and we will expand it. So, we make an entire anaesthetic machine, built on the same principles; cheap, reliable, affordable, doesn't break down, can be fixed in a hospital workshop, all this really basic stuff. And something that works well, and, so that is how it started.

The co-founder also said that he had been confident that together they could achieve a machine like ['Project C']. Subsequently, both founders together came up with the idea of a compact machine that is portable with a protected cover and carrying handle, and so therefore quite easy to carry at a weight of about 8 kg. The machine should also easy to use, and easy to maintain in hospital workshops in the developing world.

Compared with other anaesthesia machines being used in developed world hospitals, the 'Project C' performs all the necessary functions at 1/13th of the cost. According to the co-founder, it is strange that no one has previously made a machine like the 'Project C' but believed this is because of money as mostly big companies seek big profits.

Apart from the cost, 'Project C' is minimal in size as compared to the modern anaesthesia machines being used in developed world hospitals. It is its size and the materials used that makes it extremely portable, as it weighs just 15kg with a monitor screen, and 8kg without.

According to the co-founder, the size and the portability of their anaesthesia machine matters a lot. Moreover, the 'Project C' is much simpler compared to the machines being used in modern hospitals, which is what gives it higher value for emerging markets in terms of low maintenance costs. Speaking about the simplicity of the 'Project C', the founder used the analogy of a Maserati versus a Toyota Corolla, when he said:

So, what they need is a simple machine, but a really reliable machine, and the corollary I use, or the analogy rather, is a Toyota Corolla versus a Maserati. The machine I drive is a Maserati in operating theatre, that's no good in a developing country. What they need is a Toyota Corolla, it's cheap, it's reliable.

Apart from its simplicity, the co-founder explained that the 'Project C' is not solely dependent on a power supply, as the electronics are operated by 12-volt rechargeable battery. Similarly, the ventilator is pneumatically driven and can be powered by compressed air or compressed oxygen if there is not a primary power source. If everything else fails, the patient can still be kept alive by operating the ventilator by hand, therefore making the 'Project C' extremely reliable for the challenging conditions at emerging market hospitals. Additionally, 'Project C' has an old-fashioned flow meter in which a little ball shows the gas level, unlike the LED-lit numbers on modern machines. Even though the 'Project C' has been designed to be foolproof, it still has a bird-chirping-like alarm which is activated when the pressure readings fall to 50% of the pre-set setting.

The 'Project C' has colossal market potential. For instance, office surgery is becoming very popular in developed countries, especially in places like the United States and Canada and is also growing rapidly in Australia and New Zealand due to its low cost. According to the founder:

It is too expensive now for a lot of people to go to the hospital, so, more and more surgeons are saying, we have got our rooms, we will build a small operating suite on the rooms. And for much minor stuff, not too minor, we will do it all, and save the patients a lot of money. It is called office surgery, office anaesthesia. So, they need machines. This is perfect because it is small, it is reliable, and it is easy to use, it is cheap, but more importantly, just plug it into the wall, you do not need compressed gas.

Speaking about the benefits of office surgery, the co-founder expressed another interesting view:

When you go into hospitals, some people, and even kids, they wheel them into the theatre, and they see all these lights and things hanging down, and they start screaming and yelling. And they have found that if you induce them in a little side room with some teddy bears hanging off the wall, and you put the gas on them, when they are asleep you wheel them in, and that is much better. And often there are lots of small things to do to the patient to prepare them before you take them in for surgery, you know, and you want some room around you. You go into an operating theatre and there's nurses everywhere, and there's people, and there's bits of tubes and stuff everywhere, you know, and it's very frightening when you first go in.

The military is identified as another potential market. The founder mentioned that the Australian Air Force already want to trial it. Similarly, other services such as The Flying Doctor

Service, ambulance services, and the Malaysian and Indonesian armed forces. Additionally, another big market is the veterinary industry:

Vets now are really starting to do a lot of operative procedures. They cannot afford our machines, there's no way they could afford to buy what I use, and so, something like this ['Project C'] is perfect for them" [...] I don't know what the future holds, but I can see a potential.

The potential of the 'Project C' has also been recognised by politicians in New Zealand in terms of providing foreign aid to various counties, as so much aid gets wasted. The government approached the founder and asked if they could buy one of the 'Project C' machines and donate it, thus opening up the possibility of another exciting market opportunity. Similarly, it would be useful in natural disasters, and even in the event of industrial accidents where emergency amputations are needed.

Overall, the 'Project C' is an ingenious innovation that can solve all the problems identified earlier within emerging markets hospitals. It is designed around the customers' needs and their environment. Further 'Company C' have complied with first-world standards and their machine is proudly labelled "Made in New Zealand". This, it also has potential for developed markets.

4.3.3. Activities enabling capabilities for doing Frugal Innovation

4.3.3.1. Firm-level strategic decision-making to develop Frugal Innovation

The strategic decision of forming a virtual and flat R&D structure: Strategically, 'Company C' operates as a virtual social enterprise and does not have an onsite working arrangement. Therefore, its organisational structure is composed of distributed team members based at various locations and who have different roles. The company hires experts on short-term contract for particular tasks and therefore does not need many permanent staff. The founder explained that they had engaged people such as a software engineer and a product designer on a short-term contract basis to avoid overhead costs. The founder further explained that sometimes he needs to pay a higher hourly rate to get the task done. Nevertheless, he does not have to pay utilities or provide equipment, a place to sit, or place to eat, as the contractors work from home. As he said, "I think you have got to contract work in, contract work out at early stages and just pay them a fee for service, you know, and keep your overheads down."

The participant responsible for regulatory matters mentioned another person, who helped him in developing new software and wrote the software for the original prototype. He joined the team on a contract basis, but they are keen to keep him as he is an expert in his field. Moreover, when asked about his working arrangement with ‘Company C’, the participant responsible for regulatory matters said,

He is a software engineer, yeah. But he does work for a company, you know, full time on his own, I cannot remember what the name of the company is. So, I just go and see him at night for a couple of hours.

Similarly, when asked about work arrangements, the founder described the structure of their firm as flat and the way he organises R&D and communicates as virtual and ad hoc. He said,

They would visit, but essentially, they worked at home, that is assuming they worked night, weekends, and I told them what was required, then we would have meetings, and we would sort it out.

However, one of the participants mentioned that even though ‘Company C’ currently had an ad hoc team and people were working remotely, in future, they would bring them together in order to better manage the team. As he said, “Ultimately, [‘Company C’] will have their own team.” Thus, the strategic decision of virtual ad hoc and flat R&D significantly contributed to coping with limited resources and achieving substantial cost reduction.

Strategic decision of approaching manufacturers who possess ISO13485/FDA approval/CE Mark accreditation & in-house manufacturing capability: Complying to the ISO standard for medical devices with minimal cost and time is another major strategic decision of ‘Company C’. Previously, while being interviewed by a magazine the founder expressed the importance of having ISO 13485 certification (ISO standard for medical devices) by that saying ISO 13485 is expensive but also necessary for marketing. To cope with the cost and time needed for ISO13485 certification, ‘Company C’ identified and approached a manufacturer who already possessed ISO 13485 certification and so had in-house capabilities for manufacturing medical devices at low cost. This decision has saved ‘Company C’ a substantial amount of time and expense that otherwise would have been required in meeting the regulatory requirements. When interviewed, the founder said, “One of the requirements is that it is manufactured in an ISO approved factory, so we have got that. The manufacturer has that ISO standard for developing medical devices.” The co-founder also mentioned the significance of having a manufacturer who already complied with ISO standards. However, the participant responsible

for manufacturing had a slightly different point of view. According to him, if a product has a CE mark on it, it does not necessarily need to have ISO 13485, and ISO 9001 could be fine. He said, “You can get into the situation when you have to have ISO 13485, But this [‘Project C’] would be all right with ISO 9001 as it goes with CE mark on it.”

Nevertheless, for the founder getting a CE mark was the next step after sorting the ISO certification, as he also mentioned in his interview. Similarly, in this interview for this research, he described having a CE mark as another critical decision in terms of meeting first-world quality standards and maintaining the ‘Project C’'s branding as a high-quality device to increase market potential:

So, the thing is if we start buying substandard equipment, (1), we will not get the CE Mark, or we will not keep it, and (2), we are just shooting ourselves in the foot because it will break down, the whole machine will get a bad reputation.

He further explained that even though it is an expensive and time-consuming process, it is worth it both in terms of market competition and capturing a huge market that includes both emerging and developed markets:

Once you have got a CE Mark, it makes all the difference in the world; one, you can sell it to emerging markets and to developed countries, and that is the key. And the second thing is that a, when you’ve got a CE Mark, it’s like a huge protective moat around your business, it really cuts out the competition, because the Chinese are out of it now.

Similarly, the co-founder emphasised the importance of having a CE mark to capture a wider market, saying that even though their main objective is to sell to third-world countries, there is huge interest in Australia and NZ—and to sell in those markets, a CE mark is necessary. Another participant responsible for the CE mark considered achieving a frugal yet first-world quality product a very challenging task for any product, but it is even more challenging if it is a medical device due to the stringent regulatory requirements. As he said, “So, although you are being frugal, and you are trying to make it for western society, you have still actually got to meet the stringent regulatory requirements of the westernised countries.” He also explained that the ‘Company C’ team preferred a CE Mark over FDA approval, which is an American standard for medical devices. It is cheaper to obtain a CE Mark compared to FDA approval, although the processes require an equal length of time.

The participant responsible for manufacturing considered the design location (New Zealand) as the primary factor for reducing cost and time in the CE certification process, as there are

only a limited number of people around the world who can CE certify this product, and one of these people is based in Wellington.

The strategic decision around acquiring intellectual property: Acquiring a patent for the unique and innovative component inside the ‘Project C’ anaesthetic machine was another important strategic decision for ‘Company C’. According to the founder, the patent is under process and is not for the entire product but for a particular part, which he called an air turbine. Similarly, when the participant responsible for regulatory matters, and the key innovator behind the air turbine, was asked about the patent, he said:

Now, as I said to you before, what happened before was it was high-pressure gas, so it is not particularly economical, and if there are any failures, etc. So, what we are doing is to have a turbine, a miniature turbine, which drives the bellows. So, this is the unique area; It will have IP on it, well, we are filing now. [...] But obviously, going back to the frugal bit, it needs to be – Quite cost effective, cheap to make, and safe, and simple.

When the co-founder was asked about IP, he referred to the very simple yet innovative nature of the air turbine.

Next to the decision of filing for IP, is the decision of the location in which the patent should be filed. The founder said he is definitely not looking at the United States due to its costly and time-consuming process; instead he is looking into Europe, Canada, Australia, and the rest of the world. However, it is crucial to choose the location wisely as full coverage will be costly and, for example, patenting for China would be pointless. He further explained that the main reason for getting a patent is to protect it from big companies who might later sell it for a higher price. Other participants also confirmed the importance of the patenting decision and deciding on the location to file their IP.

Strategic decision of keeping control over the project: One of the most critical strategic decisions of the ‘Company C’ team has been to keep control over the quality, and therefore they decided to build the machine in Christchurch, New Zealand. Explaining this strategic decision, both founders of ‘Company C’ mentioned that it was crucial for strict quality control and also because they felt pride in labelling ‘Project C’ as “Made in New Zealand”. The founder put forward two main reason, as follows:

I decided to make it in New Zealand, and here in Christchurch, and I decided for two reasons. One, I wanted control, [...], so I knew exactly what was happening, and I could maintain quality. And the second thing was, [...] I wanted to see the local businesses involved in all this, rather than shipping our products overseas to be made.

The founder also mentioned that keeping control of the ‘Company C’ does not mean they are not open to external advice or expert knowledge. But they were keen on finding their own designers and software engineers, and made personal arrangements for handling matters such as ISO, CE mark, and clinical trials. Moreover, the founder said that the decision of making the machine in New Zealand was to maintain absolute integrity, quality, and sustainability:

We want to make a machine which is absolutely reliable, top quality. And we also want to build a brand, if you like, is the term, the [‘Company C’] brand, for absolute integrity, absolute integrity.

Other participants also emphasised the importance of the decision around manufacturing location and said that it is all about quality assurance and making the product reliable every time it is built. For example, the participant responsible for regulatory matters fully supported this decision, saying:

Yes, I mean, that is, that is a key, again, [name of the founder]’s philosophy is a key, he wanted it to be very reliable, and he is absolutely right, he cannot farm that out. And if you do farm that out, it needs to go local where you can see what’s going on, and that is basically what we have done. We have passed it onto them, in terms of production anyway, to an engineering company that’s approved, and is capable, and we can control quality control.

Keeping control over the ‘Company C’ also included decisions around shares. The co-founders have kept the shares to themselves (the founder has 51%, while the co-founder has 49%) and refused the partnerships offered by some organisations. They decided to stick to their own partnership otherwise they could lose control of everything. The founder said:

If I floated a company on the share market, and I had a lot of shareholders to satisfy. I wouldn’t be selling it for \$12,000, I’d be selling it for \$30,000, coz my shareholders would demand that, you know. And if I sell it for 30, you kill the goose, don’t you.

He further explained his prudent approach around handling potential competitors, as follows: “But if they [big companies] want to buy us out, I’ve said to [name of the co-founder], well we’re in control, I’m not going to sell it, so that, you know, we want to keep that.”

Strategic decision of adopting “The Robin Hood” approach: Adopting “The Robin Hood” approach was identified as another significant decision of ‘Company C’. According to the founder, he learnt it from other entrepreneurs doing similar work. He said:

[...] you know, Robin Hood stole from the rich and gave to the poor. And what [name of another entrepreneur] said is, and how we have done, we think we can market the [‘Project C’] in a developed country like Australia or New Zealand for \$18,000 US. We will sell it to a developing country for \$12,000 US.

Thus, they intend to keep the price lower for the developing the world and relatively higher for the developed world. Additionally, he explained how passionate he is about this Robin Hood concept:

And always, I come back to this Robin Hood principle, I am not in it to make money, but if we can make from developed countries, I will use that to subsidise emerging markets, which is a passion I have. I want to see this machine in widespread use across the developing world.

He further said that even though he cannot see much profit due to their low pricing, which is their main objective, he wished to see high volume sales from emerging markets and was keen to make some profit through economies of scale, to be reinvested in R&D activities in order to achieve self-sustainability.

The core intent of co-founders of ‘Company C’ is not to make money but to bring positive change in the emerging market healthcare industry. They recognised that the big companies have no interest in the needs of emerging markets and are only interested in making a high-profit margin, which is why they sell machines for \$200,000 USD instead of \$15,000 USD.

The founder also mentioned in his interview with [name of the magazine] that they are not keen to go into big business but to keep the device affordable for emerging markets.

Lastly, the founder explained that one of their reason for filing for IP rights for their air turbine was also to protect it from big companies which could otherwise incorporate that technology into their machines and sell them for a higher price.

Strategic decisions around inspired publicity and adopting a moral strategy—with limitations: A moral strategy is another important strategy for ‘Company C’, with implications for acquiring skills and services at a reduced rate. ‘Company C’ clearly did not opt for free services, even though these were offered several times by people who wanted to contribute to a good cause. The founder held a different opinion about acquiring free services. According to him:

And we have had people coming out of the woodwork, and software, website developer, they came and said they would like to be involved, they would like to set up a website

for us. So, I said, oh, that is good, and they said, we would like to do it free, and I thanked them, but I paid for them, but they gave us a reduced rate. Because once you get things for free, nothing comes for free, you know, [...] and you're always the last job in the queue to get attended to.

When asked about strategic decisions around marketing and distribution, the founder commented that as most of the anaesthetists in a particular region will know each other, initially they will only need to sell the 'Project C' anaesthesia machine to a couple of hospitals, and if they like it, news will spread quickly. He calls it the word of mouth marketing approach. Another important aspect of their marketing is what the founder called "publicity through inspiration", otherwise known as "inspired publicity. According to the founder:

Now what's also helped is the, it seems to have inspired certain people like, they have given us a few awards, which made a big difference. [...]. And all these things, I do not like it, but it is all good publicity, and I have realised that is important, publicity is important.

Strategic decision of developing a customisable and scalable machine: Yet another critical strategic decision of 'Company C' was to make the 'Project C' modular and customisable as per the market's requirements. For instance, in the developed market, reusable soda lime for anaesthesia machines is obsolete. Practitioners and hospitals prefer to use disposable canisters of soda lime. On the other hand, using disposable canisters within emerging markets would be very expensive and therefore they reuse the canister but just change the soda lime granules, which turn from white to blue when they need to be replaced. Thus, the 'Project C' anaesthesia machine offers both options so that it can be sold to either market as per their requirements and budget. This was confirmed by all the participants of the team and was mentioned earlier where the reusability aspects of the design were discussed.

Instinctive entrepreneurial capabilities: According to the founder, entrepreneurial capabilities are crucial for making suitable strategic decisions and being able to innovate a product like the 'Project C'. He further stated that he possesses instinctive entrepreneurial and leadership capabilities, saying:

All my life I have been told that I have got the entrepreneurial ability. I do not really know what that is, I do not try to be an entrepreneur, but I have started a lot of businesses; I just do it, and I do not know, I have never found it difficult. And people say, well, you

just do it instinctively. It is like leadership; I don't think you can be taught leadership, you're a born leader, I do believe you can develop it, but you've got to be born with certain acumens. I've obviously been born with a bit of flair to get things up and running, make things work.

Emphasising the instinctive nature of his entrepreneurial capabilities, he mentioned that he sees many business opportunities for solving existing problems in emerging markets. Consequently, he planned to add other product lines to 'Company C' in the future:

This is the plan in my head, and this is the thing about this entrepreneurial thing we started with, I seem to have an ability to make things happen and push things ahead. Now I have never learned that I just seem to be able to do that, and I think it is important. [...] New Zealanders as a group are actually pretty good, they are very entrepreneurial, you know. But I can see a whole lot of opportunities of how to do things.

Apart from leadership capabilities, he also emphasised administrative capabilities, and considered deadlines as one of the most crucial things in projects such as the 'Project C'. He also said, "You have to be focused, and these things do not happen by accident, it takes a lot of energy you know. And a lot of sleepless nights."

The founder also noted that one of the essential factors leading to successful innovation is having a "passion for purpose". He said that his 30 years of work experience, and in particular the volunteer work that he did in emerging markets had made him passionate about doing something to could solve the anaesthesia machine related problems in those markets. According to him:

You have got to identify a need, and then be passionate about it. No, you cannot be half-hearted about it. What I did, I'm an anaesthetist, and I'm not driven by money, [...] this project is not about making money. That is key. It is about fulfilling a need, and I'm quite passionate about that, that is the motivation, not money, and that is key.

The co-founder was also drawn to this project by a passion for purpose rather than for money. He mentioned that many of his inventions had been simply to help others, not to make a profit. He also mentioned that passion for purpose, persistence and perseverance, and in particular coping with crisis when things go wrong are key factors in the success of their entrepreneurial business. Similarly, the founder also emphasised the criticality of persistence and passion for purpose, and said that the key is to learn from your mistakes and never give up:

You have got to avoid, you have got to, I do not think it is possible to do anything without making mistakes, but I have learned a lot so that I would not do the same things again, you know, that is the big thing.

Other participants were also very positive about the founder's intent and considered him persistent in achieving his objectives.

According to the founder, it is not only the passion and enthusiasm of the founder or leader that matter, but that of the whole team. However, in his opinion, to build that passion within a team, leadership capabilities are essential:

You have gotta keep it simple, you have got to have honest working relationships with people, you have gotta motivate people to actually want to do it. And there's tremendous passion in this, even all our people who work for us, they are all really enthusiastic, you know, and that to me is what makes it work.

The founder also mentioned that to do something different is not easy, and one needs to go through a lot of trial and error, and there will be the occasional bad strategic decision. However, the important thing is to learn from mistakes instead of giving up and losing hope. He described attitude and motivation as key factors for success, saying:

Whenever you do anything, there are always obstacles. I think a lot of people look at obstacles and think, oh that is too hard. I ignore obstacles, coz you can always get over them. Sometimes it's hard to get over them. But you've got to just keep, have the goal in mind, and just keep moving towards it, you know.

However, the co-founder had a slightly different point of view about their journey of trial and error and plenty of mistakes. He felt they could have saved a lot of money by accurately and thoroughly ideating and finalising the design parameters instead of relying on a hit and trial mechanism. However, he also agreed that even with the trial and error approach, they spent far less developing the machine as compared to other companies, who might spend millions of dollars. When other participants were asked about the main reason for the success of the project, they also considered the enthusiasm of both founders as key. Additionally, they acknowledged the core team members' prior knowledge and experience in related areas and their networking capability as other key factors in the success of 'Company C'.

In sum, the 'Company C's firm-level strategic decisions to achieve cost minimisation and value maximisation and to develop frugal innovation included forming a virtual, adhoc and flat R&D structure and management approach; quality control through approaching manufacturers that already complied to first-world quality standards and possessed similar

project manufacturing capability; partially acquiring patents to protect the IP from being exploited by developed market competitors, keeping control over project by holding maximum shares; and for the purposes of maintaining quality, adopting a moral strategy to onboard stakeholders without acquiring free services, developing a customisable machine, adopting the Robin Hood approach, and having limited entrepreneurial experience but instinctive entrepreneurial capabilities.

4.3.3.2. Project-level knowledge integration to develop Frugal Innovation

Integrating developer's existing knowledge and experiences:

The integration of the existing knowledge and prior experience of 'Company C' team members were one major contributing factor in the successful development of the 'Project C'. Both the founders have many years of relevant prior knowledge and experience, which has enabled them to achieve a high-value yet low-cost innovation for emerging markets. For instance, the co-founder has been involved in developing anaesthetic equipment for many years and has also developed his own business around it. He has serviced anaesthetic equipment all around New Zealand and in other countries such as Thailand and the Pacific Islands. Previously, the co-founder had innovated a small, portable, simple, easy to use ventilator and sold thousands of them around the globe. While doing volunteer work in the Cook Islands, the co-founder developed an oxygen concentrator which reduced costs for Rarotonga's hospitals from around \$300 a bottle to just \$12, and which won an award from the NZ Society of Anaesthetists. He has also been involved in developing equipment for the veterinary side of anaesthesia. which, in the 1980s, put an end to the high death toll during embryo transfer in valuable Cashmere goats. The founder spoke about the co-founder, saying he is the multi skilled person an architect, an engineer whereas he himself is the project manager.

In his interview with [name of the magazine] in 2016, the founder emphasised the brilliance of his co-founder. Further in the interview for this research, the founder not only talked about his co-founder's prior experience and knowledge, but also considered his intellect as a key to the success of this project. Comparing himself with the co-founder, he said that while he is good at getting things up and running, the co-founder is the intellect behind 'Project C'. He added:

He's [the co-founder] very, very experienced and knowledgeable. But more importantly, he is just a genius in terms of invention, being able to make things from nothing, he is very, very capable. A very eccentric man, but very capable.

Thus, the co-founder's vast prior knowledge and more in-depth understanding of emerging market needs enabled him to innovate 'Project C' as a sustainable machine that never breaks down and is at the same time affordable for emerging markets.

The founder's prior knowledge of anaesthesia machines and experience of using them in emerging markets also contributed substantially to understanding the first-hand user experience. It helped in developing a more profound understanding of the design and functionality requirements for anaesthesia machines as per emerging markets users and their environmental conditions. In his interview for this research, the co-founder praised the founder's knowledge and capabilities:

Well [name of the founder] more than me because, you know, me having an engineering background I can go around the islands, to Fiji, to Thailand, and I can see machines are broken, but I can fix them, you know. That is because I'm trained in biomedical engineering as well. But [name of the founder] would go there, and a lot of anaesthetists, they are good anaesthetists, but they don't like playing with the machines. And where [name of the founder] went they said oh, all the machines are broken down, the one he used was leaking, and nobody could fix them.

Another participant who was responsible for the manufacturing side sincerely acknowledged the knowledge and experience of both 'Company C' founders as behind the successful development of the 'Project C'. According to him:

So, from the product development point of view, the innovators needed to be absolutely perfect, and these two guys are exactly perfect for this job. They have knowledge in the field. They have technical skills to work with the product to make it actually physically work. They have a very good understanding of the science that is involved and dealing with patient, the risks and everything associated with it.

In summary, the above-mentioned participant emphasised three key capabilities of the founders that brought success to the 'Company C' project. These were: 1) identifying the need through self-experience; 2) the co-founder's fairly typical method of working, as like other medical technicians he understands the procedure for ensuring the machine is working well; 3) the founder's complete familiarity with the process as an anaesthetist. The participant involved in the manufacturing side also brought a vast amount of knowledge and expertise to the 'Project

C', including knowledge around acquiring the CE mark, knowledge of compliances for medical equipment, and, most importantly, knowing the experts and suppliers for various components of the 'Project C', who he introduced to the 'Company C' team, and later collaborated with on various tasks.

The fourth team member joined the team to manage the development of devices for 'Company C', overseeing any troubleshooting and later any services required. With a background in electronic engineering and anaesthesia equipment, he had previously developed a medical device for coagulating blood vessels, which was patented in the United Kingdom. He is trained in technical anaesthetic equipment and had 12 years of experience in this area in Christchurch, where supervised a team of 24 technicians. He has been able to apply all that previous knowledge and experience in acquiring a CE mark for 'Project C'. More significant has been his contribution to innovating the air turbine, the most ground-breaking part of the 'Project C'. Further, he was currently utilising his prior knowledge around patenting medical devices to patent the air turbine. When asked about the skillsets of the 'Company C' team members, he said that it's unique in the way that all the four key team members have a vast variety of knowledge, skills, and experience, and saw this as very significant.

Identifying and approaching the right skillset: One of the approaches through which the right-skilled people for 'Company C' were identified and approached was serendipitous networking. Both founders mentioned that they met serendipitously. They had first met at an anaesthesia conference in Dunedin around 12 years ago. Another example of serendipitous networking was the involvement of the third team member, who was responsible for manufacturing in the 'Project C'. The team member explained that he worked for a medical manufacturing company and the founder, being a medical specialist, was also working for them. This medical manufacturing company therefore introduced and recommended this team member to the founder. This team member commented that he brought with him a huge multi-disciplinary network across various industries. As an example, an informal communication between himself and one of his suppliers of plastic material eventually led to the supplier developing a plastic body frame for the 'Project C' instead of the previous one, which was made of aluminium sheet metal.

To identify and access suppliers, vendors, foreign partners and experts, 'Company C''s approach was mostly based on snowball networking. They first contacted their friends, relatives and colleagues to find the right skillsets. For instance, according to the founder:

I have got a few contacts who are friends, relatives, and I said to my daughter, she is in computers in Christchurch, I said, I want somebody who can do all the software work for me, who is really capable, and who will be prepared to work after hours. And she gave me three names, and that was great. The second thing is we needed to get somebody to do all the design work, because even though we knew what we wanted, you've got to get it all designed, so we had to get a design person. And [name of the person], again, I found him through a friend, who is in that field, and we got hold of him.

Consequently, the software engineer and designer were identified and approached through friends and family. In another instance, the founder identified and approached the right skilled people to provide low-cost yet good-quality electronics for the 'Project C' through a friend who owned electronics company and suggested approaching a company based in Malaysia, which operates under a US licence. His friend assured him of the quality of their products and said that he had some 30,000 PCBs made by them and had never had a problem with any of them.

The fourth team member was a colleague of the founder. The founder was aware of his skills and knowledge around anaesthesia and invited him to join the team in order to integrate his knowledge, skillset and experience into the 'Project C'. Therefore, it was more of an inviting close connections approach to networking. The core team members, themselves holding vast prior experience and connections, also used the snowball approach to identify right-skilled people. For instance, the fourth team member who was responsible for patent matters, said:

I think from my perspective; if I wanted something done, I would draw on my knowledge of people from experience, of who I have had in the past. And if I cannot do that, I will still ask somebody that I know to recommend me, somebody, rather than, I would not trawl the internet, necessarily, to find something, unless, you know, unless it is a component. If it is something that I need doing, that actually is a close relationship. It is like [name of the founder] finding me, I suppose.

The co-founder, being in his 70s, has lifelong experience and networks of friends, colleagues including people in India and China with whom he had previously done business, and in particular, links with hospitals in Thailand. According to the founder, "You have got to have somebody like [name of the co-founder], who has been around, knows a lot of people, and you know, that has been invaluable, absolutely invaluable." However, when the co-founder was asked about his approach for identifying and involving the right skill set, he mentioned you either look on the Internet, or find them in trade/medical/equipment fairs.

Integrating knowledge through collaborative partnerships: After identifying the right-skilled experts, suppliers, and partners for a particular task, acquiring and integrating their knowledge and skills for the success of ‘Company C’ was a huge contributing factor in achieving low-cost yet good quality innovation. According to team member responsible for IP and the CE mark:

We have got a wide variation of skills from different areas, bringing it together. [...] [‘Company C’] has got a number of four people if you count myself that are fully understanding of what the end result of the device is. And I think that is quite significant, really.

To avoid overhead costs and keep full control on the development process, the ‘Company C’ team identified and hired experts on a contract basis. These experts contributed various aspects to the ‘Project C’, such as software development, product design, and the design of the PCB circuit board. For the founder the most important collaborative partnership has been with engineering firm based in Christchurch, who design, develop, manufacture, market, and distribute products for their customers. The founder considered this partnership a big breakthrough in their project:

The big breakthrough really was there’s an outfit called [name of engineering firm based in Christchurch], and they make hi-fi gear, and he was very keen to get involved with us. So, now, he is manufacturing the whole thing, from beginning to end, in his factory, so that is great for us now.

The co-founder named the collaborative partner in Malaysia providing electronics, saying, “Well we are getting some electronics made for us in Malaysia now, and that is owned by an American company. And obviously they go there for the cheaper labour cost.”

Three of the four participants including both co-founders explained that originally a sheet metal company was tasked with making the initial model of the ‘Project C’. Later the ‘Company C’ team realised that the cost of manufacturing could be further reduced, and the quality maintained, through the use of vacuum moulding to create a plastic body for the machine. Both suppliers (of metal and plastic) were also the suppliers for engineering firm based in Christchurch, and were introduced to ‘Company C’ by the CEO of engineering firm based in Christchurch.

The third team member, who was responsible for manufacturing, said that his team had brought in and integrated their in-house capability and knowledge into the ‘Project C’. He further emphasised his contribution to ‘Company C’ in the following words:

We have manufactured componentry for three early prototypes that are going to Thailand for clinical trials. And so, from an operation point of view, that is what our company has brought to the project. And in addition to that, we are experienced at understanding and managing compliance, so this a unit that will interface with a human being in a position where their life could be at stake.

The co-founder explained that for the flow meters within the ‘Project C’, he found and contacted a Chinese company who were making flow meters for an American company. According to him, this collaboration has substantially reduced the cost of the ‘Project C’ without compromising on the quality:

You cannot say, you know, everything from China is junk because it is not. If the factories are supervised by foreigners and they have got good machinery then it is good, they will not cut costs. The only thing that can save is there’s a labour cost.

Additionally, the monitor for the ‘Project C’ is also made in China for around a quarter of the price of the alternative monitor available in the market—and at the same quality. The ‘Project C’, however, utilises a modular design, which is why any monitor can be attached to it. Another crucial collaborative partnership has been with the University of Canterbury and Auckland University of Technology. A group of students were hired on a six-month research contract to develop feasibility around the use of CPAP (continuous positive airway pressure) technology as the heart of the ‘Project C’ and, according to the founder, due to that report the initial idea was considered doable.

Integrating knowledge to achieve alternative material, alternative design and design for manufacturability: After rigorous thought and design efforts, the ‘Company C’ team decided to come up with an alternative design for an anaesthesia machine to minimise the cost and maximise the value of the product for emerging markets users. Another reason for developing an alternative design was to keep the machine very simple, portable, rigid, and sustainable. As the co-founder said, “By design and the materials that you select you can get the price down. And of course, that has brought the price down a lot in that case.”

The founder also explained that even though they had outsourced parts and materials from around the world, including China and Japan, all the design work was done in Christchurch, New Zealand. This is significant because the design work was done in the developed world for emerging markets according to the needs of users and the requirements of the resource scarce environment. According to the founder, “We actually manufacture quite a few of the

components here in Christchurch. [...] but we have done all the design work here in Christchurch.”

One of the major elements incorporated in design efforts is simplicity. Accordingly, not only has the number of parts been reduced, but the design has been made simple to use and easy to maintain. With reduction in parts and simplicity have come portability, which creates huge market potential. Above all, the design had been made to be fail-proof. When speaking of these substantial changes in design and functionality, the founder said:

What’s transformative about this machine, [...] these anaesthetic machines need compressed gas to drive them, to drive the ventilator, so they operate cool, it is called a pneumatic system. You get, you plug it into the compressed gas in the wall, and it drives the machine. What we have done, which is really different, is we have got a high-speed electric fan, and it is made in Japan, and we doctored all this, so that can plug into the wall, and drive the ventilator. Now, so you do not need high-pressure gas, which is a big saving, and also it would work if you are in an ambulance, or whatever. But the thing about that is when we plug it into the wall, it comes via a power pack in this machine, so if the electricity was to fail, as it often does in emerging markets, that should keep the ventilator going for several hours. So, it is completely self-contained, and then, of course, you can take over and do by hand, if you are, if everything fails.

All the team members agreed the ‘Project C’ utilises a modular design. For example, it is designed in such a way that any monitor screen can be used simply by installing the software needed to operate the screen, whereas most machines in the developed world have a built-in, integrated monitor screen. According to the co-founder, “Any monitor can be attached, and we just offer it as an option, some companies will not be able to afford it.”

Regarding the modularity of the design, another participant also mentioned that almost everything is an individual module and easily replaceable:

So, the other idea that it is design is, if there’s a failure in that, it is just bolted onto a chassis, the whole box. So, you just take the box out, put another one in very quick, and just connect your hoses on [...]so any of these components, right down to the hose connections, you can virtually send the part, and they can just replace it very quickly, and it is all.

The participant further mentioned that even though they buy some parts such as flow meters from China to keep the cost low, they have made the design modular enough to switch to another supplier if necessary to maintain the quality.

All the participants pointed out the unique element of the design that is to be patented, namely the miniature air turbine. This is far cheaper than a high-pressure gas system built into a hospital wall, which could fail in an environment with a lot of electricity disruption. In addition, the machine also needs to be user-friendly, as even though the back-end process has not been straightforward, the user interface is. In his interview, the co-founder also described that overall design, and in particular the turbine, as unique, and further that the turbine design is more compatible with the resource scarcity typical in an emerging market environment. He explained that a lack of oxygen tanks is a common problem in emerging markets, and therefore the idea of an air turbine is of great value.

All the participants explicitly mentioned the reusable and customisable component of the design in the form of the disposable soda line canister, which also enabled cost reductions. They explained it is designed so that it can be used as a disposable canister in the developed world as per their regulations and market demand, whereas in emerging markets it can be reused, leading to a substantial cost reduction. One of the participants compared the cost-effectiveness of both approaches, noting that users in emerging markets can just top it up for less than a dollar, whereas the disposable unit used in developed countries cost twenty dollars.

Apart from keeping all the costs low, the founder mentioned that even though they have put a relatively expensive blower in the 'Project C', because of the many other parts they have acquired cheaply, the design still offers advantages from the perspective of simplicity, quality, and cost. He further said that the decision of going for the CE mark also helped decisions around taking out parts they thought could be removed. According to him:

That has (preparing for CE mark) been a great thing for us because we have gone through everything, said, well, we do not need that, we can chop that out. And we've simplified it and rationalised it, but always kept it safe and simple and reliable, you know.

In addition to the alternative design, cost minimisation has also been achieved through the use of an alternative material, such as switching from handmade aluminium bodies to ABS plastic with vacuum mould manufacturability, as described by the founder:

So, each of those aluminium bodies had to be made by hand, and that was costing us about \$1400, New Zealand, to make. This, these reproductions cost us about \$100, so that is a big saving.

Other participants also mentioned that switching material was the best decision they made, as it improved the quality and fitness for purpose of the 'Project C'. Plastic is the usual material used in these types of devices worldwide, and it is sturdier. The participants also mentioned

that changing the material from metal to plastic was not just for manufacturability, but also mainly because of cost. As one the participant said, “We have moved from metal for design continuity reasons, but also for cost.”

The co-founder explained the manufacturability benefits of ABS plastic as compared to aluminium. Plastic material can be vacuum formed, which is a low-cost manufacturing technology; it minimises material wastage while at the same time increasing the speed of production. The participant responsible for manufacturing also explained the issues around the manufacturability of the ‘Project C’ using metal sheet. He commented that is much more expensive as it requires a lot of trade skill and time, and there are greater margins for imperfection as well as differences in each piece of sheet, which is why it was much better to opt for plastic material. According to him:

And it becomes the critical path for two things. One, because of the amount of skilled labour that are able to do it two. The length of time it takes to make each one. And, so it was a much better idea to have it in plastic.

Apart from its manufacturability in terms of cost, and sturdiness, the alternative material also contributed in achieving portability. According to one of the participants:

So, it has got a battery in there, which are nickel metal hydride battery, not a lithium battery, because obviously it is transportable, so we do not want a lithium battery there, sitting in an aeroplane. So, it is a nickel metal hydride battery.

All the team members emphasised the iteration and reiteration process by which the prototype was made, and how they kept on rethinking other ways of making it simpler, more sustainable, efficient, and cost-effective. However, the co-founder said that in their iterative innovation process to achieve the desired specifications for the ‘Project C’ anaesthesia machine, the cost and time could have been further reduced if they had done more planning and design work before they began prototyping. However, he acknowledged that their do and fix approach, and strategic handling of the innovation process was still far cheaper than what other companies spend on their innovation processes.

Integrating existing technological knowledge: ‘Company C’ also lowered the cost of the ‘Project C’ through using existing technological knowledge, which enabled them to incorporate lean manufacturing concepts throughout their innovation process. Foremost was the use of the existing technological knowledge of the previously invented ventilator, which became the primary building block and the core of the ‘Project C’. Apart from that, the air turbine

developed for the 'Project C' was achieved by reverse engineering several turbines and existing ventilators. The final innovative air turbine used in the 'Project C' got its core idea and technology from the existing HDMZ1 ventilator. According to the participant responsible for regulatory matters, "Well, there's a number of Japanese companies that make turbines, and there's American companies that make turbines as well. But we found that really from disassembling the HDMZ1."

The 'Company C' team also used inventive analogies on multiple occasions, both from within and outside the industry, such as the example of the air turbine described above. One team member mentioned that the initial idea came from the air turbine that is used to blow up air beds for camping. As he said, "It is also a turbine that's used for just blowing up beds for camping as well." Another example of using analogies from within the industry relates to the utilising the technology behind CPAP as the heart of the 'Project C'. Use of existing manufacturing technologies such as vacuum forming also substantially contributed to achieving cost reduction. Finally, 'Company C's collaboration with research institutes enabled them to make use of rapid prototyping technology, which contributed to improving the functioning of the 'Project C' and assisted in brainstorming towards stripping down the price by changing its design, materials and a number of components.

Integrating customer knowledge: Traditionally, when someone wants to develop a product, they first do the market research to determine customer needs and then make it. However, the founder's approach to conducting market research was the other way around, mainly because he had lived the customer's experience as an anaesthetist working in emerging market hospitals. As the founder said:

I have done it the opposite way. I have decided what I think the customer needs, and I have built it. However, I, in a way, am the customer, because I am the anaesthetist, I have built something I like.

Later, to broaden their market research and understanding of customer needs and wants, the founder also talked to other anaesthetists and let them trial the machine:

And we have done a trial here at this hospital. [...] And that was very gratifying for me because I directly recruited about four of my colleagues, who I had a lot of respect for, very capable. And I showed them how to use it, and they loved it. And that to me was the most important thing of all that these people who I respected, they were not just telling me what I wanted to hear, they said, I really like this. You've gotta remember, it is what

it is, it's a bit like if, these fellows probably drive Mercedes Benz and BMWs, and I've given them a Toyota Corolla to run. Well, of course it's different, you know, but there's nothing wrong with a Toyota Corolla, you know what I mean.

The founder said that he received useful feedback about minor things such as about making it more user-friendly, but overall the users were happy with the 'Project C'. Moreover, the founder mentioned that he enjoyed using this machine, not because it belonged to him but because of its simplicity and ease of use:

[...] I've found, having used this machine, it's a lot more hands-on, it's not automatic, but if I was told for the rest of my time in anaesthesia I had the choice of using this machine, or the one up [advanced one], I would use this machine. I find it more interesting, it is great, you know, it is like driving a fully automatic car with all the bells and whistles or driving something simple, and manual. I really prefer to use it ['Project C'].

When the participant responsible for regulatory matters was asked about 'Company C''s approach for identifying customer needs, he also mentioned this occurred the other way around, as explained by the founder. However, he said that this approach worked for them because it's a niche product with standards and regulations that must be met during development and use. According to him:

It would not be enough, as I said, if it was not a niche product, for one individual to make a decision [...]. But because, it works within a regulation and its niche, and, you know, everybody uses them the same, and that is an important safety aspect of those devices anyway that principally, you should be able to use it without an instruction manual.

With regard to user feedback in terms of product improvement, he said some of the minor aspects mentioned could not be changed, mainly because things within medical devices that are standard cannot be changed. He gave an example of user who asked for different coloured flow meters. However, this was not possible due to the regulatory requirement for white with black, or in America, green.

The team member dealing with regulatory matters believed that clinical trials were essential to have user feedback and to bring improvement to the current version of the product, and to confirm its functionality. The founder mentioned that the clinical trials would be done in Thailand for two reasons. First, the co-founder has good relations within Thailand and is well aware of the regulatory requirement, and secondly, the regulations allow for such clinical trials.

In sum, to develop frugal innovation, ‘Company C’'s project-level knowledge integration activities focused on cost minimisation and value maximisation from the consumer’s perspective. The knowledge integration activities included both internal and external knowledge integration. The internal knowledge integration included the prior knowledge of developers and knowledge from prior prototypes. The external knowledge integration included identifying and approaching the right skillsets; achieving alternative design, materials, and manufacturability; and integrating the knowledge of collaborative partners, technology knowledge, and customer knowledge.

4.4. Case 4: The ‘Project D’

4.4.1. Company profile: ‘Company D’

‘Company D’ was founded in 2015 and registered in Australia in 2017. It emerged out of a company in Papua New Guinea [here after PNG], which was founded in 2001 and had been manufacturing and supplying agricultural machines and renewable energy technology in PNG and the Pacific region. Initial work towards the case project was done in PNG, when a first-generation product was developed. However, the second-generation frugal innovation product called the ‘Project D’, which has a solar power solution, is being developed under ‘Company D’, and all the R&D work is happening in Australia.

The founder of the company, a civil engineer, has spent many years working as a volunteer in the Pacific Islands due to his philanthropic drive and desire to work for an underprivileged population in an emerging market. The initial work of the company in PNG was designing and manufacturing a small machine for use by the local community within their homes that could expel oil from coconuts and a local seed called *Jatropha*. From there, the company in PNG flourished to become an innovative small engineering company. Inspired by the work of the company in PNG, the Asian Development Bank contracted the company in PNG to design a rice mill for PNG, as the current mills were very expensive at around 23,000 kinas at that time for a small rice mill. The Asian Development Bank recognised the potential for a rice growing industry in PNG as it had already become part of the staple diet. However, very few people were growing it, and 99% of the rice consumed in PNG was imported from overseas. Thus, the idea was to come up with a low-cost, affordable rice mill that would encourage the local community to grow their own rice. After redesigning a small, low-cost rice mill, the company in PNG were awarded a contract by a start-up company to manufacture and test their solar power systems in PNG. Their experience of designing and manufacturing the affordable rice

mill, oil expeller and solar power system for an emerging market, along with close cultural observation and familiarity with the needs of the local community, led the company in PNG to approach ‘Company D’ with the idea of developing an affordable, modular, customisable, portable, sustainable, and solar-powered agricultural machine called the ‘Project D’.

The founder and director of ‘Company D’ mentioned that immediately after the birth of the idea of the ‘Project D’, the team proposed it at the Climate Challenge programme in Paris, and not only became one of the prize winners but also attracted lots of attention and a tremendously positive response. Additionally, agencies of the French government also showed substantial support by providing millions in funding upon the launch of the product in Africa.

As the founders explained, they therefore continued to fund the company in PNG to finance the new venture—‘Company D’. ‘Company D’ now has five core team members. Two core team members are also founders, and both have multiple tasks such as director, operations manager, and handling the finance and marketing. The other three members have sole responsibility for R&D, manufacturing and sales, respectively.

Currently, the R&D and design efforts of ‘Company D’ are based in Australia, while the manufacturing for ‘Company D’ happens in factories in China, which are all owned by a sister company of in PNG. The primary objective of ‘Company D’ is to create opportunity from adversity by providing innovative solutions with multiple aspects, including “social” by empowering the community and creating jobs for them; “economic” by making a profit, and “environmental” by incorporating solar energy instead of diesel. Thus, the company’s aims to provide solutions that are fit for purpose and the environment of emerging markets.

4.4.2. Frugal innovation project: The ‘Project D’

Market research & problem identification: The existing problem of a lack of affordable agricultural machinery and in particular rice mills was not only identified by the founder himself through his years of volunteer work in the region but was also highlighted by the Asian Development Bank. It was apparent that rice was a staple food in the region, yet 99% of rice was imported. The local people were not growing rice even though the climate was perfect for rice growing. The founder identified the reason as the unaffordable cost of rice mills. Even though the Asian Development Bank had already done some work on encouraging people to grow rice, they were having to mill the rice using the TomTom, which is a mortar and pestle made of wood. The founder explained that it was very hard slow process and produced poor quality rice, which was not liked by the local people as they were already used to commercially available rice. Moreover, he explained that almost none of the companies in PNG were willing

to import and sell rice mills at an affordable price. Instead, the few companies that showed an interest in importing and selling rice were marking the price up by 500 to 600%. The founder of 'Company D' mentioned in his interview for this research that the above-mentioned situation created an intense need for affordable and locally manufactured rice mills in PNG.

The 'Company D' team also identified the problem of inadequate infrastructure in PNG as a barrier to manufacturing their own rice mill. For instance, there were no smelter works or foundry, in particular a cast iron foundry, which is crucial in the manufacture of machinery as it can bring the cost of the machine down by casting the components. He further explained:

So, a piece that on a milling machine might take two or three hours to mill down and manufacture, and costs say 20 US dollars with all the inputs. In a smelting works, a foundry in China, that same part could be produced for maybe one dollar. But of course, if you have not got a foundry, you cannot do that. So, we had quite a challenge, and the Asian Development Bank said that the rice mills on the market at the time were about 23 thousand kinas. They needed us to manufacture one for less than five thousand.

The founder said despite all those issues, they still managed to manufacture 25 machines of the first design for less than five thousand kina each, and which sold out very quickly. However, this exercise demonstrated to them the pressing need to change the way agriculture was running in emerging markets. The founder said, "We basically run agriculture in emerging markets in a very inefficient way and a very un-green way. Most machinery in the third world runs off of filthy dirty diesel engines."

There was an obvious need to provide alternative green and more efficient ways. Thus, they took the initiative of linking solar energy with agricultural food production. However, the founder explained that linking these two was a problem as the agricultural machines required 5.5 horsepower, which was easy to generate through a diesel engine, but very expensive to produce through a solar system. The co-founder pointed out the same issue for the already existing rice mills, as they lack mechanical efficiency and are expensive to run due to their massive size. As he remarked about the existing machines in his interview:

When those [old and existing agricultural machines] machines are designed, they are not designed with efficiency in mind. They are not designed with mechanical efficiency as the priority, because it is just very easy to put on a larger engine or a larger motor.

Apart from all the issues related to coming up with an alternative in this market and its pricing, the 'Company D' team put a lot of effort in to identifying the needs of the community and the environment before they started designing the grain mill. Both founders not only

brought in their own experience of living in that environment, but also utilised market research organisations and NGOs from other countries. For example, the co-founder named some of the countries from which they gathered information related to market requirements. These countries included Indonesia, Kenya, Bangladesh, Zambia, and Vanuatu. More details of the organisations involved are provided in later sections.

On the other hand, the founder mentioned that the information they received was at times conflicting, mainly because of the diversity of the region. The founder further explained that they learnt a lot about their target market and realised that many of their original assumptions needed to be changed. Similarly, the team member substantially involved in R&D and designing of the product said, “We try and get into the perspective of the person who’s going to buy and use the product.”

Another critical challenge that arose during the problem identification and market research phase was in relation to the three main players in the rice industry in PNG. Because of their vested interest, they had communicated to the local community that they could not grow rice locally. According to the founder:

And it had been publicly posted and declared through all of that work that rice would never grow in Papua New Guinea, it was completely uncommercial, unsustainable and the environment did not work for it as well. Now obviously we now know that that was complete total market protection.

Thus, changing this false perspective and the resulting mindset of local communities was another challenge facing the ‘Company D’ team.

Solution and product description: In order to solve the existing problem of a lack of affordable rice mills and to create opportunity from adversity, both founders started ideating an affordable and efficient alternative. They realised that the reason existing manufacturers were not developing smaller machines was that the cheapest drive motor the manufacturer could get produced 2.2 kilowatts of power, and if you go for less horsepower, it gets more expensive from a manufacturing point of view. Therefore, every agricultural machine manufacturer was making 2.2kw of power rice mills. The founder further ideated that the machine needed to run on a solar system instead of diesel or any other fossil fuel, so the solar system also needed to produce 2.2kw to power the large existing machines. They realised that the 2.2kw power was the root cause of not having smaller machines for villagers with a driver motor producing less kW of power. Thus, the founder figured out that the users of those machines in PNG do not actually need that amount of power, as they do not need to operate at the same level of

production and capacity. He thus came to the conclusion that they needed to get the driver motor at the lowest possible cost. The founder explained this through the following example:

If you are in a village and you need to process say 50 kilograms of rice in a day, does it really matter to you whether it takes 30 minutes, or it takes one hour? At the end of the day you just need that rice, so the production capacity of the machine is very often not that important to you.

The founder further explained that here a cost-benefit analysis was crucial to convincing the community to purchase their own rice mills, saying that was when they started looking into solar power and lower wattage usage of the machine to solve the problem of unaffordable, un-green milling machines:

[...]. But once you start looking at solar power, obviously if we can reduce the size of the machine. If we can reduce the wattage usage of the machine, but still give our customers, our clients what they need, which is a hundred kilograms of rice at the end of the day. But we need to do that by reducing the overall cost and the consumption of that solar system. So that is what we started looking at.

So, the initial prototype the ‘Company D’ team developed was mainly due to an ambition to see how much they could reduce the power of the driver motor. They therefore started purchasing agricultural machines, disconnected their DC motors and tried them with AC motors and inventors. After designing a few prototypes and after returning from Paris where they had presented their prototypes, both founders made the decision to launch the first range of machines in PNG. After the success of the first generation ‘Company D’ machine, the ‘Company D’ team decided to innovate the second-generation machine completely from scratch with the idea of having a smaller machine run by a solar system that does the job using less wattage with an overall reduced cost. The founder explained that to build such a machine they needed to completely rethink the design:

What we realised was that it meant that we needed to rethink and redesign the machines. We could not just keep picking machines off the shelf and then fitting, you know attaching them to a renewable energy system.

Thus, the second-generation machine was named the ‘Project D’. From the very beginning they had identified core issues of a lack of affordability and efficiency, they decided to achieve both in ‘Project D’. The ‘Company D’ team described the ‘Project D’ as a multiple-crop machine with interchangeable milling heads for multiple functions such as hammer mill, pin mill, disk mill, flaking mill, and flour production. It is an adaptable and inspirational

alternative to diesel mills, incorporating maximum affordability, efficiency, ease of use and sustainability due to the minimum or no maintenance required. As the co-founder explained:

So again, it is this idea, a customer can start with a base machine and get value out of that, and that might work perfectly well, and they are happy with that. But then if they want to go to the next level of kind of professionalisation they can add another component which will be perfectly compatible with that base machine, and it will feed into that new component which will do, say, grain separation.

Consequently, the 'Project D' has a smart solar control box with 24V outlets that can power milling machines, clean water supply, small businesses or a nano grid. The solar system is expandable with a simple plug-and-play system to add solar panels, batteries and other machines. Thus, it is a modern, clean, robust, modular and customisable design that facilitates micro-farming and empowers disadvantaged communities within emerging markets. When the founder was asked how he would describe the 'Project D', he said, "A very practical and smart innovation at an engineering level." Similarly, the co-founder believed that running the machinery on solar power can drastically improve mechanical efficiency, saying, "Well certainly with some of the machines like the hammer mill flour mill, we expect that we can improve the mechanical efficiency by 30 to 50 per cent compared to the existing ones." When the founders were asked about the price of their machines, the co-founder said:

You have got to understand, PNG is a really weird economy. Everything is expensive there, there's a massive security problem so we priced the system at, you know, based on the context of the country. We would be hoping in the future that it would, we could sell it for half that price.

The co-founder further explained that at the moment they are not making a big profit from their first-generation product. However, for the 'Project D', which is more innovative and improved, they are seeking a good profit margin. He also said that both from a company's and consumer perspective, their plan is to concentrate on the design and manufacturing of the machine. They won't be selling solar panels or batteries etc. and therefore the pricing will vary. As he said, "Our current pricing is not representative of what our future pricing will be."

When the team member responsible for design work was asked about the pricing of 'Company D' machines, he had a different opinion. For him, the price can be only be reduced to a certain level before the functionality and quality of the product are compromised, and for the rest, the 'Company D' team needs to focus on the marketing and selling strategies, such as whether they rent machines to farmers or sell them by instalment. As he said:

And then really, the price is the price. Once you've done that, you do not want to compromise functionality too much. Otherwise you are starting to eat into acceptance. [...] and then it is going to come down to how clever they can get to sell that in, and there's a lot of different ways to sell it in.

He also explained that in 'Company D's' case, setting the price for the milling machine is a challenge as everything is from scratch. Putting the R&D, the design and the lean manufacturing concept all together could land them on some price that cannot be known until the project is finished. However, the 'Company D' team still settled on a price structure which was tested in the market. He said this approach is quite the opposite of more advanced markets with existing products, where the company already has precedents for the price.

When the founders were asked about the market potential of their innovation and the primary target market, they mainly mentioned both PNG and the African market. The co-founder further said that in PNG approximately 75% of the revenue generated for 'Company D' is from sales through PNG's largest rice producer and rice trader company, and the remaining 25% has been in partnership with an NGO who will be their first main customer, and responsible for the marketing and sales of 'Company D' machines in Vanuatu and Indonesia. He further explained they have also sold some sample machines to partners in Kenya, Zambia, Nepal, Bangladesh, and India and therefore they could also be potential target markets in the future. Moreover, when he was asked about the market potential of their product in developed countries, he explained there could be a very niche market for the mill say in New Zealand or Australia, but added, "[...] but really it is all for developing markets." He further said that the process of grinding or threshing is not new to humans and therefore they do not want to reinvent the wheel with their process. Instead it is a purpose-built design for those emerging markets and less wealthy customers:

This is the thing about what we are designing. It is designed like its purpose-built and designed for those markets, and for our intended customers. And we are doing that because there's nothing, there's nothing out there like that at the moment.

4.4.3. Activities enabling capabilities for doing Frugal Innovation

4.4.3.1. Firm-level strategic decision-making to develop Frugal Innovation

The strategic decision of forming a virtual and flat R&D structure: The R&D of 'Company D' operates virtually through fixed relationships with their collaborative R&D partners based

in Australia to outsource its product design, marketing, and sales activities. Therefore, 'Company D' does not need many permanent staff and has limited to none onsite R&D activity. When the founders were asked about the number of team members, they said that in the beginning it was only the two of them plus a collaborative partner who was helping them in their marketing and distribution efforts. However later they engaged other people and organisations by having a virtual-fixed and commercial relationship with them in order to acquire expert knowledge and resources. Consequently, their organisational structure is composed of distributed team members based at various locations and who have different roles. As such, the collaborative partner who runs the product design company and co-founder are based in Australia, whereas the founder and operations manager are based in China. As the co-founder said, "We have like a factory warehouse, a logistics base in China, and we have two permanent staff there, and we also bring in some casual staff when we need them."

Considering the virtual communication nature of the R&D and design effort, the founder was asked about the means and modes of communication, in particular what approaches, techniques and mechanisms they used with the 'Company D' team being based in various locations. The founder explained that it was mainly email and Skype. He added that they were not using any particular communication technology that could facilitate communication errors. Because the 'Company D' team has outsourced the design work, the founder believes that better technology is crucial. He also explained the communication challenges the team face between Chinese and English-speaking locations. These communication issues at the time caused unnecessary delays, and therefore he prefers to be close to the team, or at least be based in same geographical location. As he explained:

We found communication to be very, very difficult [...]. Trying to do it over Skype can be incredibly frustrating, and backwards and forwards with e-mails. That sort of inter-reaction, you know the design work, the work where you're talking about ideas as much as you are about, you know actual physical decisions, it can be very, very frustrating and difficult.

When the product design company team member was asked about a particular technology they use for virtual communication with their clients, he said they are not using any particularly sophisticated technology as its mostly just screen sharing and videoconferencing. However, he also mentioned using a programme called TeamViewer, through which they can take control of client's screen.

The founder explained that, for now, he has no strategies to cope with communication difficulties, but in the future he is keen to change some of his working parameters, in particular,

having all the collaborative partners based within a hundred miles of each other. He believes that proximity of the collaborative partners would strengthen the relationship and communication. As he put it, “[to] have a cup of coffee with, and talk to, is infinitely more valuable than somebody who is on the other side of the world”. However, the product design company team member had a completely different response as he believed that in some cases being very close to the client and frequent communication slows down the process. He said, “But, you know, the client sitting here every day does not speed things up, it slows things down profoundly.”

When the product design company team member was asked about communication challenges and his strategy to tackle them, he explained that at the product design company they have documented internal practices, according to which they need to be contacting the client twice a week regardless of whether they have anything to say. It is just to build the relationship. As he said:

There’s a lot of relationship building that goes on with the communication, so we always try and build a relationship that is strong enough to communicate what everybody needs. But also, strong enough to deal with the errors and the mistakes and the frustrations that people feel and have. Because it is inevitable, it is absolutely inevitable in a design and development programme; you’ll annoy your client at some point. So, all of that stuff is really about the frequency of communication.

He also mentioned that it is important to understand that their usual way of communication is that the client comes to them and sits and discusses the specifications of their product with them for a couple of days. Other times it's through skype and emails. Moreover, most of these communications are to extract the specifications from their client, which is a live document on which every decision with the client gets recorded. He added:

But fundamentally we are the ones extracting from them a decent specification because they do not know what they want really. They know what they would like, but they do not know what’s possible.

Strategic decision of conducting R&D in Australia: Another critical strategic decision by the ‘Company D’ founders was organising and outsourcing the R&D and the design work in Australia, as they had identified advantages for claiming back money and acquiring funds there. The founder explained that initially, the main reason for registering their company in Australia and conducting their R&D and design activity there was to be able to claim reimbursement for

the cost of R&D. With regard to the strategic decision of registering ‘Company D’ in Australia, the director gave several reasons. Firstly, the co-founder was based in Australia. Secondly, they realised that a lot of grant funding and any monetary support was coming out of Australia, which was very important for them as a start up with scarce resources. Thirdly, because they were paying for all the R&D work, they could claim back up to 40% of that cost by having the company registered in Australia; otherwise they are couldn’t claim that money back from the Australian government.

Strategic decision of keeping control over the project: Another critical strategic decision of the ‘Company D’ team was to keep control over the business to maintain the assurance of good quality. Both the founders of ‘Company D’ mentioned that keeping control of ‘Company D’ meant they were not open to external advice or expert knowledge, but further they were keen on finding their own personal designers and software engineers and made their own arrangement for handling ISO matters and other big ‘Company D’ related decisions. So, at the moment, both the founders have kept the shares to themselves at 50% each, but the co-founder explained that this would change very soon as they are keen to bring in another team member. The new shareholding options will be 20% of the company equity. He said, “If [name of the founder] and I can hold 26 per cent each, that would be good, and then the remainder for an equity investor. But we have got to see how that plays out.”

Strategic decision of approaching manufacturers who possess ISO13485/FDA approval/CE Mark accreditation & in-house manufacturing capability: In line with strategic decisions around quality control, the ‘Company D’ team remained very particular about identifying ways of reducing cost by not themselves getting into the expense of obtaining regulatory compliances. They explained this was one of the reasons they set up a factory in China as they found Chinese manufacturers very capable and it was a much cheaper option as compared to manufacturing in Australia, while still complying to all ISO standards. The co-founder emphasised the importance of having suppliers who were already developing motors with CE standards. As he said, “For example, the motors we are buying already come with the CE standard. They are made in China, but they are also sold under another, a brand for European market.”

Further, the ‘Company D’ team acquired the in-house research and design capabilities of their collaborative partner the product design company, which substantially contributed to minimising their costs and maximising the value to their product. As the co-founder said:

So, you know, [name of the product design company] have an ISO9000 rating, so you know, like the machines and products are going to be designed to what would be considered Australian standard. [...] They have got all the design, industrial design people in the house.

The team member from the product design company also said that their team is well rounded and has experience across various things. Therefore, it possesses the in-house capability to do all sorts of projects. He also mentioned that they are a 9001 accredited company, which means they have a documented process of complying with standards and regulations.

The strategic decision around acquiring intellectual property: Another strategic decision of the ‘Company D’ team was around patents. The co-founder explained there is no other machine out in the market that has been purpose built or designed to run on DC motors, which is why he believes that they are the first company to do this. He said; “At the moment we are the only company that we know of internationally that are making dedicated DC powered agro-processing machines that are designed to be run off solar power.” Nevertheless, the co-founder explained that ‘Company D’ has no plan for patenting and at the moment everything is open. Instead, they have another strategy to cope with their potential competitors:

Yeah, so we have shared everything very widely with our network. The risk is that someone copies us, but we think that already we are, if someone copies our old stuff, our new stuff coming out is going to be so much better than the old stuff it does not matter.

However, the co-founder also mentioned that the ‘Company D’ team might get a patent at some point in future as their new design for the ‘Project D’ will be their own proprietary design. As he said:

With the new products we are developing, which we call our second-generation products, they are the products we are, developing in partnership with [name of the product design company]. So, they will be our own proprietary design.

The product design company team member, however, had a different opinion about IP, saying that up until that point, ‘Company D’ had nothing to protect and nothing novel has been done. He said:

It is just a good purpose-built focus design. So that does not mean, that you cannot patent it. You can get design registration if they want, we have talked about that. But for the moment they are just concentrating on getting them out there.

When the product design company member was asked if they will be playing some part in IP protection for ‘Company D’, he gave a clear ‘No’, saying it would be a free service for ‘Company D’, but for some of their projects they do maintain and own the IP, but these are their own products. However, if they are getting paid to do the work, the intellectual property they create goes to the client who has paid the bill.

Strategic decision of developing a modular, customisable, scalable and sustainable solution:

One of the essential strategic decisions of the ‘Company D’ team has been to build the ‘Project D’ to be modular and customisable as per market requirements. The founder gave the example of rice growers in remote places in Africa who need two machines to achieve finished rice, a rice huller and a rice polisher. Now they will be able to buy one machine and two interchangeable heads for hulling and polishing. He further explained that Africa is a huge place and there are vast differences in their eating habits. In some places, they use wet cassava and eat it as a wet product, whereas in other places they prefer to dry it and use it as a flour. Accordingly, the ‘Company D’ team will be looking at two different machine heads to provide options for processing the cassava. Another example of modularity and customisability is interchangeable heads. As the founder said:

A couple of the machines will have interchangeable heads on them, so for instance once; we aim to introduce a very, very efficient Hammer Mill. But that Hammer Mill will also be able to change over to become a Plate Mill or a Rice Mill.

The co-founder noted that different regions of Africa prefer different textures of flour, and therefore a customisable machine is crucial to be successful in this market. He also explained that this modularity and customisability increases the value of the machines for the farmers as at any stage they can buy an extra module to add to their existing set. The co-founder also explained that another benefit provided by the modular and customizable design is having both AC and DC versions. Since miniature AC machines coupled with a solar power system don’t currently exist for agricultural purposes, he believes their small AC machines are going to be better than any other alternative in the market. Moreover, when the product design company team member was asked about any particular strategic decision of the ‘Company D’ team that had led to cost minimisation and value maximisation, he also said that the modular design was key.

All the participants emphasised increased market potential as a result of the modular and customisable product. From the perspective of sales, the co-founder also explained ‘Company

D's micro-financing plan, and how the farmer is going to earn back their invested money within a year. The farmer's only cost then will be the maintenance cost. He explained that the batteries need replacing once in every three to four years, and some tiny internal parts may need replacing due to wear in six months to one year, depending upon use. Therefore, he believes that for customers the actual payback period will be two years. However, he also said that for the 'Project D', they're mainly focused on making the machines sustainable, so it requires less or no maintenance.

Strategic decision of adopting a "Cost-Driven" approach: The founder explained that for a start-up company to be self-sustaining requires making use of scarce resource and strategies that will enable substantial cost reductions from the production side. Therefore, the 'Company D' team decided to build a manufacturing site in China to reap the benefit of cheap utilities and low labour costs. He also explained that for a Western firm, setting up a factory in China is a very complicated process, which is why they decided to sub-contract with the now operations manager of 'Company D', who is a Chinese national and who already runs a factory in China.

Another approach through which the 'Company D' team tackled an initial lack of resources was to launch a trimmed down version of their innovative product to fund the main product. This not only helped in financing the project of the 'Project D', but also facilitated in acquiring specific regional feedback from customers. Consequently, this brought improvements in the ongoing innovative project. As the product design company team member said:

We have finished a cut-down version of the new product and have given them all that data. And they are off getting that made, that is the unit they are talking about. And what will happen is, we will learn from that.

Speaking of the Cost-Driven approach, both founders mentioned that in every strategic decision they have taken related to R&D location, design, manufacturing, marketing, sales and distribution, they have carefully thought of cost reduction, primarily because of the idea of a frugal product, but also because they were investing their own money in it. As the co-founder said:

I suppose what shapes our idea of frugal manufacturing; one is that we have self-funded everything to date. So, when it is your money and not someone else's money you are a lot more careful with it, and you try to get as much out of it as possible.

The strategic decision around inspired publicity and adopting a “Moral Strategy”: One of the important strategic decisions of ‘Company D’ is “inspired publicity”, which they have used to get collaborative partners on board and acquire free or low rates of service from them. When the collaborative partner from the product design company was asked how they are contributing in terms of saving money and time, he said, considering their project is for the benefit of disadvantaged populations within emerging markets:

In this case, we just work as far as we can without harming ourselves basically. So, we do a lot of work for free, effectively, at the end of the day. So, the project is on a commercial footing, and we then manage the workflow against the available budget and work with them.

Further, the team member from the product design company said while they are not doing any work for ‘Company D’ free of charge, the best way to think of it is – if the fee is \$10, they are getting \$20 worth of value, and that is just because the project needs all that additional effort.

Similarly, the collaborative partnership with the founder of the main customer company of ‘Company D’ is also based on the idea of inspired networking and relationships. Since both ‘Company D’ and its main customer have similar objectives of providing the poor with low-cost and self-empowering solar facilities, the main customer company happily became involved – not only in providing initial market research services, but also in marketing, sales, and distribution efforts.

Strategic decision of getting into commercial partnership with the biggest competitor: Apart from adopting an inspired networking approach, one crucial strategic decision of ‘Company D’ was to enter into a commercial relationship with their own biggest competitor (PNG’s largest rice producer and rice trader company). After the Government of PNG decided to grow its own rice, PNG’s largest rice trader company had to redefine their position, shifting from being importers to promoters of locally grown rice in PNG. The founder explained that it was the right timing, as they needed someone to purchase their first-generation product and supply it all over PNG, whereas PNG’s largest rice trader company needed to somehow stay in rice industry and make money out of it.

Entrepreneurial capabilities: Both founders considered entrepreneurial capability as essential to developing a Cost-Driven product. The founder, for example, mentioned that he possesses

instinctive entrepreneurial capabilities and had been involved in various businesses and understood the risks. He further said that due to the innovativeness of the 'Project D', many of the original assumptions he and his co-founder had were wrong. However, for the founder, perseverance has been key, mainly to cope with the panics when things go wrong. He further said that with the 'Project D' he felt completely wiped-out, both personally and business-wise, but it is a learning curve for him. As he said, "This sort of venture takes a massive amount of money, and we were totally, we have been completely under-resourced."

However, he said that the critical thing is to learn from wrongly held assumptions and mistakes instead of giving up and losing hope. Apart from entrepreneurial capabilities, he also emphasised leadership and administrative capabilities. He explained that in 'Company D', he is facing plenty of challenges, including challenges around communication. Moreover, he has had to do things differently after forty years of working experience, which makes him feel nervous, but he needs to stay strong to be a success. Similar comments came from the product design company team member about the founder, as he said:

I always detect a little bit of nervousness, particularly in [Name of the founder], but I expect that because he is completely out of his comfort zone. We are asking him to be and do things completely differently to the way he has done it for the last ten years, so it is a big ask for anyone.

Hence, all the 'Company D' team members emphasised the importance of entrepreneurial skills coupled with leadership and administrative capabilities. Most importantly, all of them considered perseverance, and communication and trust among team members as crucial success factors in such ventures.

In sum, 'Company D's' firm-level strategic decisions to achieve cost minimisation and value maximisation to develop frugal innovation included forming a virtual-fixed and flat R&D structure and management; conducting R&D in Australia; keeping control over the project; controlling quality by approaching manufacturers who already complied to first-world world quality standards; not acquiring intellectual property to reduce costs; adopting a moral strategy to onboard stakeholders; getting into commercial partnership with the biggest competitor; developing a customisable, modular and sustainable machine; adopting a Cost-Driven approach; and having entrepreneurial experience and capabilities.

4.4.3.2. Project-level knowledge integration to develop Frugal Innovation

Integrating developer's existing knowledge and experiences: The integration of the existing knowledge and prior experience of 'Company D' team members was one major contributing factor in the successful development process for the 'Project D'. Both founders' years of prior experience have enabled them to achieve a sustainable and efficient yet low-cost innovation for emerging markets. For instance, the founder had a civil engineering background and ran a couple of business as in England when he was young. He moved to PNG in his early 30s to work as a volunteer with a local philanthropic organisation. There, he worked for ten years as a disaster relief officer. Therefore, in his life he has very much inclined towards philanthropic work rather than business or industrial work. Later he started a small consultancy company in PNG offering civil engineering services as a site agent on construction projects. He mentioned that by this point he had some 25 years of experience in the Pacific Islands. He further said, "I made a massive impact on the commercial market of rice mills in PNG."

When the founder was asked about the knowledge and experience of the team, he particularly mentioned the four other key personnel. Foremost among them was the co-founder, who had taken on the responsibility of the presentation and development of the company and selling the company to the investors and donors. When the co-founder was in turn asked about the prior knowledge and experience of the 'Company D' team, he said of the founder:

[name of the founder] is been working around supplying and manufacturing agricultural machines for nearly 20 years. I've been working in the energy access space through the Pacific, South East Asia and Africa for the last 15 years. So, we have both got quite a history of kind of relevant experience.

The collaborative partner mentioned by both founders was Stewart, the founder and CEO of the main customer company. According to the founder, Stewart's prior experience came from his involvement in financing programmes for renewable energy in remote locations. Another key person in the 'Company D' team is the operations manager, who is from China. According to the founder, as a local person, the operations manager was of substantial help in setting up the factory in China.

The founder also particularly admired the existing knowledge and experience of their collaborative partner [name of the product design company]. The product design company's main role is helping people to turn their ideas into production, commercialise the technology, and take their innovation to the market. They operate in a variety of categories, such as consumer goods, military goods, medical devices, established companies, start-up ventures etc.

Moreover, when the team member from the product design company was asked about their prior experience with innovation related to agricultural machines, he replied:

We have done a few agricultural and ag-tech projects over the years. Yeah, mainly in the water space, so we have done water purification products, energy saving, off-grid energy saving products, water moisture detectors, all sorts of things actually.

The product design company team member also mentioned that they also have prior experience with projects for emerging markets, which gave them knowledge, experience and exposure to customer needs. He said:

Well we did a project with a company called [name of the company], and they make battery technology for storing energy. And that is going quite well, and a lot of work being done in India and I think that is an emerging market.

In sum, both founders emphasised the importance of the prior knowledge and experience brought to the project by the core team members of ‘Company D’. The co-founder in particular mentioned that the inclusive team nature of their business would bring significant value to emerging markets, saying:

[...] We are just trying to apply all the knowledge out there into a product that has never been purpose designed before. Because, you know, it is this whole thing about inclusive business. Historically businesses, manufacturers and whatever, they don’t design products for the poorest people in the world.

Identifying and approaching the right skillset: To develop the ‘Project D’, the ‘Company D’ team acquired different types of knowledge from experts in diverse areas. Both founders played the critical role in identifying and accessing suppliers, vendors, foreign partners, and experts. This was mostly based on snowball networking, inspired networking, and serendipitous networking. For instance, according to the founder, he met the co-founder in a completely serendipitous way. He further explained that in his previous work around renewable energy, the co-founder was volunteering and was therefore able to see the founder’s work. The founder further explained:

[name of the co-founder] took a look at what I was doing with, with renewable energy and the agricultural machines, particularly with the sort of reaction that we had received, from the French agricultural agencies, and the French government. And because of that [name of the co-founder] agreed to become a partner in a new venture and we would

eventually start a brand new company, and we would take the solar-powered agricultural machines, you know take it to another level.

When the co-founder was asked about how they had identified the key skilled people who are now part of their team, he said that the key suppliers they have from China were identified and sourced by the founder and their operations manager in China. He also mentioned that they both are excellent at networking. Additionally, explaining their approach for identifying the other key collaborative partners, he said, “It was just through our network”.

With regard to the product design company, the co-founder said their involvement had come about completely serendipitously. He explained that they participated in an accelerator programme sponsored by the Australian Government’s scientific organisation, where they were introduced not only to technical people from within that organisation, but also some expert people and mentors such as a person from the product design company. As he said, “And it was through one of those events that we met [name of the product design company]. So we met with them, and we were really impressed initially with them as a company, and their attitude and approach.”

When the team member from the product design company was asked the same question, he also mentioned being assigned as a mentor to the ‘Company D’ founders during the CSIRO programme. Afterwards, realising they needed all the services that the product design company provides to its clients, the founders approached him about getting into a commercial relationship. As he said, “We have also switched to a commercial footing to help design and develop a whole range of purpose-built low-capacity solar powered ag machines for emerging third world countries.” Additionally, identifying and approaching the operations manager for ‘Company D’ occurred through snowball networking, as he was the warehouse manager and shipping manager for a firm with whom the founder had worked previously. Furthermore, PNG’s largest rice producer and rice trader company became involved with ‘Company D’ through the founder’s own prior professional network.

Integrating knowledge through collaborative partnerships: After identifying the right-skilled experts, suppliers, and partners for particular tasks, acquiring and integrating their knowledge and skills for the development of the ‘Project D’ was crucial to achieving a low-cost yet good quality innovation. The founder particularly emphasised learning from their collaborative partners and integrating the knowledge of the team. He mentioned also that with the product design company, he had to go through a swift learning curve as it is a very modern engineering company and they use very cutting edge design software:

When I first saw what they were doing and how they were doing it, I did not even know that that design software existed. [...] But now I have had to quickly learn to be able to download 3D imagery and use complete total walkthrough technology on my computer. And I am trying to learn very, very fast to keep up with it.

The co-founder made particular mention of the product design company's in-house capabilities, saying their collaborative partnership with the product design company was a major contributing factor in lowering the overall cost of the product as he said, "In the design process, [name of the product design company] incorporates some kind of smart design elements so that when we do come to manufacturing, it will be cheaper." He further explained that although this is the product design company's first time working with an agricultural machine, 'Company D' doesn't need agricultural machine-related input from the product design company, and therefore it does not matter. On the other hand, he explained, the founder has a lot of knowledge around agricultural machines but does not have a theoretical or design background, and therefore integrating this diverse knowledge and expertise is of great benefit to 'Company D's' innovation processes:

So, the big advantage of working with [name of the product design company] is that they take all of our knowledge, and particularly [name of the founder] knowledge around the machines, and through kind of their logical process of applying that knowledge they help us think through all the different variables to design that best machine, to design our ideal machine.

The product design company team member, however, responded differently when asked if he had worked on agricultural machine related projects. According to him, although the product design company team have not worked specifically with agricultural machines before, the engineering and design principles remain the same. He further said that every time they work on a project, they bring that knowledge and experience to the client's product:

It does not matter whether we have had experience in a field or not, we can apply our methodology. Because it is a design methodology, not an agricultural machine methodology. And the methodology begins with a deep understanding of all of the end users, all of the stakeholders, all of the commercial requirements. So, the front end of any project builds out what you need. And then what we do is if we feel that there's a specialist knowledge that is missing, we will go and find that.

When the product design company member was asked about the knowledge and experience he has brought into the 'Company D' project, and how the product design company is helping

‘Company D’ build their capacity for developing such innovation, he said that they do a lot of things for their partners. Some are short term until the partners build the capacity to do those things by themselves, while others are long term, such as connecting them with a community of similar interest, or investors. He further said:

So, fundamentally we are now a very strong design and development centre. We are also a strong commercialisation advisor, so we build a lot of collateral for their marketing. [...] So, in the case of [‘Project D’], we have already started to share with them how to go about manufacturing and potential partners in China outside of what they are already doing. Potential investors even, to get them to the next step, and all this sort of stuff. So, it is really about the community that we have built over 20 years, is one of the biggest values that we can give back to our clients.

However, the relationship works both ways. As the member from the product design company admitted, the mill project had also contributed in adding to their knowledge and experience. Furthermore, he also mentioned that communication between collaborative partners is very crucial in building new capabilities. He also mentioned there is always conflict, which is essential to strengthening the relationship. He gave the following example:

So, part of the design and development will lead to setting up the supply chain and the manufacturing strategy. He [the founder] has a pretty fixed view on it; I have another fixed view on it and, that goes to the strength of the relationship. We can have these differences of opinion, but both of us are basically working to get the answer for [‘Project D’], not us as individuals.

Another crucial partnership mentioned by the co-founder is with the founder of the main customer company, who is mainly involved in sales, marketing, and distribution of ‘Company D’ products, and also brings in knowledge about market needs and requirements, infrastructure, environment and most importantly, feedback on already launched products. Other partners who have provided one-off help included firms from Indonesia, Vanuatu, Bangladesh, India, Zambia, and Kenya. However, when the founder was asked about the input the ‘Company D’ team received from these organisations, he said on one hand, it could be very confusing. He felt all of these organisations and companies gave them feedback that was very much focused on their particular market or their particular needs. However, he also said the various input was very valuable as it enabled them to cross evaluate the information. On the other hand, he had greater respect for the founder of the main customer company, who had been providing a lot of input from a machine specification perspective.

The co-founder also mentioned other individual experts and organisations working in this area who have given useful input into their design thinking. For instance, an engineer who had worked with solar-powered appliances in developing company for a long time provided consultancy services, as he works freelance and mostly works with the founder of the main customer company.

PNG's largest rice trader company was another collaborative partner and both founders mentioned them as helping 'Company D' by building a community mindset in PNG towards growing their own rice. Only when they started growing rice would they be purchasing 'Company D' agricultural machine, which would be a win-win for 'Company D' and for community empowerment. According to the co-founder:

And they [PNG's largest rice trader company] recognise that the only way to encourage communities to start growing rice is to put milling technology into those communities. And because of the nature of PNG, they have had a lot of failures putting diesel rice mills into communities, so they were very keen to go with our solar mills. It is like the first step to seed and encourages these communities to start growing rice, and our small solar mills work very well for that.

The co-founder also mentioned 'Company D's' aim to build strong relationships with their suppliers and distributors, so that their distributors and sales agents all have training in, and knowledge of 'Company D' products. This was mainly because in the future, 'Company D's' strategy would be not to be directly involved in selling and maintenance.

For website development and updating, the product design company member mentioned that even though they are not involved in developing the website, they are continually mentoring 'Company D' and providing all the imagery. As he said:

Not really, but we are helping them. We are keeping an eye on it, put it that way. It is like, just watching over their shoulder and if they step too far away from what we think they should be doing, I'll just talk to them. So that is more mentoring really.[...]The Product imagery that you see on it is us; we've created that as part of the product design. So we are feeding all the images to the guys, we are just physically not doing the website.

Integrating knowledge to achieve alternative materials, alternative design and design for manufacturability: 'Company D's' major design effort has been incorporating the element of simplicity, towards which not are numbers of parts reduced, but the design is made easy to use

and maintain, modular, and customisable to create huge market potential. The founder described all of these efforts as innovative design. When asked what has enabled the ‘Company D’ team to reduce the cost and maximise the value their products from the design perspective, he said, “Innovative design and establishing an assembly and logistics platform in China.” Additionally, the co-founder explained that integrating various knowledge, skills, and experience remained key success factor in the success of ‘Company D’ machines. He further said that various variables in product design and specifications have implications for the cost. Moreover, integrating various knowledge and experience has enabled the ‘Company D’ team to design products based on the most appropriate variables and a substantially reduced cost. He also gave an example of how their integrated design efforts were organised:

So you know, we sit down, we give [name of the product design company] as much information as what we know, but then their job is to go away and, you know, review and research all of these different variables to try to, and then present a selection of options, or a process about how to go forward.

The co-founder further explained that the significant change they have brought to their machines is to use brushless DC motors (explained further in the “integrating technology knowledge” section). By switching from a brushed to a brushless motor, he claimed the ‘Company D’ team was now looking at an 80 per cent improvement on efficiency.

Another key design element that will contribute to achieving low-cost and high-value for the ‘Project D’ has been considering alternative materials, through which portability and low-cost manufacturability will be achieved. The co-founder explained they are considering a material option that is rigid, cheap, and easy to manufacture. Also, they are considering using different materials for different parts such as the body, exoskeleton frame, and hopper. He further explained, saying:

So, for example, aluminium is one example, cast iron is another, which is cheap, you know, you have got to make the cast which is a bit expensive, but kind of going into the future once you have got that cast it is a very cheap process. Yeah, but then cast steel is also, you know, it can have quite a wear factor. But with these new powder coat materials, they can greatly improve the hardness, [...] So with this new kind of powder coat materials, that is definitely an option and something we’re exploring.

However, for the product design company team member, the key approach to reducing the cost is not utilising alternative materials, but rather being specific about parts and identifying the best purchasing approach from the supplier-end. He further said that for their various

innovative projects, ‘Company D’ have used different approaches in considering the cost, time, and volume of the product required. He further explained the impact of the volume on manufacturability, and consequently the cost of the end product:

Well by comparison, if you wanted to injection mould, so what happens, typically you have a low capital expense, gives you medium to high unit price. High capital expense gives you a low unit price, that is the general rule of thumb. So [‘Project D’] has low volume, so you cannot go high volume manufacturing techniques because it is too expensive,[...] but if they suddenly got a huge order and wanted to make 20,000, say, we can transition the design to switch, to go into high volume manufacturing techniques.

In addition to alternative materials, another key design element that has enabled cost reduction in ‘Company D’'s case is modular design which also substantially contributes to reducing the manufacturing process. Modular design and its impact on achieving low-cost but high-value ‘Company D’ machines were explained by the founder as follows:

And our concept at the moment is that for our launch into Africa we want to produce a completely new range of machines. And, to assist ourselves in that what I have designed basically is a modular machine platform that can be adapted to take on all different sorts of machine heads. [...] we imagine that it could significantly reduce the overall cost of manufacturing.

As the founder further explained, ‘Company D’ may not have to produce 500 rice mills. However, say they have orders for 50 Rice Mills, 50 Cassava Graters, 50 Hammer Mills, say 50 of each machine, then 80% of the parts will be the same right across that range of machines. So, the idea is to have some generic and standard parts that can be fitted to any ‘Company D’ machine. The founder continued, then “our inventory, our sourcing liability is reduced significantly, so I would say that innovation could reduce the cost, the overall cost of the machines by about 25 per cent”.

The founder also mentioned that with modular design comes customisability, which will allow customers to get different types of works done. He said that having standardisation and making the design customisable has enabled ‘Company D’ to trial their machines in different markets within emerging markets with only minor changes in the actual machines. He explained this further through the following example:

And for instance, it [‘Project D’] was in an area. And the feedback that we got was very, very much that the flour that needed to be produced had to be super fine, like gram flour, you know for make chapatti's or something like that. [...]. If we send it to Indonesia, and

if we sent it with that kind of product quality, Indonesian people would spit it out and would just say this is disgusting, we cannot eat this. We like gritty coarse crunchy porridge-like ground up meal and that's what the machine's for, it's the same machine. But we need to be able, at a very low cost, modify the way that that machine works. And our modular approach to the design of the manufacturing programme, that gives us an opportunity to do that.

The product design company team member also said that it is the modular concept that reduces costs and increases value for the customer:

Well, I think the general modular concept, which is something we put up, where we, you know, strategically the money is in the motor and the hardware, not necessarily in the milling side of the product. So the idea that you can, at the factory level, configure the same fundamental assembly to be three or four different products, means you only have to make one type of base no matter what product you are selling. So that means, across four really small volume products, you've suddenly got one stream of parts that are a reasonable volume; manufacturing, now that you've got the reasonable volume you can go out and ask for reasonable prices so that the price will come down.

The co-founder also explained the significant impact of modular design in reducing the cost of the manufacturing process. He explained that they have standardised a lot of design elements. Therefore, instead of making six different machines, 'Company D' can make one machine with various heads for different tasks. Consequently, 'Company D' has been able to increase manufacturing efficiency with a substantial reduction in cost. He further explained that in some cases having only one motor for all machines is not possible because performing different tasks requires motors with a different horsepower and different RPM speed. However, their design efforts are still focused on overall manufacturing efficiency and cost reduction:

What we are doing now is we are trying to work out what our ideal motors will be, and then as we are designing the machining chamber, the machine part, we can adapt that machine design to fit that motor. So all of that stuff kind of, that is all about, you know, manufacturing efficiency, which again is all about cost reduction.

Integrating existing technological knowledge: 'Company D' also cuts down costs by using existing technological knowledge, which enables them to incorporate lean manufacturing concepts throughout their innovation process. Foremost has been the simple existing technological knowledge of the driver motor coupled with a solar system, which became the

main building block for 'Company D'. As the founder said, "Ours is very, very much, you know down at the bottom of the technology level – It is as low tech as we can possibly make it."

The founder said they started by reverse engineering existing machines with AC motors and rebuilt them with DC motors, and therefore it all started with making use of already existing technology. Similarly, the co-founder also mentioned that even though they put a brushless motor in their machine, which is relatively expensive, because many other parts have been reduced, this has created advantages – both from the perspective of simplicity and cost-effectiveness. He explained it further, saying that in their first-generation range of machines, they used brushed DC motors, which is an old technology. To keep the motor moving, the polarity needs to be switched. In a brushed motor that polarity is switched by the physical connection, which causes friction and a voltage drop on the brushes, therefore making it quite an inefficient process. So, to overcome this inefficiency, the 'Company D' team decided to use a brushless DC motor. The co-founder said:

With a brushless DC motor that switching of the magnetic field is done electronically, and we are probably, just to switch from a brushed motor to a brushless motor we are looking at an 80 per cent improvement on efficiency.

With regard to the cost of a brushless DC motor, the co-founder said they believe the market opportunity is changing. Five years ago, DC powered solar machines would not have been economical or viable, but recent advances have seen price of power required for brushless motors drop by 500 per cent, and they are also seeing the price of batteries dropping. Therefore, the 'Company D' team believes that in the next five years, there is going to be huge change around battery technology in terms of availability and affordability. He also explained that even though the technology for brushless DC motors has been around a while, they have only begun to be mass produced quite recently. The co-founder said:

For us to offer a product that is going to be, affordable to our end users, they need to be able to use products and motors that are mass produced. So they are more expensive, they are probably, they're still about double the cost of a brushed motor, but they're a lot more efficient. So then the size of the solar system can be reduced a lot, and they have a better lifetime, so it makes sense.

Both founders emphasised that the use of existing manufacturing technologies, in particular for a small number of units, has also contributed substantially to not only achieving cost reductions, but also to the overall success of their projects.

Both founders mentioned that for the ‘Project D’, they had used the inventive analogy of a food processor, where one base machine can run multiple heads and perform various task. Thus, in the overall innovation process, all team member said developing a machine like the ‘Project D’, the first of its kind, had involved imaginative problem solving and a continuous iterative process.

Integrating customer knowledge: The involvement of collaborative partners in the innovation and development process, and in particular those partners responsible for marketing and sales of ‘Company D’ machines, among whom will also be the first-tier customers, was considered one of the crucial decisions for ‘Company D’. The founders notably named the main customer company for their marketing and sales efforts. When the co-founder was asked if the main customer company has been also involved in helping them design products, or rather just communicating market needs and requirements, he replied, “Yeah, some of both really.” He further explained this by saying that input from the main customer company has substantially contributed to shaping their decisions on products, in particular for the ‘Project D’. Similarly, all the participants emphasised close knowledge of the end-users’ needs, requirements, and environment and innovating with them as the most crucial decision for developing a product that is fit for purpose and fit for the environment in which it will be used. For instance, the co-founder explained lead user involvement and how their feedback and suggestions have contributed to the innovation process for the ‘Project D’, using the same example mentioned earlier regarding the difference between flour consumed in East Africa and Indonesia. Based on customer feedback from various emerging market locations, the ‘Company D’ team realised they needed a more modular and customisable design so that for every market, they could send the modules that best fitted their culture of food and requirements. Similarly, when the product design company team member was asked about the importance of user involvement in the design process, he said:

[...]. You cannot design anything without knowing who your users are and what they want and why they want it. And it needs to grow up and push past just users because it should be user impact post product that gets measured as well. See if you have a beautifully designed product with a fantastic user experience, but the endpoint is then throwing them into a lake and killing all the fish, what’s the point.

When asked about the user involvement in the design process, the product design company team member also said that start-ups such as ‘Company D’ often make a minimal but viable machine that is the simplest and most basic version of their product. They then offer that to

users to find out what they think as quickly as possible. When he was asked if he and his team involved the end-user in their design process, he said; “That is not what we do. We create products against what the client asks us to do”.

In sum, to develop frugal innovation, ‘Company D’'s project-level knowledge integration activities focused on cost minimisation and value maximisation from consumer's perspective. The knowledge integration activities included both internal and external knowledge integration. The internal knowledge integration included the prior knowledge of developers and knowledge from prior prototypes. The external knowledge integration included identifying and approaching the right skillset; achieving alternative design and materials, and manufacturability; and integrating the knowledge of collaborative partners, technology knowledge, and customer knowledge.

4.5. Chapter summary

This chapter has presented detailed within-case analyses of the four cases, including their firm-level strategic decision-making and project-level knowledge integration patterns. The summary of key attributes of the cases and the respective firms are illustrated earlier in this chapter, in Table 5.

5. Cross-Case Analysis

This chapter presents the cross-case thematic analysis for the present research. According to Eisenhardt (1989a), cross-case analysis is crucial to identifying themes. Here, the themes are presented from the cross-case analysis, which was carried out using an iterative tabulation technique.

This chapter begins with section 5.1, which presents a typology highlighting the motivations for developed market firms to be involved in frugal innovation. Section 5.2 explains the underlying firm-level strategic decision and project-level knowledge integration activities within each category. Section 5.3 shows the key distinct capabilities built by developed market firms for doing frugal innovation. Next, section 5.4 presents the revised and extended model that links both the typology of firms' motivational behaviours and the key distinct capabilities for doing frugal innovation within developed market firms. Finally, section 5.5 summarises this chapter.

5.1. A typology of developed market firm motivational behaviour to do Frugal Innovation

The within-case analysis in chapter 4 reveals two main insights that are crucial for this cross-case analysis: 1) Different types of developed market firm behaviours regarding their motivation for being involved in frugal innovation; and 2) the distinct capabilities specific to developed market firm doing frugal innovation. These insights provide the basis for deriving a typology. This section introduces the typology and uses it to compare the types of behaviours the developed market firms displayed regarding their motivations to do frugal innovation.

The analysis of the four case studies indicates that developed market firms engage in frugal innovation for different reasons. In particular, the two dimensions of motivation that seem to differentiate developed markets firms engaging in frugal innovation are the degree of social empathy, and the importance of the activity being profitable. The degree of social empathy dimension is crucial for differentiating frugal innovation activities from other types of low-cost innovation activities, such as bricolage, design thinking or lean management. The second dimension of motivation concerns economic motivation, a necessary factor for any for-profit firm's survival. Beyond being profit-oriented enterprises, the economic motives for pursuing

frugal innovation related to the firms' growth through continuous innovation in rapidly changing environments.

This empirical research revealed three categories of firm motivation to do frugal innovation in developed market firms based on these two dimensions of motivation. These categories have been coined: 1) The “Philanthro-Capitalist Approach”; 2) The “Robin Hood Approach”; and 3) The “Cost-Driven Approach” (See Figure 2). Next, each category is explained.

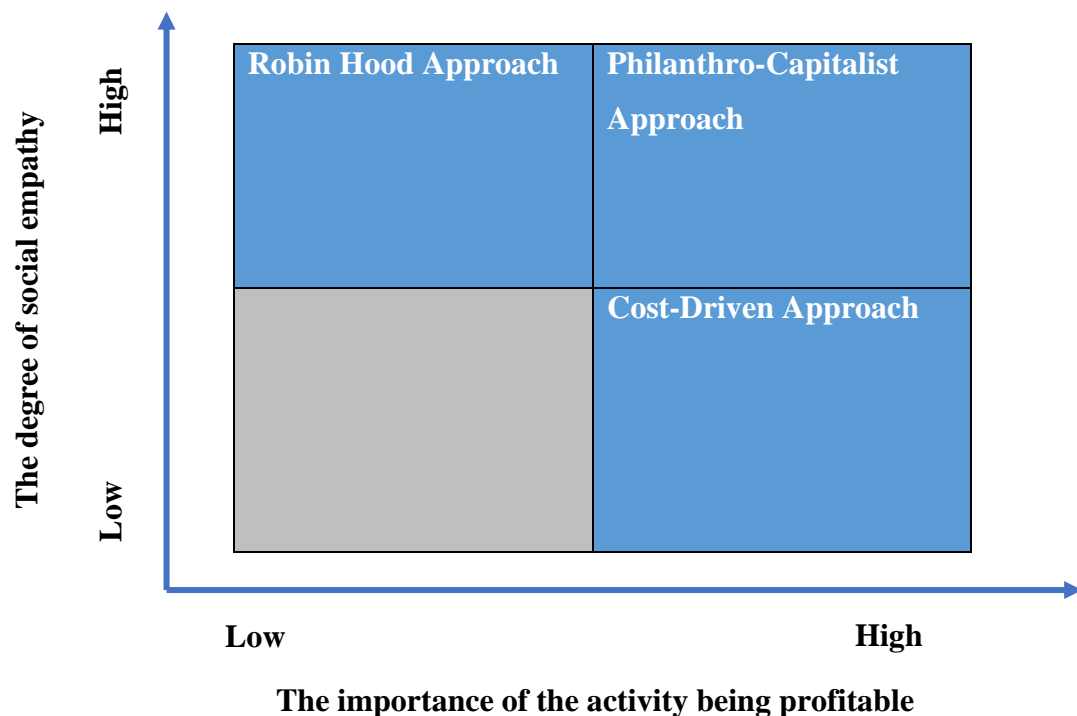


Figure 2 Typology of firms' behaviour for doing Frugal Innovation within developed markets

5.1.1. Philanthro-Capitalist approach

The Philanthro-Capitalist approach characterises the firms that were inclined towards high-profit motives and high empathic motives. These were both key motivations for developed market firms in this category to be involved in frugal innovation. ‘Company B’ and the ‘Company A’. exemplify this category. In the present research, multiple participants from ‘Company B’ and ‘Company A’ used the term philanthro-capitalist to describe themselves. In particular, ‘Company A’ cite ‘philanthropy’ and ‘capitalism’ on their website to describe their purpose, which the founder reiterated when he described the ‘Company A’s “doing well by doing good – that is, making profits whilst helping to make the world a better place”. Philanthropy refers to acts of humanity that involve helping people, the environment, or both,

whereas capitalism means gaining profit or adding value. Hence, the label Philanthro-Capitalist captures these dual motivations.

5.1.2. Robin Hood approach

The Robin Hood Approach is the second category, and, as the label suggests, firms in this category are motivated to do frugal innovation by acquiring from the affluent—in this context, taking products commercialised for customers in developed markets—to provide for the less affluent by providing those products for customers in developing markets. ‘Company C’, the one firm of this displayed motivations that were strongly inclined towards social empathy and less inclined towards profit motives. Moreover, ‘Company C’ had a clear passion for purpose and positive change that mostly originated from self-experience of resource-constrained environments in the developing world. The ‘Project C’ exemplified this category, with the founder inspiring the application of the Robin Hood label when he reported:

And always, and I come back to this Robin Hood principle; I am not in it to make money, but if we can make from developed countries, I will use that to subsidise developing countries, which is a passion I have. I want to see this machine in widespread use across the developing world.

5.1.3. Cost-Driven approach

The Cost-Driven approach emerged as the third category, as exemplified in ‘Company D’'s motivation to provide a substantially lower-cost alternative product for the customer, which is not only affordable but also enables them to be self-sustainable. The project started after ‘Company D’ identified the intense need a low-cost product alternative. It also identified that only a few competitors in the market were offering the high-priced product, which did fit with the local environmental conditions. The founder explained that to deal with the problem of costly and environmentally mis-fitting products, they got involved in developing a solution:

They [the development bank] wanted me to completely redesign a rice mill, and they saw that rice mills in Papua New Guinea were very, very expensive. They cost about 23 thousand kina at the time for a little tiny rice mill [...] they needed us to manufacture one for less than five thousand. So anyway, we did it, we manufactured 25 machines at less than that price.

Consequently, ‘Company D’ identified the high-profit market opportunity of the affordable solution to the identified problem, which is not only fit for purpose and the environment, but also brings high value to the customer. In response, ‘Company D’ began with a more frugally innovative project before started working on their second-generation product called the ‘Project D’’, which will be a substantially lower-price yet high-value solution for the end-user customer. Thus, developed market firms within this category will have a high-profit motive and relatively moderate empathic motive for becoming involved in frugal innovation related projects.

To summarise section 5.1, the analysis of all four cases identified a typology of developed market firms involved in frugal innovation based on the dimensions of motivation behaviour identified from the data. These dimensions are the degree of social empathy and the importance of the activity being profitable. The identified typology comprises three categories of developed market firms involved in frugal innovation projects. The first category is labelled the “Philanthro-Capitalist Approach”, and firms in this category hold both high-profit motives and high empathic drive. The second category labelled as “Robin Hood Approach”, applies to firms holding low-profit motives but high empathic drive. The third category identified is labelled the “Cost-Driven Approach”. Firms in the category possess a high-profit motive and moderate empathic drive. These three categories of developed market firms doing frugal innovation provide the basis for the next section, which compares the underlying activities of each of the four case firms in relation to the categories.

5.2. Comparing underlying activities of all cases in a typology

This section explains the underlying firm-level strategic decision-making activities and the project-level knowledge integration activities across the three types of firm established in the previous section. The aim is to provide more fine-grained insights into activities that enable capabilities for doing frugal innovation in developed market firms across these different types. More specifically, the cross-case analysis pays attention to the common themes across all cases, both at the firm-level and project level. It also describes the similarities and differences in underlying activities within each of those common themes that help in identifying a typology of developed market firms doing frugal innovation. Table 6 summarises the dimensions on which the four cases are compared. The case-case analysis is guided by the conceptual framework, which recognises entrepreneurial, leadership and administrative decisions as firm-level strategic decisions, and the internal knowledge and external knowledge in project-level knowledge integration activities.

Categories of firm behaviour for doing Frugal Innovation	Activities enabling capabilities for doing Frugal Innovation in developed market firms						
	Strategic decision making			Collaboration and knowledge integration			
	Entrepreneurial	Administrative & leadership		Internal knowledge	External knowledge		
		R&D & management decisions	IP & regulatory decisions	Prior knowledge of core team	Market knowledge	Technology knowledge	Stakeholder's knowledge
Philanthro-Capitalist approach	<ul style="list-style-type: none"> Experienced entrepreneurs with empathic drive Doing well by doing good Frugal thinking 	<ul style="list-style-type: none"> Virtual within, virtual outside firm & flat R&D Moral strategy Lean Management Iterative with continuous innovation 	<ul style="list-style-type: none"> Comply with ISO/FDA/CE-mark ISO/FDA/CE-mark qualified manufacturer & component Patenting Novel use of patented components/ technologies 	<ul style="list-style-type: none"> Experience of similar product/ technology development Qualification of innovator Understanding of unlive experience 	<ul style="list-style-type: none"> Needs realisation through close cultural observation Co-creating with customers Lead user involvement 	<ul style="list-style-type: none"> Technology fusion Inventive analogies Use of innovation technology Design for manufacturability Appropriate technology Sophisticated technology to simple product 	<ul style="list-style-type: none"> Virtual fixed & virtual ad hoc collaboration Serendipitous & snowball networking Involving academia, researchers Stakeholder buy-in & co-innovating with stakeholder
Cost-Driven approach	<ul style="list-style-type: none"> Opportunity & need driven entrepreneurial intent Focus on cost minimisation & value maximisation Frugal thinking 	<ul style="list-style-type: none"> Virtual outside firm & flat R&D Inspired & word of mouth publicity Lean management Iterative with continuous innovation 	<ul style="list-style-type: none"> ISO/FDA/CE-mark qualified manufacturer & component Avoid patenting Avoid patented technology 	<ul style="list-style-type: none"> Experience of similar product/ technology development Exposure & understanding of the unlive experience 	<ul style="list-style-type: none"> Needs realisation by living with customer & close cultural observation 	<ul style="list-style-type: none"> Technology fusion Use of innovation technology Design for manufacturability Appropriate technology 	<ul style="list-style-type: none"> Virtual fixed collaboration Serendipitous & snowball networking Stakeholder buy-in & Co-innovating with stakeholder
Robin Hood approach	<ul style="list-style-type: none"> Instinctive social entrepreneurial intent Passion for purpose & positive change Acquiring from rich, providing to poor Frugal thinking 	<ul style="list-style-type: none"> Virtual within firm & flat R&D Inspired & word of mouth publicity Differential pricing Lean management Iterative with continuous innovation 	<ul style="list-style-type: none"> Comply with ISO/FDA/CE mark ISO/FDA/CE-mark qualified manufacturer & component Avoid patented technology Patent only a part 	<ul style="list-style-type: none"> Experience of similar product/ technology development Self-experiencing the problem 	<ul style="list-style-type: none"> Needs realisation through lived experience & close cultural observation Co-creating with customers Lead user involvement 	<ul style="list-style-type: none"> Technology fusion Inventive analogies Design for manufacturability Appropriate technology Reverse engineering 	<ul style="list-style-type: none"> Virtual ad hoc collaboration Serendipitous & snowball networking Involving academia, researchers Stakeholder buy-in & Co-innovating with stakeholder

Table 6 Activities enabling capabilities for Frugal Innovation in developed market firms

5.2.1. Firm-level strategic decision-making activities of developed market firms doing Frugal Innovation

The firm-level empirical investigation of the case studies is done by exploring the strategic decision-making related activities with cost minimisation and value maximisation objectives. Based on the initial theoretical framework that set the ground for the empirical work, this research has mainly looked into three types of strategic decisions, namely entrepreneurial, administrative and leadership decisions. The findings for entrepreneurial decisions are categorised according to prior entrepreneurial experience and capability and entrepreneurial intent. Prior entrepreneurial experience can range from being previously successful as an entrepreneur, to limited or attempted entrepreneurial experiences. Entrepreneurial capability includes risk-taking, the courage to face failure, passion and persistence, identifying self-limitations, and openness to learning new things. Additionally, entrepreneurial decisions are shaped by the respective degrees of socio-empathic entrepreneurial intent and profitability motives that are the basis for the typology of developed market firms doing frugal innovation for developing markets.

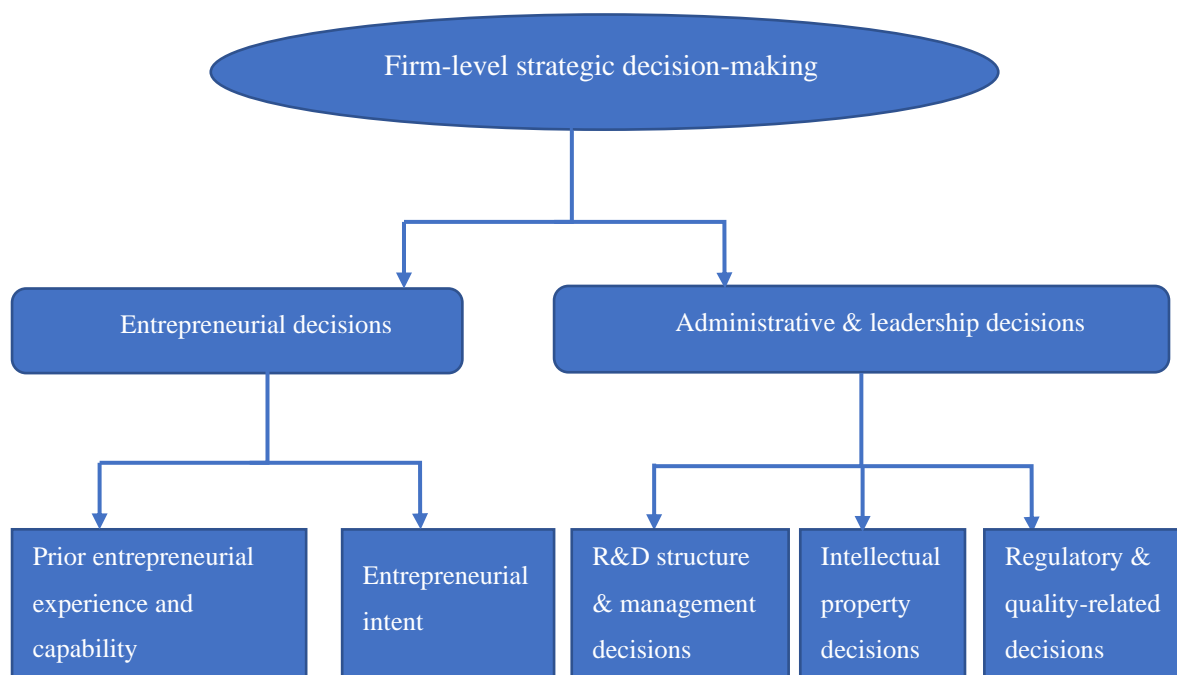


Figure 3 Firm-level strategic decisions of developed market firms doing Frugal Innovation

The findings reveal that the strategic decisions related to administrative and leadership decisions include R&D structure and management, IP decisions, regulatory decisions and

quality-related decisions. The R&D management related decisions varied across the typology, from virtual, ad hoc and within-firm, virtual, fixed and outside the firm, and virtual fixed and ad hoc both within and outside the firm. However, all case firms chose to have a flat R&D structure, applied the “Moral strategy” to identifying and onboarding shareholder, and chose developed market proximity for their R&D. The IP decisions also varied across the typology, from fully patenting, to partially patenting and not patenting at all. Additionally, similarly across all the cases with regard to regulatory and quality decisions, all four companies preferred to comply with first-world quality standards. Following are the details for strategic decisions, as identified across the cases and within each typology category. Figure 3 illustrates firm-strategic decision-making in relation to the identified themes.

5.2.1.1. Entrepreneurial decisions

The analysis of the four cases according to the three identified categories highlighted that the entrepreneurial decisions of developed market firms involved in doing frugal innovation are shaped by the prior entrepreneurial experience and capability of entrepreneurs and their socio-empathic entrepreneurial intent and profit motives. Following is an explanation of these themes.

Entrepreneurial experience and capability: Prior entrepreneurial experience and capabilities appear crucial across all the cases in this study. The analysis shows that the founders of all four case firms had prior entrepreneurial experience and capability for running an entrepreneurial venture. More specifically, the entrepreneurial capabilities identified include risk-taking, the courage to face failure, passion and persistence, identifying self-limitations and openness to learning new things.

All the cases emphasised that to be involved in frugal innovation-related ventures, the entrepreneur needs to be prepared for extra challenges such as higher risks and failures due to the challenging nature of frugal innovation. The challenges are associated both with understanding customer needs and values with unlive experience of the resource-constrained environment, as well as achieving an outcome needs to be a significantly low-priced product, of good quality and high value from a consumer perspective. Even though the above-mentioned entrepreneurial capabilities were emphasised by the founders of all four case firms, nonetheless there were differences apparent in the levels of prior experience and entrepreneurial capability of the founders which are discussed below.

Notably, the founders of the case firms within the Philanthro-Capitalist approach were successful entrepreneurs with a background of various international entrepreneurial ventures. The founder of the 'Project B' reported that founders must show perseverance and be capable of handling the panics:

If I could give somebody any advice about these [frugal innovation projects] things it is to have a panic because what happens inevitably when you are doing these things is you will have what I call good days and bad days. [...] There is always a solution to a problem that you discover. It is just that it is gonna be a time and a cost issue at worst.

According to the founder of 'Company A', the successful entrepreneur of multiple international ventures who also adopted the Philanthro-Capitalist approach, it is vital to be passionate and optimistic if involved in a frugal innovation entrepreneurial venture. However, it is also crucial to know your limitations and the risks, and to cope with those limitations and risks, one must be prepared to learn new things. Giving his own example, in the interview for this research he said he did not know anything about the codes for plastic and had to learn all of that.

The founder of the case firm with the Robin Hood approach held prior experience with at least one small entrepreneurial venture and several attempted ventures and possessed "instinctive entrepreneurial capabilities". As he said:

All my life, I have been told that I have got the entrepreneurial ability. I do not really know what that is, I do not try to be an entrepreneur, but I have started a lot of businesses; I just do it, and I do not know, I have never found it difficult. And people say, well, you just do it instinctively.

The Robin Hood approach also implies that to cope with a higher level of challenges, the passion for purpose plays the key role. The social empathy associated with such frugal innovation entrepreneurial ventures helps in boosting the level of persistence, passion and courage as it is somehow associated with the self-satisfaction of the entrepreneurs. The founder also mentioned that as a leader, the entrepreneur not only needs to be passionate and enthusiastic himself, but also needs to have a capability for build that passion and enthusiasm in all the people working in the team:

You have got to keep it simple; you have got to have honest working relationships with people; you have got to motivate people to actually want to do it. And there is tremendous passion in this, even all our people who work for us, they are all really enthusiastic, you know, and that to me is what makes it work.

The founder of the case firm with the Cost-Driven approach also held prior entrepreneurial experience through small local ventures. The founder mentioned having a vast network of professionals from various background from his prior ventures, due to which he had been able to onboard some stakeholders with shared values. The Cost-Driven approach puts emphasis on learning new things. According to the founder, entrepreneurial ventures require the capability to learn quickly. Onboarding stakeholders with various levels of knowledge and experience requires the entrepreneur to learn quickly and continuously in order to be able to communicate with them and to do things differently. Such learning needs were also confirmed by another participant of this case study responsible for R&D and design activities:

I always detect a little bit of nervousness, particularly in [name of the founder], but I expect that because he is completely out of his comfort zone. We are asking him to be and do things completely differently to the way he has done it for the last ten years, so it is a big ask for anyone.

Hence, the analysis of the cases identified that even though different levels of prior entrepreneurial experience and capability are apparent across the three categories, the prior entrepreneurial experience and capability theme is considered necessary for understanding the strategic decision-making activities that enable capabilities for doing frugal innovation in developed market firms.

Entrepreneurial intent: The analysis of the cases identified differences in entrepreneurial intent for each identified category due to related differences in the entrepreneurial motives of the entrepreneurs. The entrepreneurial intent mainly differed on two dimensions—motivations towards profitability and social empathy towards existing needs. The founders of all the case firms had a philanthropic drive to help underprivileged populations around the world. The analysis of the empirical data showed that in all three categories, the strategic decisions of the entrepreneurs involved in the frugal innovation projects were linked to their socio-empathic entrepreneurial intent, which involves the element of social empathy apart from profitability motives. However, the analysis also implies differing degrees of social empathy, leading to differences in entrepreneurial intent and critical strategic decisions. Further discussion follows on how entrepreneurial intent impacted the entrepreneurial decisions and overall firm-level strategic decisions.

The case firms with a Philanthro-Capitalist approach had the clear intent of “doing well by doing good”. In particular, the director of ‘Company A’ mentioned the entrepreneurial intent of the founder as follows:

It is the whole doing well by doing good is I guess why they call it philanthro-capitalism, you know. You're doing something good; you're making money while you are doing it, but then also you are running a business that needs to make money.

Similar to 'Company A', the founder behind the 'Project B' also mentioned needing to become self-sustainable to be able to do more similar R&D. Therefore, making some profit is crucial for them, apart from solving an existing problem within the developing world.

On the other hands, for the firm in the Robin Hood category, after being involved in several volunteer projects within the developing world, the co-founders were more inclined towards social empathy with a passion for purpose and positive change. Therefore, their intent was less about making money and more about solving a problem for underprivileged populations in the developing world. As the founder of the case firm with the Robin Hood approach commented, "Our intention is not to make money but rather to provide a cheap, ultra-reliable anaesthetic machine" (Founder, 'Company A').

Consequently, all the strategic decisions of the case within Robin Hood category occurred around the idea of 'acquiring from the rich and providing to the poor'. The founder also believed that whenever the interest in money supersedes the passion for a purpose, such as solving an existing problem or meeting a pressing need of underprivileged customers, then things could go wrong and therefore he is more passionate about meeting needs than making money. As he said in his interview:

You have got to identify a need, and then be passionate about it. No, you cannot be half-hearted about it. What I did, I'm an anaesthetist, and I'm not driven by money, [...] this project is not about making money. That is key. It is about fulfilling a need, and I'm quite passionate about that, that is the motivation, not money, and that is key.

In comparison to the other two approaches, the founders of the case study firm with a Cost-Driven approach were involved in a frugal innovation project with an entrepreneurial intent to seek opportunity in the absence of innovation that fitted the local population's economic and environmental needs. Therefore, they got involved in an opportunity to develop a product that is affordable and gives high value to customers with sustainability. Their intent was driven by the opportunity and the need within the target market. The co-founder of this case firm said:

This is the thing about what we are designing. It is purpose-built and designed for those markets, and for our intended customers. And we are doing that because there is nothing, there is nothing out there like that at the moment. [...] We are just trying to apply all the knowledge out there into a product that has never been purpose-designed before.

Because, you know, it is this whole thing about inclusive business. Historically businesses, manufacturers and whatever, they do not design products for the poorest people in the world.

Hence, the empirical analysis for the present research identifies entrepreneurial intent as a significant theme that enabled differentiation between the three categories with regard to motivations for doing frugal innovation in developed market firms.

5.2.1.2. Administrative and leadership decisions

From the empirical analysis across the four cases and within the three categories, the present research categorised the administrative and leadership decisions into activities and decisions related to R&D structure and management, intellectual property, and regulatory and quality-related decisions. An explanation of each of these themes follows.

R&D structure & management: The strategic decisions relating to R&D structure and management identified within the four cases are: having a flat R&D structure with virtual R&D management within the firm, and virtual R&D management outside the firm. R&D management related activities included: virtual-adhoc, virtual-fixed, or both modes in collaborative networks of experts from various locations; adopting a moral strategy that enabled onboarding stakeholders with shared values and intent, acquiring discounted services from them, or acquiring services for free initially as a way into a long-term commercial relationship with surety, and no waste of time and money. A strategic decision in all four cases also included the primary location of R&D activities. Below is further discussion on R&D structure and management-related decisions, including the differences in underlying activities for these decisions among the four case studies.

The empirical analysis identified that unlike the traditional R&D lab where a firm needs to hire experts and they work together under one roof, the case study firms across all three categories have virtual R&D management and a flat R&D structure. This strategic decision enabled all four firms to conduct R&D through collaborative networks of experts both within the industry and from other industries, who contributed their knowledge and expertise from various geographical locations. Despite all the case firms being involved in virtual R&D management, firms within the three categories have implemented it in slightly different ways.

The firms within the Philanthro-Capitalist approach organised virtual R&D management both within and outside the firm with a flat R&D structure. Instead of having permanent employees, they decided to have virtual fixed and virtual ad hoc employees, thereby acquiring

skillsets and expertise as per the requirement of a project and tasks within it. Subsequently, they do not have to pay continuous salaries or provide space, which consequently contributed to cost minimisation in the project. According to the founder and innovator of the 'Project B', they needed a variety of skillsets at different stages of their frugal innovation project:

So what we learnt was it is better to make a virtual organisation and getting the skills that you know you need to do a particular raft of work. And then once the project is finished, they get a pat on the back because they have been part of something that's very successful. But we have not had to, you know pay their salary or, you know look after them as a career path guarantee.

Another benefit of virtual R&D management approach identified for this approach was that it enabled the firm to have easy access to expertise in various fields and from various locations, and in turn enabled employees to work in isolation with the luxury of doing their own thing. The founder of the firm behind the 'Project B' explained such working arrangements, giving the example of an expert engineer who works from home:

He has got the luxury of doing that, and he picks his kids up at a certain time of the day. And I know that, so I do not call him at those times. But he communicates to a sale [...]. And they are the people that are involved in making the key decisions about say the power supply or the software.

The case firm within the Robin Hood category organised virtual R&D management within the firm with a flat R&D structure. They decided not to have a R&D team consisting of permanent long-term employees. Instead, they acquired skillsets and expertise as per the requirements of a project and tasks within it, thereby setting up their R&D collaboration to be virtual-ad hoc. The founder of the case firm mentioned that by having both virtual ad hoc relationships with the people working with them, they do not need to keep the person employed for the long term if they are not needed anymore. The founder also revealed that having a virtual organisation and not having permanent staff plays a significant role in scarce resource management:

And that is the other thing; we have not got overheads, we do it all from home, you know, so we have not had to pay wages, salaries –Utilities, and – Yeah, so what we have been doing is just contracting work out. [...] And I think that is absolutely essential.

On the other hand, the case study firm with a Cost-Driven approach, even though they organised virtual R&D management, their collaborative R&D partnerships were long term and fixed. The founder explained that while often they do bring in casual staff as required, with

their key collaborative partners involved in R&D, product design, marketing, sales and distribution, they have built long-term fixed relationships. Explaining their working arrangement with collaborative partners contributing to R&D and product design, the co-founder said:

So you know, we sit down, we give [name of the product design company] as much information as what we know, but then their job is to go away and, you know, review and research all of these different variables to try to, and then present a selection of options, or a process about how to go forward.

Within the three categories, however, all the case firms emphasised the importance of administrative capabilities along with virtual R&D management. They considered setting internal deadlines and milestones as a crucial way of administering and leading the overall innovation process successfully. They also explained that their firms constantly focus on the value of engineering throughout the innovation process. For such an innovation process, they needed experts from all around the globe and therefore made the R&D structure flat.

Another exciting and unique strategy highlighted within the virtual R&D management approach related to inspirational publicity or having a “moral strategy” (the term coined by one of the participants of ‘Project B’ case, but the related strategic approach was described by multiple participants). The activities in a moral strategy included: philanthropic marketing of the firm; acquiring funding from the developed world through inspired publicity; keeping the philanthropic intent upfront in collaborations with stakeholders; motivating experts to be ‘seen good’ by being involved in frugal innovation projects; acquiring free or low-cost services; and getting into commercial relationship with the surety of no waste of time and money. The analysis suggested that all the cases have been implying this strategy, but in different ways. For instance, within the Philanthro-Capitalist category, the founder of the firm behind the ‘Project B’ said:

What is happening in society is that in commerce it is becoming more and more important not only to be good in the way that you run your business in terms of ethics, but it is also important to be seen good.

The founder further said, “It sounds a bit ad hoc, but it actually works in terms of spinning speed to market.” The analysis showed that the cases under the Philanthro-Capitalist approach were even able to get services and tasks done entirely free of cost. As the director of ‘Company A’ said, “A lot of people have helped out, and either has not charged or have not charged a lot for their time. You know, everybody believes in the project.”

On the other hand, the case firms within the Robin Hood category and Cost-Driven category stated that due to their inspired publicity, they have been offered low rates, but they have not taken up offers of free services. The founder of the case within the Robin Hood category expressed the following opinion about acquiring free services:

And we have had people coming out of the woodwork, and software, website developer, they came and said they would like to be involved, they would like to set up a website for us. So, I said, oh, that is good, and they said, we would like to do it free, and I thanked them, but I paid for them, but they gave us a reduced rate. Because once you get things for free, nothing comes for free, you know.

Nevertheless, a moral strategy proved useful to all the case firms, not only for identifying a collaborative partner with shared values and intent, but also for facilitating the onboarding of stakeholders with the required expertise and skillsets. For instance, when the director of the 'Company A' case was asked about his reason for being involved in the frugal innovation project, he responded as follows:

To be part of a very important aspiration to help people in need, by providing them architecture, or good design. To help people who do not have houses, adequate housing, or suitable housing, or any housing.

Another crucial strategic decision relating to the R&D management made by all the case firms related to the main location for administration of R&D activities. All the founders emphasised the importance of geographic proximity to the developed market in terms of enabling access to expert knowledge, sophisticated technology, and for ease of controlling quality to meet first-world standards. Notably, an additional reason given by the case firm within the Cost-Driven approach for organising R&D in proximity to developed markets was the availability of funding for social entrepreneurial ventures:

We needed to do that because we are doing a lot of the research and development work in Australia. And a lot of the grant funding and any support money that's been offered to us is coming out of Australia.

Thus, across all three categories, virtual R&D management and flat R&D structure related administrative and leadership decisions, and their underlying activities, facilitated in resource flexibility to minimise the overall cost of projects and significantly contributed to coping with limited resources through achieving substantial cost reductions.

Intellectual property (IP) decisions: The empirical analysis indicated that the intellectual property decisions, varied between the three categories (but were similar in both cases within the Philanthro-Capitalist category) and were influenced by the initial entrepreneurial intent. The identified differences for IP decisions ranged from fully acquiring IP and using already patented technologies and components in a novel way, partially acquiring IP and avoiding the licensing costs of already patented technology or components, and not acquiring IP and staying ahead of the competition through continuous innovation. Below are the details of these IP decisions across all four cases according to the three categories of developed market firms involved in frugal innovation.

The case firms within the Philanthro-Capitalist approach were keen on long-term profit benefits and the firm's sustainability, and therefore patented their product and core technology and copyrighted the designs. These cases also used patented technologies and components in a novel way, which made the product development process efficient and cost-effective. For instance, the founder of the firm with the 'Project B' decided to patent the technology to make some profit from the product so that the firm could be self-sustainable in the long run. The main idea was to become a Philanthro-Capitalist organisation that earns a profit by doing good. Therefore, they filed IP for the most innovative part of their product—the humidification and sterilisation system. As the founder further explained, that they also adopted the strategy because any firm obtaining a license for their humidification and sterilisation system technology, would most likely also obtain a license for the technology for the sensors relating to this system, which would eventually add extra benefit. This innovation was internationally patented initially in 2011, and later improved, modified and internationally patented in 2015.

Similarly, the 'Company A' participants mentioned obtaining IP on their panel, mainly the material, and considered this crucial to being sustainable as a business considering 'Company A' is not a charity. The director of the firm, however, emphasised continuous innovation rather than getting into copyright issues when developing an architecture, as it is costly and time-consuming, and such protection has limited value within the housing industry. As he said, "The best protection is to keep developing your ideas, so you are ahead of those who copy."

On the other hand, the case within the Robin Hood category did not initially have any plans for patenting anything, mainly because the intent was to help the developing world rather than make a profit. However later, to avoid paying the licencing fee for a technology that could be used by 'Company C', they decided to innovate their own technology. The founder explained that on one side they need to consider the cost involved in IP matters, whereas on the other side he believed that certain countries such as China will anyway ignore the IP and make copies

anyway. Therefore, he decided to partially patent their machine, in particular the most innovative part—the turbine. He further explained that he took this decision mainly to have protection from established competitors in the developed market, as their machine would then comply with first-world quality standards if they decided to enter that market later. This strategy potentially gave them dual benefits. First, they avoided licensing costs and procedures, and second, they protected the core technology of the product from big firms in the developed market.

The case within the Cost-Driven category certainly had no interest in getting into patents. This was to avoid any additional costs, and they saw no great value in having a patent. They also avoided the use of patented technology/components in their product to avoid the licensing costs. One of the founders mentioned that as per their knowledge, currently, they are the only company internationally making dedicated, DC powered agro-processing machines that are designed to be run on solar power. Nevertheless, they are not keen on having IP. Instead, their approach of competing without patenting is to innovate at a fast pace and continuously launch newer models with better performance and reduced cost. The co-founder of the case firm said:

So, we have shared everything very widely with our network. The risk is that someone copies us, but we think that if someone copies our old stuff, our new stuff coming out is going to be so much better than the old stuff it does not matter.

Hence, the analysis indicated that the intellectual property decisions varied in the three categories. The main objective, however, remained to take a strategic decision that facilitates resource minimisation and reduces the overall cost of the project, along with achieving a sustainable solution.

Regulatory & quality-related decisions: The empirical analysis identified similarities in the regulatory decisions of all four cases across all three categories. These decisions included acquiring CE mark/FDA approval/ISO certification and collaborating with manufacturers that already hold these certifications. The quality-related decisions included complying to first-world quality standards or, in case of the ‘Project D’, acquiring quality that maximises value for customers. Below are the details of these regulatory and quality-related decisions across all cases for the three categories of developed market firm involved in frugal innovation.

One of the most exciting insights that emerged from the analysis is that the cases studies within two of the three categories, namely the Philanthro-Capitalist and Robin Hood categories, had developed their products to first-world quality standards by complying with first-world regulatory requirements, such as the FDA, CE mark and ISO standards.

The cases within the Philanthro-Capitalist category complied with first-world regulatory requirements, namely the FDA in the case of the 'Project B', and the CE mark and ISO standards in the case of 'Project A'. To cope with the cost and time needed to meet the regulatory requirements, the case firms within the Philanthro-Capitalist category took the strategic decision of identifying and approaching manufacturers with in-house capability for manufacturing similar products to theirs, at low cost. Moreover, these manufacturers already possessed FDA approval, ISO certifications, and CE marks. This strategy had been particularly crucial for the 'Project B' as a medical device requiring ISO13485 certification. According to the founder, "We ameliorated the cost of FDA approval by going to a company that already is FDA approved."

Similarly, the case in the Robin Hood category also complied with first-world regulatory requirements by identifying and approaching a manufacturer with in-house capability for manufacturing similar products who already possessed the ISO certifications. As the founder said, "One of the requirements is that it is manufactured in an ISO approved factory, so we have got that. The manufacturer has that ISO standard for developing medical devices."

From the design perspective, all three cases within the Philanthro-Capitalist and Robin Hood categories focused on simplifying the product design and reducing the total number of parts, which also contributed to lowering the cost and time required to meet the regulatory requirements. Additionally, focusing on complying to first-world quality standards enabled tremendous market opportunities in both developed and emerging markets. As the founder of 'Company C' said:

We want it 100% right, and we were going to sell to third world countries, and it would've been easy but we've had so much interest from Australia, the Army, the Navy in New Zealand that we have to get what's called a CE mark, and it's a sort of a European Standard, it's a sort of a quality mark, and once we get that it'll be easy to sell.

The case within the Cost-Driven category also complied to ISO standards, in particular the Australian standard, by collaborating with designers and manufacturers who already met ISO standards. As the co-founder said, "So, you know, [name of the product design company] have an ISO9000 rating, so you know, like the machines and products are going to be designed to what would be considered Australian standard." Further, with regard to components, as the co-founder mentioned, the components for their motors already come with CE mark despite being made in China, as they are also sold in the European market under a different brand name.

Nevertheless, in terms of quality standards, the case within the Cost-Driven category had mainly focused on marketing their product in emerging markets, and therefore purposely built for these markets to maximise value for them. The founders, however, mentioned that there could be a niche market among organic food lovers in the developed market who would like to use their product.

Thus, across all four cases, the strategic decisions related to regulatory and quality-related decisions such as complying with first-world quality standards and having CE mark/FDA approval and ISO certification not only contributed to minimising the overall cost, but substantially contributed to maximising the value of the product in terms of making it customisable for both developed and emerging markets.

5.2.2. Summary of firm-level strategic decision-making activities of developed market firms doing Frugal Innovation

This subsection summarises the answer to the first half of the research question for the present research, which aimed to explore the firm-level strategic decision-making activities that enable capabilities for doing frugal innovation in developed market firms. The firm-level strategic decision-making activities of developed market firms involved in frugal innovation projects are first categorised into entrepreneurial decisions and administrative and leadership decisions, as per the dynamic capability perspective detailed in Chapter Two.

The findings reveal that for developed market firms doing frugal innovation, the entrepreneurial decisions are shaped by the prior entrepreneurial experience and capability of founders and their entrepreneurial intent. Prior entrepreneurial experience can range from being previously successful, to limited or attempted entrepreneurial experiences. Entrepreneurial capability includes risk-taking, the courage to face failure, passion and persistence, identifying self-limitations, and openness to learning new things. Additionally, entrepreneurial decisions are shaped by the various degrees of socio-empathic entrepreneurial intent and levels of profitability motive that led to the identification of a typology of developed market firms doing frugal innovation in the developed markets.

The findings also reveal that the strategic decisions related to administrative and leadership decisions include R&D structure and management, IP decisions, and regulatory and quality-related decisions. The R&D management related decision varied across the typology, from virtual ad hoc and within-firm, virtual fixed and outside the firm, to virtual fixed and ad hoc both within and outside the firm. However, all the case firms chose a flat R&D structure, the moral strategy of identifying and onboarding stakeholders, and developed market proximity

for their R&D. Similarly, IP decisions varied across the typology, from fully patenting, to partially patenting, to not patenting at all. Additionally, the regulatory and quality-related decision across all cases were found similar, such that they all preferred to comply with first-world quality standards. Hence, the analysis for all four cases suggests the underlying activities of the administrative and leadership decisions of developed market firms involved in frugal innovation facilitated resource flexibility to minimise the overall cost of the projects and achieve first-world quality standards.

The present research, therefore, suggests that it is these commonly identified themes relating to entrepreneurial, administrative, and leadership decisions that together constitute the firm-level strategic decisions of developed market firms doing frugal innovation. Additionally, the underlying activities within each identified theme also show some differences across the four cases that are shaped by the firm's motivational behaviour towards dealing with frugal innovation projects, thereby supporting the typology of firms described in section 5.1.

5.2.3. Project-level knowledge integration activities of developed market firms doing Frugal Innovation

The project-level cross-case analysis considered themes across the three categories of firm based on cost minimisation and value maximisation objectives. The initial theoretical framework (see Chapter Two) set the grounds for the empirical work examining internal knowledge and external knowledge integration activities. The findings reveal that the internal integration activities mainly relate to integrating the prior knowledge of the innovators and suggest that all the innovators in the cases either had a formal qualification related to the field of the project or had prior experience of developing similar products and technology.

Similarly, as per the initial theoretical framework, the external knowledge is further categorised into market knowledge, technology knowledge and stakeholder knowledge, as supported by the analysis for this research. Within market knowledge, the present research identified different approaches towards identifying customer needs and their environment and building the capability to learn from completely unfamiliar setting. This included needs and product realisation via close cultural observation, living within the customer's environment, self-experiencing the problem within that context, and integrating market knowledge within the design and development by involving customers and lead users.

The technology knowledge integration activities identified across all four case studies are: use of appropriate technology; technology fusion; the use of inventive analogies, in particular from outside industry; use of innovation technology such as rapid prototyping software; design for manufacturability, which is related to the design and materials of the product so as to enable low manufacturing costs; and manufacturing technologies such as vacuum moulding instead of injection moulding.

In terms of stakeholder knowledge integration activities, the present research revealed three main elements were common to all four cases: identifying and onboarding stakeholders; modes and means of communication with stakeholders; and integrating stakeholders' knowledge by co-innovating with them. Following are the details of the identified knowledge integration activities across all four cases, and within the three categories. Figure 4 illustrates the project-level knowledge integration activities.

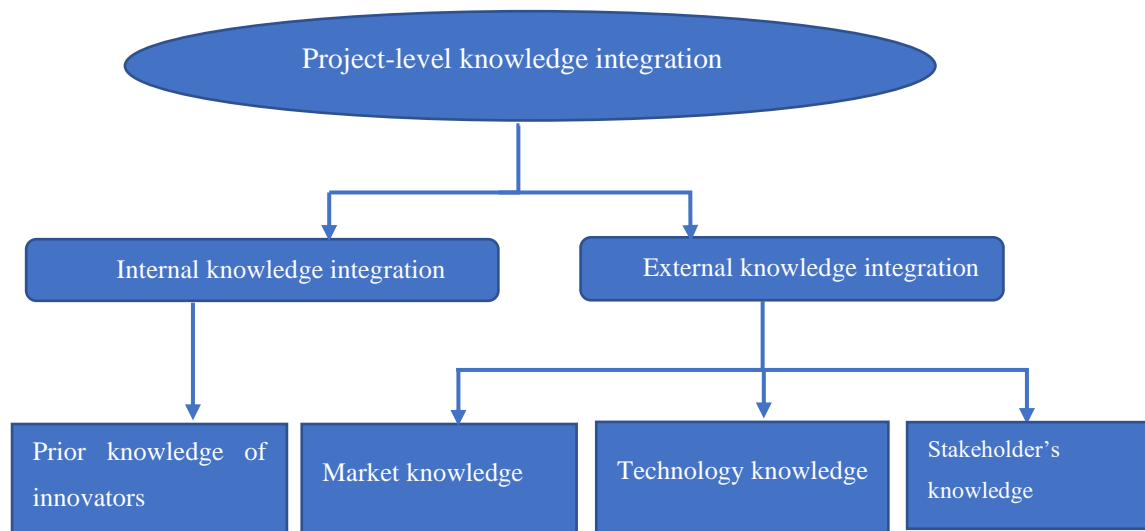


Figure 4 Project-level knowledge integration activities of developed market firms doing Frugal Innovation

5.2.3.1. Internal knowledge integration

Prior knowledge of innovators: The integration of the knowledge of core team members resulted in high-value products. In all three categories, innovators held formal qualifications around the project and related field or had prior experience of developing similar products and technology. The findings reveal that for frugal innovation projects, having innovators with relevant prior knowledge is crucial to overcoming the challenges associated with achieving substantial cost minimisation and value maximisation. Within the Philanthro-Capitalist category, the founder in the ‘Project B’ case had 20 years’ experience of developing low-cost innovation for emerging markets and extensive prior knowledge on projects similar to the ‘Project B’. Similarly, the founder of ‘Company A’ had already run multiple multinational ventures as well as starting a new business. Core team members in the Philanthro-Capitalist category were experts on their project, with multiple years of experience in similar projects. For example, the lead architect for ‘Company A’, who according to the founder of ‘Company A’, trained for ten years under the famous Italian architect Renzo Piano, had expertise in modular and indigenous housing. The lead architect said in his interview:

The reason [name of the founder] and I hit it off so well is I have been working on prefabrication and low-cost housing. I have been working with indigenous Australians and researching their self-built housing. I have travelled to Indonesia and studied the traditional Kampong villages. And so, I had the sensitivities that [name of the founder]

needed to develop housing for the poor or housing for, let's say, emerging markets. And it is a wonderful thing to be doing.

Likewise, the founders in the Robin Hood category has been considered as an intellectual person with Kiwi ingenuity by his other participants. The co-founder said that he admired and appreciated the founder's capabilities, while the founder particularly emphasised the prior experience and knowledge of the co-founder by considering him a master mind and himself the project manager, as well as appreciating the knowledge and experience of his other core team member:

The founder in the Cost-Driven category was a civil engineer and had spent many years working as a volunteer in the Pacific Islands due to his philanthropic drive and desire to work for underprivileged people in the developing world. The co-founder particularly emphasised the importance of the years of relevant experience both he and the founder had:

[The founder] has been working around supplying and manufacturing agricultural machines for nearly 20 years. I have been working in the energy access space through the Pacific, South East Asia and Africa for the last 15 years. So, we have both got quite a history of a kind of relevant experience.

Thus, in all four cases, the founder, lead innovators and core team members had prior experience of a similar projects and formal education and expertise in the area in which they were involved. The integration of this expert knowledge and experience enabled all four cases to develop a frugal innovation. The prior knowledge and experience of the core team members enabled them respectively to solve the existing problem in the emerging market and maximise the value of the product in terms of making it fit for purpose and the environment with maximum affordability and without compromising on the quality.

5.2.3.2. External knowledge integration

Market knowledge: The findings reveal variation in approaches towards integration of market knowledge across the four cases. Different approaches were used to build the capability to identify customer needs and their environment, and to learn from an entirely unfamiliar setting. While the Philanthro-Capitalist category focused on needs and product realisation via close cultural observation, the Robin Hood category self-experienced the problem within that context, and the Cost-Driven category lived within the customer's environment. Understanding these varied approaches is important as their empathic motives were shaped as per the nature of their exposure to the problems within emerging markets.

Conducting several months of hospital visits for first-hand observation of some repeated problems and mishandling within emerging market hospitals was the approach used by ‘Company B’ in the Philanthro-Capitalist category, because this enabled the project to isolate some critical problems with existing infant incubators in use within those hospitals. Similarly, the founder of ‘Company A’ said they did initial research by taking the architect to the emerging markets to understand market needs by being close to the people living in it.

These firms integrated market knowledge in the design and development stage in different ways. ‘Company A’ involved users, as reported by the founder of ‘Company A’:

It is very important that the village, the people who are receiving the houses, feel some sort of ownership and feel part of the process. [...] They have dignity by living in that house coz they helped design in, it is what they want.

Involving users was important to not only to understand their requirements, but to give them a sense of ownership. In contrast, the ‘Project B’ case deferred user involvement until the testing phase, using an artificial doll prior to this to identify any potential technical problem and functions. After testing, the product was set for soft release into hospitals in India.

On the other hand, the case within the Robin Hood category identified customer needs and their environment through self-experiencing the problem. The founder explained his experience using the following example:

I went to the [name of the hospital] in Fiji, which is probably the best hospital in Fiji, and the anaesthetic equipment was just terrible, it was dangerous, and I did not like using it. Every operating theatre had different machines; they had been inherited from other parts of the world; the Americans donated some, the Japanese donated some, the Australians, New Zealand, all a mish-mash of gear, none of it worked, you know. They had cobbled it all together, and it was really dangerous, and I used to have used it.

Innovators having a lived experience of the problem is an important approach particularly emphasised in prior literature. It enables the innovator to better understand the problems and develop a solution accordingly.

While the lead user involvement method of understanding needs and developing fit for purpose solutions was similar between the Robin Hood and Philanthro-Capitalist categories, there was a clear difference in how that knowledge was integrated. The founder of the case in the Robin Hood category took the opposite to the usual innovation process approach of involving the customer and lead user, as he had lived the customer’s experience as an anaesthetist working in developing world hospitals. He, therefore, leveraged his experience as

a customer to inform the product design. The founder said, “I have decided what I think the customer needs, and I have built it. However, I, in a way, am the customer, because as the anaesthetist, I’ve built something I like.” Later, he recruited other users for testing. Involving these lead users was of great importance in terms of providing immediate feedback and bringing improvements to the design and functionality of the solution.

The case within the Cost-Driven category opted not only for close cultural observation of customers’ needs and environment, but also collected market knowledge from various sources. The sources of market knowledge included talking to: people involved in the renewable energy area with a focus on agriculture, a specialist in agricultural machines, and a non-governmental organisation that is closely linked with their customers

The case within the Cost-Driven category also had an entirely different approach towards customer involvement. Having their primary customers as their collaborative partners helped them in designing the product through communicating the market’s needs and requirements:

[...] the feedback that we get from partners [who is also the main customer company], kind of shapes some of those thoughts, ideas and design thinking. So yeah, [CEO of the main customer company] been a key partner. Others have included [name of a firm] out of Indonesia, [name of the firm] out of Indonesia, [name of the firm] in Vanuatu, [name of the firm] out of Bangladesh, [name of the firm] out of India, [name of the firm] out of Zambia and, what are they called, [name of the firm] out of Kenya. (co-founder)

The findings reveal that market knowledge related to customers needs and the product fit with the environment in which it will be used played key roles in articulating the design parameters. Market knowledge enabled the developer to prioritise and modularise the needs, thereby focusing on what matters the most to achieve cost minimisation and value maximisation.

In sum, the innovators in developed market firms involved in frugal innovation for emerging markets build capabilities to understand the unlived experiences of emerging markets. Such understanding is achieved through: close cultural observation and by spending extended periods with customers in their environment; co-innovating with customers and involving lead-users; self-experiencing; and working closely with partners who hold maximum exposure to their customer’s needs and environment. The approaches to understanding needs and product realisation enabled the developed market firms to identify the root causes and drivers behind problems and articulate solutions fit for purpose and fit for the environment.

Technology knowledge: The analysis revealed differences in the activities related to technology knowledge integration between three categories, as well as some conventional approaches. These conventional approaches were the use of appropriate technology, making use of existing technologies through reverse engineering, use of the innovation technologies (for example rapid prototyping), and design for manufacturability. Different approaches were using sophisticated technology to create simple products and the use of inventive analogies. All cases used appropriate technologies to ensure the product was fit for the purpose in the environment in which it was going to be used. The use of appropriate technologies enabled the cases to design simple, easy to use, energy-efficient, self-powered, locally autonomous, environmentally sound, and robust machines that required minimal knowledge on the user's side to operate and repair. However, the way appropriate technology was used differed across the categories. The use of inventive analogies, even though common to all, was prominently found in the medical device cases. The 'Project B' used an analogy from the automobile industry, and the 'Project C' anaesthesia machine used the analogy of the air turbine used for inflating air mattress for camping.

The Philanthro-Capitalist cases used sophisticated technologies from the developed world to create simple products.

We are trying to use the most sophisticated tools we can get a hold of, the most sophisticated technology we can possibly bring to bear on the challenge. And deliver the simplest cheapest thing we can. It is not easy because we are up against people making terracotta pot homes, you know, with just youth pulled from the village who work for free, or very low wages. (Director, 'Company A')

Other participants from 'Company A' gave similar examples of adapting sophisticated technology, including their US based foreign partners' technology for making big curved barge covers using recycled plastic. That technology was identified as a result of collaborative R&D activities between the two companies to develop the prototypes for the panel using the PIM (powder impression moulding) process, which used a lot more waste plastic than the initial panel 'Project A' had designed.

Sophisticated technology was also used by the cases in the Philanthro-Capitalist category in the form of "innovation technologies", such as rapid prototyping software, which according to the founder substantially contributed in reducing the cost and lead time of the project. Emphasising the importance of rapid prototyping, the founder of 'Company A' said, "You can only do that [reduce the cost substantially] when you have got it working and saying well what else we can do to, you know make it cheaper?"

In contrast, the cases within the Robin Hood category and Cost-Driven category both put more emphasis on technology fusion by making use of existing technology through the reverse engineering approach. The Robin Hood case innovated their air turbine by reverse engineering several turbines built by Japanese and American companies, and their core idea came from the existing HDMZ1 ventilator. One of the participants considered their product not an invention but an innovative technology fusion of existing technologies.

Also, all four cases placed emphasis on design for manufacturability, where the design focus is on reducing the cost of manufacturing. They preferred to use existing manufacturing technologies such as vacuum forming, which also substantially contributed to cost reduction.

In summary, the technology knowledge integration activities identified are: use of appropriate technology that is fit for the purpose and environment; technology fusion which is a new combination and new application of existing technologies; the use of inventive analogies, in particular from outside the industry; use of innovation technology, such as rapid prototyping software; and design for manufacturability, which relates to the design and materials of the product to enable low manufacturing cost, and manufacturing technologies such as vacuum moulding instead of injection moulding.

Stakeholder knowledge: Integration of stakeholder knowledge was identified during the empirical analysis of data as another important theme. The analysis identified three main elements of stakeholder knowledge integration that were common to all four cases. These were: 1) identifying and onboarding stakeholder; 2) modes and means of communication with stakeholders; and 3) integrating stakeholder knowledge by co-innovating with them. The analysis of each of these elements that follows reflects the overall micro-level activities of stakeholder knowledge integration.

The first crucial element of stakeholder knowledge integration is to identify and onboard stakeholders. In particular, onboarding people with similar interests and values is identified as a crucial element of the stakeholder knowledge integration process. All four cases were co-innovating with their stakeholders, such as collaborative partners for R&D activities, as well as suppliers, distributors, and customers. Similar to the core team members, the stakeholders and collaborative partners involved in co-innovating with firms were identified and approached by various means, such as knowing through people within family, friend and professional networks, inspired networking, snowball networking, exploring for key personnel over the Internet, and serendipitously.

The cases within all three categories particularly emphasised the importance of family, friend and professional networks in identifying and approaching stakeholders. The founder of the 'Company A' case within the Philanthro-Capitalist approach mentioned that he had involved an immediate family member (his brother) in the project. All the participants from this case admired the approach of the founder of 'Company A' for networking and identifying stakeholders. They mentioned that being a surfer and successful entrepreneur, the founder had a colossal network of friends and professionals, some of whom were inspired by the 'Project A' and got involved. For instance, the director of 'Company A' said:

[name of the founder] finds them all. [name of the founder] being a surfer and who he is, he is extremely well connected all around the world, and most of these crazy contacts all come through just [name of the founder], through meeting people or introductions, or friends of friends.

Similarly, the founder of the case within the Robin Hood category also mentioned that he first contacted his friends, relatives and colleagues to find the right skillset:

I have got a few contacts who are friends, relatives, and I said to my daughter, she is in computers in Christchurch, I said, I want somebody who can do all the software work for me, who is really capable, and who will be prepared to work after hours. And she gave me three names, and that was great.

The remaining two cases, the 'Project B' and the 'Project D', did not specifically mention family members. However, all four cases emphasised friends and professional networks as providing the first contacts when starting their project. This was mainly because the founders for all four cases had long histories of working relationships in their areas, and those networks of friends and professionals were an immediate help and source to other experts through snowballing.

The participants from all four cases emphasised the importance of snowball networking coupled with inspired networking, which implies that identifying potential stakeholder through snowball networking and onboarding them through inspired publicity remained a frequent activity in all four case projects. According to the founder of 'Company A', the project itself was a very inspiring story and whoever hears becomes enamoured:

Every time I tell the story about what we could do people go wow that is a social, economic and environmental solution to affordable housing. And then you start talking about the community and what does that mean to the community.

Further, the founder of ‘Company B’ considered inspired networking and publicity as working like osmosis for identifying and approaching stakeholders. He further explained that in some instances, people with empathic drive approached them as they had heard about their work. Similarly, the founder of the case within the Robin Hood category considered inspired publicity particularly helpful in attracting experts into the project:

Now what is also helped, it seems to have inspired certain people like, they have given us a few awards, which made a big difference. [...]. It is all good publicity, and I’ve realised that it is important, publicity is important.

Another approach through which all four cases identified their stakeholders and approached them was serendipitous networking. All the cases within all three categories considered serendipitous networking as a contributing factor in identifying and onboarding their crucial stakeholders. For instance, the founder of the case within the Robin Hood category mentioned coming across his co-founder at an anaesthesia conference, and his manufacturing partner through a medical firm for whom he worked. The co-founder of the case in the Robin Hood category also mentioned trade fairs and medical fairs as the best places to find stakeholders, apart from the Internet. Likewise, the co-founder of the case within the Cost-Driven category mentioned meeting their R&D partners at an event where they had been exhibiting their first working prototype. As he said, “And it was through one of those events that we met [name of the product design company]”.

The Internet was considered another good way of identifying experts in a particular area and approaching them by all four cases but was notably prominent in the cases with medical devices. For instance, the founder of ‘Company B’ explained their approach of surfing the Internet, saying:

What we do is we go, you know really on the internet and find suppliers [...] we already know from our technical people what we are looking for. So, we know what kind of technical specs, what sort of technology area we want to sort of pursue. And then we go and do some cold calls to a number of different people and the ones that respond in the best way, you know that is the important thing [...] are probably the ones that are going to deliver.

The second element of stakeholder knowledge integration is the mode and means of communication with stakeholders. The empirical analysis indicated that within all four cases, the mode of communication was mostly “virtual”, meaning through communication technologies such as email, Skype video call, telephone and other communication software

such as TeamViewer. The empirical analysis, however, identified the diverse nature of the relationships between the case firms and their collaborative partners. They were variously virtual fixed, virtual ad hoc, and a combination of both.

The cases within the Philanthro-Capitalist category had both virtual fixed-term and ad hoc collaborative partners with whom they were virtually communicating, depending on the type of knowledge, skills and expertise required within the project. On the other hand, the case within the Robin Hood Category had opted for only virtual ad-hoc collaborative partners. As the founder said:

They would visit, but essentially, they worked at home, that is assuming they worked night, weekends, and I told them what was required, then we would have meetings, and we would sort it out.

The case within the Cost-Driven category chose to only have virtual fixed and long-term collaborative partners.

All four cases mentioned that having virtual communication both fixed and ad hoc comes with challenges. To manage such virtual collaboration with stakeholders, the participants of all four cases emphasised a few key strategies that can potentially minimise the cost of having to redo things, mainly as a result of miscommunication. The founder of MM mentioned strategies such as thorough documentation from the very beginning until the end, continuous feedback while delivering instructions, having “standard operating procedures (SOP) written and understood to achieve efficiency, and uniformity of performance to reduce miscommunication. Most importantly having a flat management structure was considered crucial by the founder. As he said, “Well, again it is very, very flat because again what I have learnt is that if you have, you know a pyramid type structure you lose the communication through the different layers.”

The participants of the ‘Company A’ case also mentioned some challenges of having virtual communication and strategies to cope with them within minimised cost. For instance, the participants mentioned that their means of communication is often Skype, if both parties have good internet, or else through email or phone. It is mainly because their collaborative partners are living all over the world or in different cities in Australia. However, the participant responsible for the design and architecture emphasised that it is crucial to first get to know people living in different geographical locations face-to-face before collaborating with them through Skype or phone. He explained his view by saying that it is crucial to give respect for others’ opinion and know their skills and expertise or else team building would be at risk. He further explained that from his experience, projects such as ‘Project A’ are rarely done over

Skype or phone. Nevertheless, if it needs to be done virtually due to the diverse locations of collaborative partners, knowing each other well is vital. As he said; “[...] you do not attempt these sorts of things [‘Project A’] without knowing each other face to face at a certain time, the sooner, the better”. On the other hand, the director of ‘Company A’ considered differences in time zone as the most critical challenge. Otherwise he appreciated the ease and benefits that come with the technology that makes virtual communication possible and convenient, as he said; “[...] Skype, I mean technology makes it very, I guess it makes the world a lot closer you would say these days”.

However, the founder of the case within the Cost-Driven category found communicating over Skype very difficult and frustrating:

[...] Trying to do it [communication] over Skype can be incredibly frustrating, and backwards and forwards with e-mails. That sort of interaction, you know the design work, the work where you are talking about ideas as much as you are about, you know actual physical decisions, it can be very, very frustrating and difficult.

He believed proximity between collaborative partners strengthens the relationship and communication. As he put it, having someone there to “[...] have a cup of coffee with, and talk to, is infinitely more valuable than somebody who is on the other side of the world”. However, another team member responsible for design work for this case had an utterly different response, as he believed that in some cases being very close to the client and frequent communication slows down the process, saying “The client sitting here every day does not speed things up, it slows things down profoundly.”

The third and most crucial element of integrating stakeholder knowledge identified through the analysis of empirical data is co-innovating with stakeholders. The participants of all four cases particularly emphasised its importance. The founders of both the cases within the Philanthro-Capitalist category believed that to achieve the objective of frugal innovation, experts in various fields and industries play a vital role. According to the lead architect of the ‘Company A’ case:

It is not a one-man job; it is basically a combination of knowledge of experts from different industries. So somebody would have said that okay, so for instance you propose the diagram and then those, making it hollow was proposed by someone else to make it like maybe good for insulation as well? you know the beauty of this.

The analysis indicated that the Philanthro-Capitalist founders played a key role in identifying their limitations, then searching for experts who could fill that gap through their

knowledge and expertise and onboarding them into the project to integrate their knowledge and co-innovate with them. For instance, the founder of ‘Company A’ explained they have a consortium consisting of individual experts and companies who provide their expert knowledge and expertise in areas such as water sanitation, agroecology, renewable energy, waste management, and materials and components to build the houses.

The medical devices cases from both the Philanthro-Capitalist and Robin Hood categories also emphasised the knowledge of academic researchers and academic institutes for stakeholder knowledge. For example, the firm developing the ‘Project B’ partnered with New Zealand's largest institute of technology. Unitec students helped the firm in creating all the engineering drawings required throughout the innovation and development process to be approved by the FDA. Also, a senior lecturer at that institute had developed a noise-cancelling technology for the latest version of the incubator. The objective of this partnership was to harness the creative minds to develop novel technologies and to improve global healthcare outcomes. Likewise, ‘Company C’ employed the services of a student team at Canterbury university to conduct feasibility research for a component of their machine. According to the founder:

So, I went to the University of Canterbury, the engineering, and they have final year engineering students who need a project. So, I paid for them, four of them, to develop the fan idea, and they were brilliant, they were very, very capable, these young folks.

Hence, through cross-case analysis, the present research identified three elements of stakeholder knowledge integration process, namely identifying and onboarding stakeholders, modes and means of communication with stakeholders, and integrating stakeholders’ knowledge by co-innovating with them. The analysis also highlighted that within all three elements, the underlying activities of stakeholder knowledge integration towards cost minimisation and value maximisation played a substantial role in enabling developed market firms to do frugal innovation.

5.2.4. Summary of project-level knowledge integration activities in developed market firms doing Frugal Innovation

This subsection summarises the answers to the part of the research question concerning project-level knowledge integration activities that enable capabilities for doing frugal innovation in developed market firms. The project-level knowledge integration activities of developed market firms involved in frugal innovation projects are first categorised into internal

knowledge and external knowledge. External knowledge is market knowledge, technology knowledge and stakeholder knowledge, as per the dynamic capability perspective detailed in Chapter Two.

The findings reveal:

- Different approaches towards identifying customer needs and their environment and building the capability to learn from completely unfamiliar setting. This includes need and product realisation via close cultural observation; living within a customer's environment; self-experiencing the problem within that context; and integrating market knowledge within the design and development by involving customers and lead users.
- The technology knowledge integration activities identified for the four case studies are: use of appropriate technology; technology fusion; the use of inventive analogies, in particular from outside the industry; use of innovation technology such as rapid prototyping software; design for manufacturability, which relates to the design and material of the product that enable low manufacturing cost; and manufacturing technologies such as vacuum moulding instead of injection moulding.
- Three main elements of stakeholder knowledge integration are common across all four cases: identifying and onboarding stakeholder; modes and means of communication with stakeholders; and integrating stakeholders' knowledge by co-innovating with them.

It is these commonly found themes that together constitute the project-level knowledge integration activities of developed market firms doing frugal innovation. Moreover, there are some differences in the underlying knowledge integration activities for each firm type based on the typology of firm motivational behaviour for doing frugal innovation described in section 5.1.

In summary, section 5.2 has presented the answer to the research question: *How do strategic decision-making and knowledge integration activities enable capabilities for frugal innovation in developed market firms?* The firm-level strategic decision-making activities that enable capabilities for frugal innovation in developed market firms were explored in section 5.2.1 and summarised in subsection 5.2.1.3. The project-level knowledge integration activities that enable capabilities for frugal innovation in developed market firms were explored in section 5.2.2 and summarised in subsection 5.2.2.3. These findings and summaries provide more fine-grained insights into the activities that enable capabilities for doing frugal innovation in

developed market firms, recognising the motivations of developed market firms involved in frugal innovation as described in section 5.1.

5.3.Capabilities built for doing Frugal Innovation in developed market firms

The analysis revealed some distinct capabilities for developed market firms doing frugal innovation. Two sets of distinct capabilities were identified: 1) Domain-specific capabilities, and (2) Process-specific capabilities. These apply to firm-level strategic decision-making activities and project-level knowledge integration activities, providing more fine-grained insights into the activities that enable capabilities for doing frugal innovation in developed market firms.

From the cross-case analysis, it is apparent that some common firm-level and project-level activities enabled the domain-specific capabilities of developed market firms doing frugal innovation. These capabilities are grouped as domain-specific capabilities because they are entirely related to understanding the emerging market domains. While the firms, case projects and innovators in the present research were based in developed market contexts, the findings show that these firms considered it crucial to be involved in activities that enabled their capabilities relating to changing their usual mindset, developing deeper levels of sensitivity towards unfamiliar socio-economic and cultural contexts, and identifying the key drivers of the customers' needs. Therefore, this research labels the capabilities enabled through commonly found activities related to understanding the target customer domain—domain-specific capabilities.

Similarly, the cross-case analysis revealed that some common firm-level and project-level activities enabled the process-specific capabilities in these developed market firms involved in frugal innovation. These capabilities are grouped as process-specific capabilities because they entirely relate to the new product development process and related top management strategic decisions with frugal innovation objectives. While the case projects were in firms based in developed market contexts, the findings reveal a high degree of influence of top management motivation and strategic decisions on the new product development process to achieve the cost minimisation and value maximisation objectives. The firms therefore considered it crucial to be involved in activities that enabled their capabilities related to: prioritising and modularising the problem to pilot the design parameters; utilising both sophisticated and old technologies to develop high quality products; identifying and onboarding empathic stakeholders; and organising virtual R&D collaboration, while at the same time exploiting a developed world R&D location. Therefore, the present research labels the capabilities enabled through

commonly found activities related to the new product development process and the related firm-level strategic decisions—process-specific capabilities.

Below the two sets of capabilities are outlined in Figure 5.

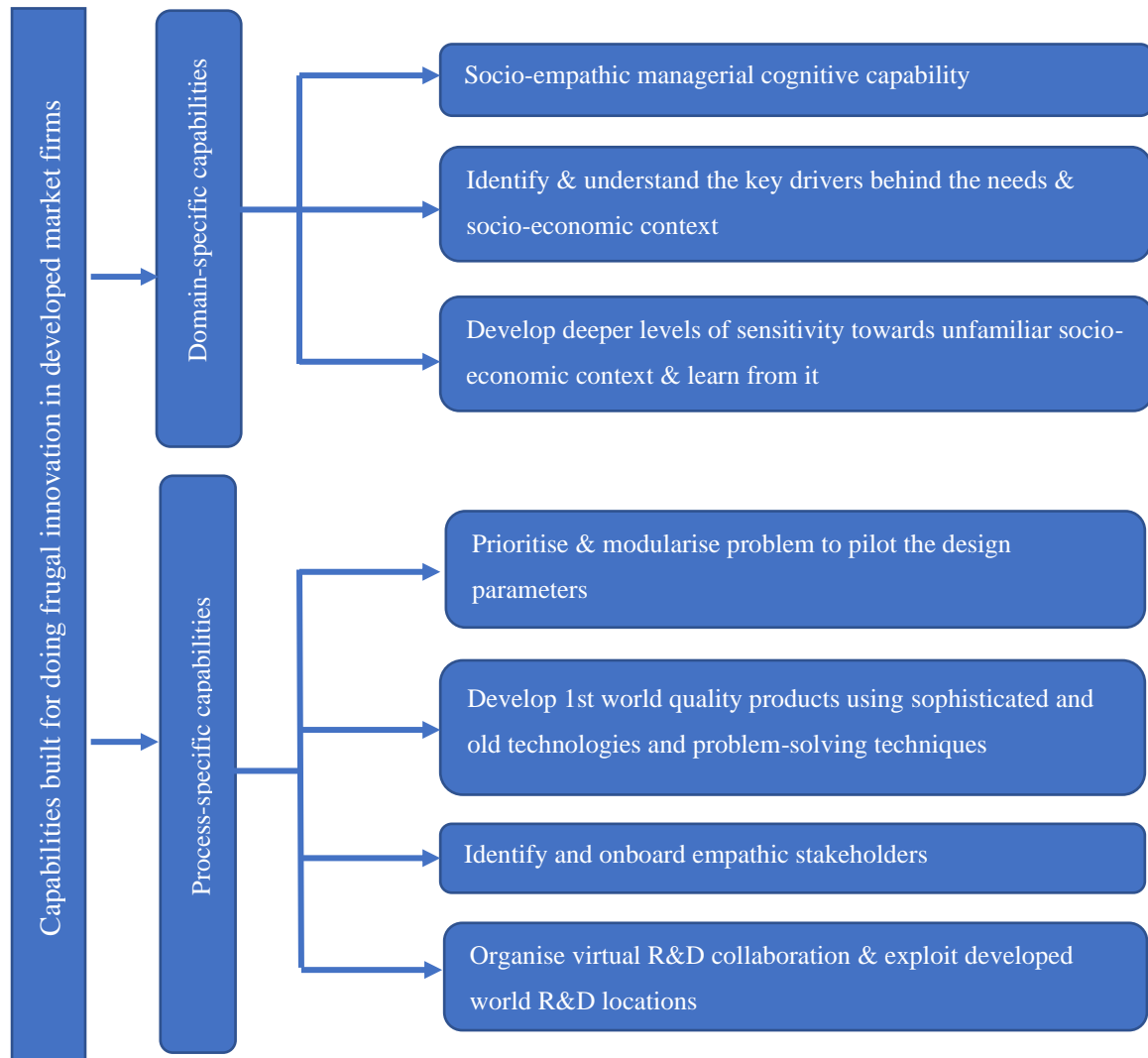


Figure 5 Capabilities built for doing Frugal Innovation in developed market firms

5.3.1. Domain-specific capabilities

Domain-specific capabilities are those capabilities that are entirely related to understanding the emerging market context. For affluent innovators in developed markets, building domain-specific capabilities to understand the needs of customers in emerging markets is crucial because they have minimal exposure to that context. Three domain-specific capabilities were apparent in the four cases. Moreover, all four case firms had to build these capabilities to integrate frugal innovation activities into their normal innovation activities.

5.3.1.1. Socio-empathic managerial cognitive capability

All the founders and their core team members had built the socio-empathic cognitive ability to learn from vast prior exposure and experience within resource-scarce environments. For instance, the co-founder of the firm developing the 'Project D' explained that they had not developed empathy and frugal cognition in a day. Instead, it was years of experience and exposure within resource-scarce environments:

[name of the founder] and I, like combined, we have spent over 40 years in developing countries and working, you know, really face to face with village level people, who are really poor. So certainly, we have talked to these people, we have stayed in their houses, we have eaten their food, we understand their problems.

Such exposure to emerging market customers and their needs also came through the involvement of all founders and their core team members in volunteer work. They developed empathy towards the people in those resource constrained environments, and that empathic feeling motivated an understanding mindset well suited to the socio-economic context of their customers and their needs. The 'Company C' case illustrates this. The founders had experienced first-hand the devastating consequences of scarce resources and inadequate equipment for those needing life-saving surgery, which compelled them to develop a solution for the specific needs and environment. The element of social empathy is particularly crucial in this case, because it underpins the overall intent of the founders, shaping the firm's motivational behaviour.

The analysis showed that exposure and experience within the developing world enabled all the founders to integrate their social empathy with their managerial cognitive ability to better understand the customer needs and environment in emerging markets and develop a solution fit for the purpose and that environment. A team member responsible for manufacturing emphasised the importance of the prior experience of founders within the developed world. He believed that it was their exposure to, and experience of resource scarce environments that not only made them empathic, but also enabled them to combine their socio empathic feeling with their managerial cognitive ability:

The key thing that happened here is that these two guys [both founders] were absolutely aware of what the product needed to do. They had the end customer in mind; it was for the developing world. They were aware of exactly what is needed to do, and they build

into every aspect of it, the idea that it needed to be cheaper. That was where they started from. And that is the key to it.

Thus, what all cases show is that frugal innovation requires the founders, core team members, collaborator partners and stakeholders to share the same values and beliefs towards doing good for the underprivileged population of the world, which then subsequently drives the firm's motivational behaviour towards empathy along with profit.

5.3.1.2. Capability to identify & understand the key drivers behind the needs within a particular socio-economic context

All cases had to build a capability to identify and understand the key drivers behind the needs in emerging markets. This was achieved in a number of ways, including failure mode effects analysis, avoiding quick-fixes and offering solutions fit for the purpose and environment, cultural observation and understanding, and identifying the root cause of the problem. A common aspect of the methods was they enabled all the case firms to develop a design brief for their solution to the identified problem, and therefore facilitated in building a frugal innovation mindset.

Three of the four cases reflected on their approaches for identifying and understanding the key drivers behinds customer's needs, emphasising a failure mode effects analysis (FMEA) to assess the root cause of the problems. The primary root cause identified was the misfit between the solutions offered to the customers within emerging markets and their environment. For example, the founder of the case 'Project C' noted:

I went to the [name of the hospital] in Fiji, which is probably the best hospital in Fiji, and the anaesthetic equipment was just terrible, it was dangerous, and I did not like using it. Every operating theatre had different machines; they'd been inherited from other parts of the world; the Americans donated some, the Japanese donated some, the Australians, New Zealand, all a mish-mash of gear, none of it worked, you know. They had cobbled it all together, and it was really dangerous, and I used to have using it. And I decided, about 30 years ago, what I would like to do is make a simple cheap anaesthetic machine, which would be really reliable, never break down, or if it did break down, they could fix it up easily in the hospital workshop. That is the important thing, easy to use, simple, safe, reliable, those are the key things.

The 'Project D' case, however, had to go an extra step back to identify the root cause as the absence of affordable agricultural machines. They needed to understand the reason for why rice was not grown in PNG despite favourable soil, weather condition and rice being a dietary

staple there. Subsequently, they identified multiple facets to the identified problem, such as the monopoly of the firms importing rice to PNG; the only few companies importing and selling agricultural machines, and at a very high price; and existing machines that were inefficient and environmentally unfriendly because of their dirty diesel engines.

Building this capability to identify and understand meant the frugal solutions developed by these firms not only fulfilled the objectives of cost minimisation and value maximisation, but they were also fit for the purpose and the environment. The present research thus infers that affluent innovators from the developed world are capable of building a frugal mindset through building capability to identify and understand the key drivers behind the needs within the socio-economic context.

5.3.1.3. Capability to develop a deeper level of sensitivity towards an unfamiliar socio-economic context & learn from it

In all cases, another domain-specific capability for doing frugal innovation among the founders was developing a deeper level of sensitivity towards the unfamiliar socio-economic context. This capability was built by closely observing the context and being sensitive to cultural norms; listening and building trust; learning by adopting a clean slate approach, including by forgetting the known from developed markets; and not generalising the learning from one domain to another.

The ‘Company A’ case illustrates this. They developed housing for underprivileged populations through their lead architect’s experience of prefabrication, low-cost housing, and travelling to rural areas in emerging markets. He had researched self-built housing by indigenous Australians. Explaining that research work, he said:

[...] when you first go there, most white people would see a slum, and so you have to wait and build up trust and learn. And you start realising that what you are seeing is very, very carefully thought out. Generations of knowledge, and generations of experience, technical, social, sustainability, everything, was embedded in those self-built homes. So, it is that level of sensitivity and awareness that I bring to the [‘Project A’].

The ‘Company A’ case illustrated the importance of forgetting what is known from the developed market context and not generalising the leanings from two different contexts.

You cannot think that because one community in indigenous Australia, applies to anywhere else, no. But what you learn is the ability to look and listen, and what you learn and what you bring to the project, to answer your question is to not assume. And you

learn to try to reduce as much as possible your arrogance, to start from zero. (lead architect, 'Company A')

The clean-slate approach of developed market firms is about building a frugal mindset, sensitivities towards problems and a process of learning from scratch about an unfamiliar socio-economic domain. The clean slate approach in this scenario is also about being sensitive to the cultural and social norms and values of potential customers within emerging markets that may influence their needs.

Developed market firms build the capability to learn and that is achieved in three ways: learning by observing, learning by listening, and learning by doing. Building sensitivities towards unfamiliar socio-economic context enables this process.

5.3.2. Process-specific capabilities

The cross-case analysis revealed process-related capabilities were built within a new product development project to achieve the objectives of cost minimisation and value maximisation. These process-specific capabilities are linked with the product development process and frugal innovation objectives, but they also impact higher-level strategic decisions and top management practices. The following sections describe the cross-case analysis findings for the process-specific capabilities built in the four cases.

5.3.2.1. Capability to prioritise & modularise the problem to pilot the design parameters

All four cases had built their capability to prioritise and modularise the problem to pilot design parameters towards achieving a solution fit for the environment within which the problem exists. Such capability was achieved through thorough market research and learning about the most critical problems for the customer within their environment. The principal objective of piloting such design parameters is twofold: 1) Achieving affordability by focusing on the essential elements of design specification and functionalities; and 2) Targeting the most critical problem and design to appropriately solve the problem and maximise value for the consumer.

Finalising the appropriate design parameters, and functions were among the most critical processes in all four cases. This was also very challenging because they were attempting to innovate for a completely unfamiliar customer and markets and were still learning about the domain-specific and customer-specific attributes.

All the cases started prioritising and modularising the problem at the ideation stage by doing thorough market research to learn about the customer and their environment. The methods used were direct observation, spending time with the potential customer, and experiencing the issues related to existing problems. For instance, the ‘Project B’ case saw the urgent need for such an incubator, having identified several fatal problems in existing incubators. They aimed to develop an incubator that was safe and caused no harm to the infant by solving all those fatal problems.

With regard to prioritising the design elements, the founder explained that unlike developed country hospitals, in developing countries, a clean water source is often not available and therefore it was essential to have specialised water treatment equipment within the incubator. Also, the incubator needed to be substantially low cost to make it affordable and accessible for developing countries, but without compromising on quality. Hence, the intent was to meet first-world quality standards, so the incubator can be used both in developing and developed markets. Consequently, their priority design parameters were affordability, simplicity, fewer parts, portability, water treatment, and a shape that regulates the air properly to avoid any potential air contamination inside the incubator.

Regarding modularising, all the cases built this capability to develop a solution with maximum affordability. Modularisation became a crucial part of their design parameters to minimise the cost of manufacturing and maintenance, and overall R&D. Also, modularisation helped the firms design for and sell to diverse emerging markets, and also developed markets. For ‘Company C’, case modularisation was crucial to developing a customisable solution. This was explained through the example of the soda lime canister in terms of making it reusable for emerging markets and disposable for developed markets. As the co-founder said:

And this thing here, which is Soda Lime, that absorbs the carbon dioxide from the breath, we have a reusable one which we got from Korea [...] In Australia we talked to them about reusable and disposable, and they said no, they want disposable, they don’t want to be bothered with reusable. It depends on the market.

The capability to prioritise and modularise the problem in order to pilot design parameters was needed for solving the problem for the environment within which the problem exists. Modularity also facilitated customisability enable the firms to market their products in multiple emerging markets and developed markets.

5.3.2.2. Capability to develop first-world quality products using sophisticated and old technologies and technical problem-solving techniques

Developing a substantially affordable solution for emerging markets with first-world quality standards was another unique capability built by all the cases. This was achieved by utilising more sophisticated developed-world technologies and problem-solving techniques through collaborative R&D, and by using old technologies to come up with novel and appropriate yet extremely affordable solutions.

Two of the four cases ('Project A' and the 'Project B') had developed the capability to use sophisticated developed world technologies and problem-solving techniques. For instance, according to the lead architect of the 'Company A':

I would say that what you are seeing with ['Project A'] is that the technology that we bring from a developed market perspective. And the very high levels of sophistication will deliver something that's very, very simple with low cost, without the need for skilled labour on-site to remote areas. Now that is a very different process or a very different product to low-cost, that is done in an emerging market.

In contrast, the other two cases (the 'Project C' and 'Project D') developed this capability by using old technologies to come up with novel, yet extremely affordable solutions. For instance, the founder of the 'Company C' humbly stated that they had not invented anything for their solution. Instead, they used old technology and their knowledge to put it together in novel ways to solve the emerging market problem.

Another 'Company C' participant responsible for IP also said they he did not consider the 'Project C' as an invention, but rather as an innovation that was a "conglomeration of many devices brought into a very simple cost-effective one".

The capability of using both sophisticated and old technology and integrating knowledge from various expert sources through collaborative R&D enabled these firms to achieve first-world quality standards. This included using product components or incorporating manufacturers who already possessed FDA approval, CE marks and ISO standards. The founder of 'Company C' explained that even though getting a CE mark was an expensive and time-consuming process, it was worthwhile because it helped them compete to capture both emerging and developed markets. The developed market firms also built the capability for forgetting advanced technological knowledge and know-how and adopting the clean slate approach by considering old technologies and using them in novel ways.

5.3.2.3. Capability to identify and onboard empathic stakeholders

Identifying and onboarding stakeholders with the same values and philanthropic drive as the founders and core team is another critical capability identified for developed market firms doing frugal innovation. All four cases had been co-innovating with their stakeholders, such as collaborative partners for R&D activities, as well as suppliers, distributors, and customers. Therefore, this capability enabled firms to have stakeholders whose motivational intent aligned to the firm's motivation, which facilitated having a cohesive vision and shared strategic actions to help in overcoming challenges associated with doing frugal innovation. This capability also enabled firms to acquire services at low cost, and in some cases for free ('Project A' and 'Project B'), thus minimising R&D costs for the firms. All four firms achieved this through a variety of techniques such as: involving family members, friends and professional networks and snowballing through them; serendipitous networking; inspired publicity and networking (by adopting a moral strategy); and informal networking in social events and with due diligence to ensure shared values, beliefs and emphatic drive.

The 'Project A' and 'Project B' cases considered a moral strategy useful in acquiring low cost and in some instances free services. According to the operational director of 'Company A':

A lot of people have helped out, and either haven't charged or haven't charged a lot for their time. You know, everybody believes in the project. When you speak to [Name of the founder] or anybody about the project, everybody is like wow that is amazing, and people just fall in love with it. Moreover, I guess our overall vision of what we want to achieve is such an amazing thing, so you do find a lot of people that are getting involved or have been involved in the past.

The 'Company C' case considered inspired publicity particularly helpful in attracting empathic stakeholders into the project, As the founder said:

Now what is also helped, it seems to have inspired certain people like, they have given us a few awards, which made a big difference. [...]. It is all good publicity, and I have realised that it is important, publicity is important.

The 'Company A' case emphasised the importance of due diligence to make sure that stakeholders' values align with the values of the founder and core team members. The 'Company A' director said:

So I think from that a huge lesson is really researching and doing your due diligence, and making sure that the people that are aligning with you or even working with you [...]

their values align with yours and what you're trying to achieve, what your end goal is, and what your objective is.

The developed market firms built the capability to identify and onboard empathic stakeholder by leveraging their networks, a moral strategy and inspired publicity, and through due diligence with potential stakeholders to ensure shared values, beliefs and emphatic drive towards doing good for the disadvantaged populations of the world.

5.3.2.4. Capability to organise virtual R&D collaboration & exploit a developed world R&D location

All the firms built the capability to organise virtual R&D with fixed and ad hoc collaborations. They achieved this through a flat R&D structure and being open to using external expert knowledge, sophisticated technology, and adopting modern problem-solving techniques from different locations, in particular in the developed world. The firms built this capability through identifying the required experts and offered a task-oriented flexible working arrangement from remote locations. Mostly, task related communication was done by Skype or email, with face-to-face communication arranged on an occasional basis.

The founder in the 'Project B' case explained that the overarching reason why this project had been successful in acquiring expert knowledge from all around the world was a virtual working arrangement related to R&D. He gave the example of an expert engineer who worked from home, saying:

He has got the luxury of doing that, and he picks his kids up at a certain time of the day. And I know that, so I do not call him at those times. But he communicates to a sale [...]. And they are the people that are involved in making the key decisions about say the power supply or the software.

All the cases acquired knowledge and expertise as per need on a short- or long-term contract basis. Therefore, the capability for organising virtual R&D collaboration not only gave access to a wide variety of experts from all around the world, but also helped them in substantially reducing the R&D cost by not paying for building space and utilities, and by not having to pay salaries to fixed long-term employees. As the founder of 'Company C' case said,

And that is the other thing; we have not got overheads, we do it all from home, you know, so we have not had to pay wages, salaries –Utilities, and – Yeah, so what we have been doing is just contracting work out. [...] And I think that is absolutely essential.

All four cases had strategic reasons for organising R&D in the developed market, and therefore built the capability to exploit the developed world R&D location. The common reason given was to leverage the benefits of the developed world in terms of access to broad expert knowledge, sophisticated technologies, modern problem-solving techniques and new product development techniques. Both the New Zealand based firms considered New Zealand as a favourable location for innovation due to the availability of advanced knowledge and technology and the flexibility it offers regarding regulations. The founder of ‘Company C’ mentioned New Zealanders are naturally innovative and ingenious. He added that for him it was also a matter of pride in labelling their innovation as “made in New Zealand”. The other two firms based in Australia also considered their Australian location, as also true for other developed countries, as favourable for their R&D and prototyping efforts in terms of acquiring sophisticated technology, expert knowledge and having wide and known network around them. In some instances, such as the case of the ‘Project D’, the Australian R&D location facilitated in acquiring funds from the Australian government for use in the early stages of R&D.

The developed market firms built the capability to organise virtual R&D, enabling them to achieve substantial cost reduction and access to a wide variety of expert knowledge in their new product development process, which then led to successful frugal innovation. These firms also considered their R&D location in the developed world as a facilitating factor in the success of their project.

To summarise section 5.3, two main sets of distinct capabilities were identified. These are Domain-specific capabilities and Process-specific capabilities. Domain-specific capabilities are those that are entirely related to the understanding of the emerging market context by the affluent innovator from the developed market. Process-specific capabilities are built through the underlying processes for achieving the objectives of cost minimisation and value maximisation within a new product development project.

5.4. Revised and extended model

Based on the empirical findings, the model for this research has been revised and extended (see Figure 6). The cross-case analysis not only confirms the initial theoretical framework, but also extends it with the typology of developed market firms’ motivational behaviour presented in section 5.1, and the differential activities that enable capabilities for doing frugal innovation within developed market firms presented in section 5.2. The revised and extended model also

includes the distinct capabilities built for doing frugal innovation within developed market firms presented in section 5.3.

The typology of developed market firms' motivations for doing frugal innovation expands the current discussions within the existing literature, which only focus on emerging market firms' reasons for doing frugal innovation. The typology shows three different developed market firm motivations based on their degree of empathy with market needs, and the importance of the activity being profitable. These motivations, termed the Philanthro-Capitalist, Robin Hood, and Cost-Driven approaches, reveal the different reasons developed market firms pursue frugal innovation. The model also illustrates a relationship between the firms' motivations for pursuing frugal innovation and their activities enabling capabilities for frugal innovation.

Including multi-level activities also adds value to the extended model by clarifying that multi-level processes are important by showing there is a relationship between the reasons firms pursue frugal innovation and the activities they undertake, both at the firm level and project level, to build capabilities for that type of innovation. The model also shows there are common and type-specific activities at both the firm level and project level. Clarification of the activities that are common across firms versus the ones that are firm specific is important to understanding the difference firm behaviours that are shaped by their differential motivations.

The extended model also shows the distinct capabilities built by the developed market firms for doing frugal innovation. Identifying these capabilities and showing how the firms developed these through firm-level and project-level activities relates the specific topic of frugal innovation to wider discussions around how developed market firms can complete by serving the emerging markets they have traditionally ignored.

5.5. Chapter summary

This chapter presented the cross-case analysis, identifying a typology of developed market firms' motivational behaviour. In particular, two dimensions seem to differentiate the motivation of the firms to engage in frugal innovation: a) empathy with market need, and b) profitability. Using these two dimensions of motivation to engage in frugal innovation, three categories of developed market firm motivational behaviour for doing frugal innovation were identified: the Philanthro-Capitalist, the Robin Hood, and the Cost-Driven approach. This chapter also presented the firm-level strategic decision-making activities and project-level knowledge integration activities that underpin the capabilities for frugal innovation within

developed market firms. As per the activities, the findings identify the distinct capabilities built for doing frugal innovation within developed market firms, thereby presenting a revised and extended model.

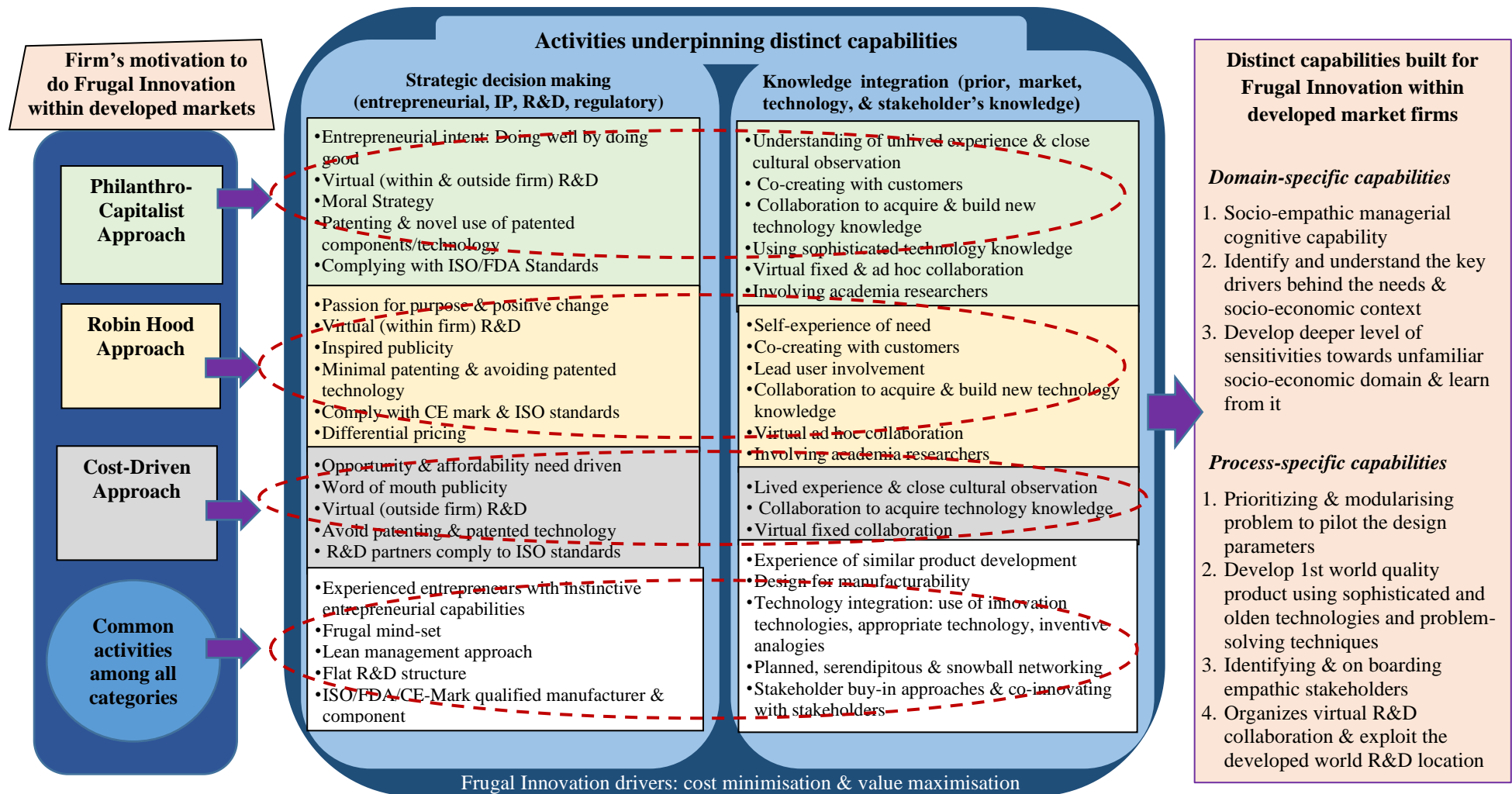


Figure 6 Revised and extended model

6. Discussion and Conclusion

This final chapter presents the discussion of the key findings in relation to the current status of the frugal innovation literature. The objective is, as suggested by Eisenhardt (1989a), to identify and elaborate on conflicts and similarities between the findings of this study and the existing literature on frugal innovation. This will not only support the internal validity of the empirical findings, but also help draw out theoretical implications from this study.

The chapter is structured as follows. Section 6.1 summarises the research, including the research objectives, research question, theoretical framework, and the research methods used to answer the research question. Section 6.2 summarises the main findings and discusses the theoretical contributions in light of the existing knowledge about frugal innovation. Section 6.3 outlines the practical implications of this research, followed by section 6.4, which acknowledges the limitations of the research and suggests future research avenues. Finally, section 6.5 concludes this thesis.

6.1. Overview of this research

The overarching objective of the present research is to understand how developed market firms build capabilities for doing frugal innovation for emerging markets (the term ‘developed market firms’ in this thesis is used for firms operating within a developed market context). The research empirically examines the strategic decision-making activities at the firm level and knowledge integration activities at the project level that enable capabilities for doing frugal innovation in developed market firms. Figure 7 illustrates the structure of this thesis.

Frugal innovation is a nascent concept recently introduced into the innovation management literature to characterise the processes occurring in emerging markets. Frugal innovation substantially reduces the costs of goods from the consumer’s perspective and delivers this by concentrating on core functionalities and using them to optimise product performance level given the market needs (Weyrauch & Herstatt, 2016). Frugal innovation started in emerging market firms that were delivered good enough quality, yet substantially low-priced products for consumers in emerging markets. However, the success of these emerging market firms has caught the attention of developed market firms. They recognise that their traditional export and resale models for serving emerging markets are no longer competitive and are now considering frugal innovation as part of wider resource minimisation activities (Christensen, Baumann, Ruggles, & Sadtler, 2006; Nakata & Weidner, 2012; Prahalad, 2005).

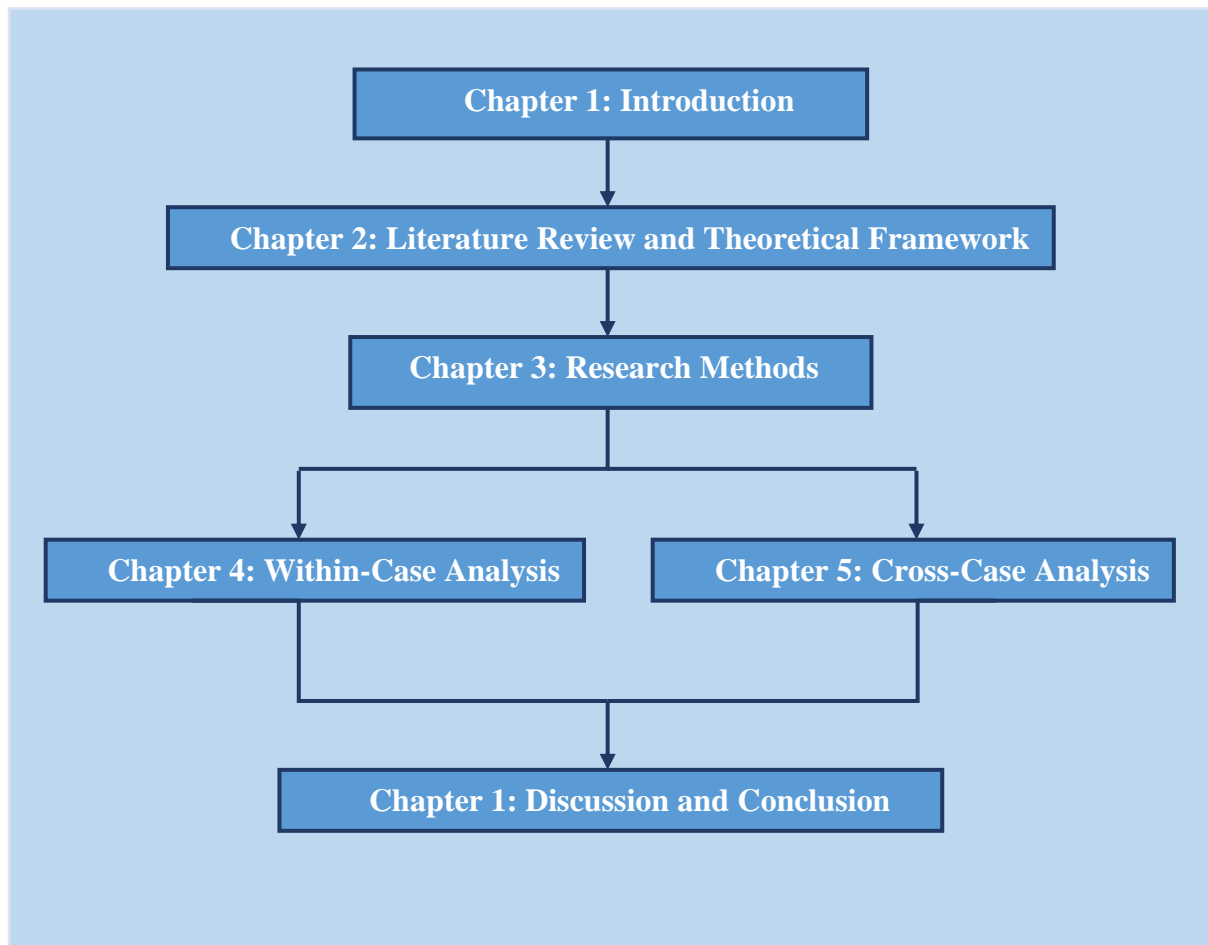


Figure 7 Structure of the research

As mentioned as in the introduction to the present research (Chapter One), while researchers and practitioners assert frugal innovation as a potentially relevant innovation process for developed market firms (Agarwal & Brem, 2017; Agarwal et al., 2017; Radjou & Prabhu, 2015b; Subramaniam et al., 2015), almost all the extant knowledge about frugal innovation is based on the experiences of emerging market firms. Emerging market firms operate in radically different conditions to developed market firms, due to the impoverished economic conditions, lack of infrastructure, and weaker institutions (Govindarajan & Trimble, 2012c; Porter & Stern, 2001; Sheth, 2011). In these conditions, the product development process is different from that in developed market firms and operates on different capabilities (Brem & Wolfram, 2014; Subramaniam et al., 2015; P. Williamson & Zeng, 2007, 2009). Since emerging market firms are able to compete with developed market firms, these differences mean that for most developed market firms, addressing emerging market needs may be easier said than done (Subramaniam et al., 2015). Therefore, while the current literature generally informs the research, it is insufficient to understand the capabilities for frugal innovation in developed market firms.

The literature review identifies a few studies on frugal innovation in developed market firms. While these demonstrate that the phenomenon does exist (e.g., Radjou & Prabhu, 2015a; Rosca et al., 2017), they are few in number and descriptive in nature, lacking the systematic exploration that helps toward theoretical explanation. A few recent studies have explored frugal innovation within the developed market context in attempt to clarify some definitional and conceptual issues (Lim & Fujimoto, 2019; Melkas et al., 2019; Winkler et al., 2019). However, these studies are yet to take account of the underlying activities of frugal innovation in the developed market context. An empirical study by Altmann and Engberg (2016) is a rare exception as it examines frugal innovation by a developed market firm for emerging markets. They suggest the transferability of market and technical knowledge to the new context and the willingness of the developed market firm to manage the difficulties of innovating for emerging market consumers are two key factors determining whether developed market firms can create breakthrough products for emerging markets. Nonetheless, these scholars point out that their study is an initial step in theorising what influences frugal innovation by developed market firms, and its applicability is limited to large firms who use formal R&D in their innovation process. Hence, the calls for systematic research to empirically examine frugal innovation in firms in the developed market context (Agarwal & Brem, 2017; Agarwal, Grottke, Mishra, & Brem, 2017; Barczak, 2012; Govindarajan & Ramamurti, 2011; Hossain, 2017, 2018; Nakata & Weidner, 2012; Subramaniam et al., 2015), and to understand the capabilities that enable such firms to innovate for emerging markets (Subramaniam et al., 2015) remain unanswered, hence the following research question:

How do strategic decision making and knowledge integration activities enable capabilities for frugal innovation in developed market firms?

Conclusions from the literature review and theoretical framework in Chapter Two suggest that using dynamic capabilities as a theoretical lens to explore the capabilities for doing frugal innovation within developed market firms could reveal a new theoretically driven explanation of the capabilities and underlying activities through new product development processes. Such an approach could expand extant knowledge about frugal innovation activities in developed markets firms in particular, and for innovation management in general. The review of the extant frugal innovation literature from a dynamic capability perspective in the second part of Chapter Two reveals that firm-level and project-level activities are important in capabilities for frugal innovation and provides the basis for the initial conceptual framework.

The empirical work adopts a qualitative case study approach and is informed by the interpretivist paradigm (Chapter Three). Four in-depth purposive case studies are generated. Theoretically driven criteria guide the case selection and new product development projects within developed market firms involved in frugal innovation for emerging markets is the unit of analysis. The analysis is multi-level at the firm level and project level. The data are collected through semi-structured interviews using current and retrospective questioning approaches and triangulated with reports and archival data to increase internal validity. Thematic analysis is used following the framework suggested by Eisenhardt (1989a). The analysis is iterative, starting with within-case analysis (Chapter Four), and then moving to the cross-case analysis (Chapter Five). The final step of moving between findings and the literature to revise the framework and abstract the finding for theory building (Eisenhardt, 1989a; Miles & Huberman, 1994) is presented in next section.

6.2. Discussion and theoretical implication for Frugal Innovation literature

This section presents and discusses the contribution of the research to the frugal innovation literature. The following four contributions emerge from the research:

1. First, the typology of developed market firms' motivations for doing frugal innovation expands the current discussion that is focused on emerging market firms' reasons. The typology shows three different categories of firm motivation based on the degree of empathy with market needs and the importance of activity being profitable. These categories of firm motivational behaviour termed; Philanthro-Capitalist, Robin Hood, and Cost-Driven approaches, offer a new way to describe the different reasons of developed market firms for pursuing frugal innovation.
2. Second, while the activities within emerging market firms have been described in illustrative case studies, it is unclear which of these activities matter to all firms, or where in the firm the activities occurred. This study clarifies both of those points, showing the common and type-specific activities at the firm- and project-level. Clarification of the activities that are common across firms versus those specific to the motivation of a firm is important, since, from a dynamic capability perspective, the idiosyncratic nature of such activities can be a source of competitive advantage through innovation. Moreover, the findings reveal the distinct capabilities these developed market firms developed for frugal innovation. Identifying those capabilities and showing how the firms developed these through firm- and project-level activities relates the specific topic of frugal innovation to

wider discussions of how developed market firms can complete by serving emerging markets, which they have traditionally ignored.

3. The third contribution pertains to the illustration of developed market firms' capabilities for frugal innovation with a model (see Figure 6). As frugal innovation is emerging as a topic, theory-building efforts are required to address key questions about why and how different types of firms pursue it. Also, theorising is necessary to understand what insights can be drawn from the four case studies to inform this new field. The model put forward in this study contributes to that endeavour in two particular ways. First, as a multi-level model it shows the many firm-level and project-level activities underpinning distinctive capabilities for frugal innovation. Multi-level models have certain implications for scholars and practitioners (Hitt, Beamish, Jackson, & Mathieu, 2007). Clarifying these multi-level processes is important since it provides a more comprehensive understanding, thereby enabling theorising at multiple levels, which in turn helps in bridging the micro-macro gap in theory. Second, it conceptualises three categories of developed market firm motivation. The models show a relationship between a firm's motivation to pursue frugal innovation and the activities they undertake that enable capabilities for that innovation.
4. The fourth contribution is the focus of the present research. Responding to the obvious lack of in-depth and systematic frugal innovation studies conducted within the developed market context, the present research attempts to fill this gap. Most importantly, within the developed market context, the present research focuses on the developed markets in the Asia-Pacific, region such as Australia and New Zealand. Even though a few recent studies are reported in the frugal innovation literature that explore the involvement of developed countries such as the UK, US, Canada and European countries in frugal innovation, these studies mainly attempt to understand the concept of frugal innovation from the developed market perspective (e.g., Rao, 2017; von Janda et al., 2020; Winkler et al., 2019). Therefore, to the best of the researcher's knowledge, the present research is the first attempt to conduct in-depth and systematic exploration of the underlying activities that enable the capabilities in developed market firms doing frugal innovation within Australia and New Zealand.

The Australia and New Zealand based developed market firms examined in this research are targeting emerging markets in the Asia-Pacific region, in particular Pacific Islands such as Papua New Guinea, Vanuatu, and Fiji, but not limited to them. Since the emerging markets of the Pacific Islands have been a consistently neglected research avenue for innovation related studies, the present research therefore contributes to the innovation literature in general, and the frugal innovation literature in particular, by exploring these

Asia-Pacific regions. To the best of the researcher's knowledge, the present research is the first frugal innovation study to be conducted on developed market firms based in the Asia-Pacific region primarily targeting emerging market customers in the Pacific Islands, but not limited to them.

The literature suggests that frugal innovations from emerging market firms, and their potential to capture global markets, have turned the attention of developed market firms for three main reasons. Firstly, they recognise their potential threat for capturing global markets (Zeschky et al., 2011) and even superseding developed market firms in some sectors (Immelt, Govindarajan, & Trimble, 2009). The second reason is the potential growth opportunities offered by low-income market segments in emerging markets (Agarwal et al., 2019, 2017; Rosca et al., 2017), where only a few developed market firms have taken an interest by getting involved in frugal innovation in the emerging market context (Govindarajan, 2012; Immelt et al., 2009). Third is the increasing trend towards and appearance of low-cost innovation and general awareness of resource minimisation (such as financial, environmental and time) within developed markets, and the evident relevance between frugal innovation and disruptive innovation (Christensen, 1997; Christensen & Raynor, 2003; Corsi & Minin, 2014). Frugal innovation is partially driven by resource minimisation activities such as lean management practices and deskilling of labour (Prahalad, 2012), therefore the developed market firms are starting to engage in setting a new engineering culture, revamping product development and manufacturing methods, reorganising organisational structures, reorienting approaches towards innovation, and going for unspecialised, experimental, adaptive and lean approaches (Sinha, 2013). The new trend of adopting low-cost innovation or disruptive innovation activities within developed market firms is also turning the attention of other entrepreneurs in developed markets towards low-cost innovation and approaches such as frugal innovation.

The present research broadens the knowledge and discussion on the motivations for engaging in frugal innovation and brings insights from the developed market firm's perspective by recognising that developed market firms engage in frugal innovation along two main dimensions of motivation that also seem to differentiate their behaviour when engaging in frugal innovation. These dimensions of motivations are the degree of social empathy towards market needs, and the importance of the activity being profitable. Based on these two motivations, the present research develops a typology that categorises firm's motivational behaviour into three approaches, namely 1) Philanthro-Capitalist, (2) Robin Hood, and (3) Cost-Driven. The typological differences also highlight differences in underlying firm activities related to the frugal innovation product development process. Among those underlying activities, the ones that are distinct to particular developed markets firms substantially contribute to understanding the capabilities built for frugal innovation within developed market firms. Knowing that innovation activities within emerging markets are different from developed markets, the present research confirms that developed market firms

require distinct capabilities and are involved in distinct activities to do frugal innovation (Subramaniam et al., 2015). More importantly, the present research asserts that developed market firms already possess some capabilities and can build other capabilities for frugal innovation.

The extant knowledge on frugal innovation, informed by strategic and process perspectives, suggests a multi-level explanation. The strategic perspective suggests that firms doing frugal innovation hone existing capabilities and acquire and build new capabilities to solve problems, thereby creating entirely new markets instead of creating low-end segments of existing markets (Winterhalter et al., 2017). Additionally, the strategic perspective indicates that firm-level activities influence a firm's ability to generate innovations that matter for inclusive growth (George et al., 2012). The studies that focus on processes primarily explore the new product development process of frugal innovation to understand the capabilities of firms doing frugal innovation within emerging markets. Some studies also directly apply the capability lens (e.g., Ansari et al., 2012) in order to understand the firm's capabilities for doing frugal innovation within emerging markets. Altogether, these studies highlight certain underlying activities within new product development processes such as: the innovator's approaches towards product design, alliances or acquisition, collaboration, and openness to external knowledge—all to achieve minimised cost and maximised value of the product from a consumer perspective (e.g., Lim & Fujimoto, 2019; Lim et al., 2013; S. Ray & Ray, 2011; Tiwari & Herstatt, 2012c; Tiwari et al., 2014; Viswanathan & Sridharan, 2012).

The theoretical lens provided by the dynamic capability perspective and the frugal innovation literature suggest that both strategic decision-making activities with cost minimisation and value maximisation objectives at the firm level and knowledge integration activities to achieve cost minimisation and value maximisation at the project level are required to explain the capabilities for frugal innovation in developed market firms. This perspective asserts that processes such as new product development and knowledge integration are more important than a bundle of resources for building capabilities or shaping existing capabilities (Eisenhardt & Martin, 2000; Iansiti & Clark, 1994; Marsh & Stock, 2003). This perspective also asserts that entrepreneurial strategic decisions and managerial orchestration contribute to new value-creating strategies, thereby enabling firms to deploy their scarce resources to create high value, which enables firms to meet current market needs and technological trends (Eisenhardt & Martin, 2000; Teece, 2014).

Drawing on the dynamic capability perspective and frugal innovation literature, and through conducting a multi-level theory-driven exploration, the present research reveals that developed

market firms built capabilities for frugal innovation through firm-level general and type-specific strategic decision-making activities and project-level general and type-specific knowledge integration activities. The focus of the developed market firms primarily remains on achieving minimised cost and maximised value from the emerging market consumer perspective, but there is also recognition of the relevance for budget-oriented consumers in the developed markets.

In terms of firm-level general and type-specific strategic activities, the present research reveals new interesting insights related to entrepreneurial decisions shaped by an entrepreneurial intent and mindset for doing frugal innovation. The existing literature claims that to do frugal innovation, entrepreneurs within developed market contexts need to revamp their existing mindset, the structure of their firms, practices and overall approach towards innovation (George et al., 2012; Govindarajan, 2012; Immelt et al., 2009). The existing literature also asserts that frugal product innovators require—a frugal mindset, which is facilitated by resource scarcity and institutional voids (Soni & Krishnan, 2014), a lived experience of the customer's needs (Subramaniam et al., 2015; Viswanathan & Sridharan, 2012; Zeschky et al., 2011), local people within the team (Zeschky et al., 2011), and a strong local presence within emerging markets to develop frugal innovation successfully (Ernst et al., 2014).

Although this research confirms the suggestion of revamping the entrepreneur's existing mindset, it also affirms that affluent innovators from developed market firms within the developed market context can develop a frugal mindset. The existing frugal innovation literature associates a frugal mindset with lived experience and a strong local presence in resource scarce environments that are lacking infrastructure and have institutional voids. While these suggestions are correct for the firms doing frugal innovation within the emerging market contexts, the present research, however, provides an alternative explanation of developing frugal mindset by the innovators of developed market firms. The present research suggests that through ample exposure, close cultural observation, and self-experience of resource-constrained customers and the environment within emerging markets, socially and economically affluent innovators from developed markets can build the capability for learning from completely unfamiliar market settings and develop the frugal mindset necessary for the successful development of frugal innovation products.

In addition to claims associated with the frugal mindset, the existing frugal innovation literature also claims that leveraging institutional voids within emerging markets is a necessary supporting factor to engage in frugal innovation (Ansari et al., 2012; Asakawa et al., 2019;

Bhatti & Ventresca, 2012; Ernst et al., 2014; Soni & Krishnan, 2014). The present research supports this claim. However, the present research also suggests that formal institutions within the developed market, along with access to a superior knowledge base and sophisticated technology alongside empathetic motives, enable developed market firms to innovate a frugal product for emerging markets while meeting first-world quality standards.

Additionally, Asakawa et al. (2019) argue that while a lack of infrastructure provides a frugality-based advantage to firms operating in emerging market contexts, they also assert that stricter environmental regulations such as those in developed markets may facilitate innovation and enable better quality innovation that can pay off the initial cost of regulation through increased profits. From the perspective of the present research their argument is partly correct as it suggests that developed market firms operating in a developed market context can comply to regulations and develop high quality products. However, the present research findings also suggest that those high quality sophisticated products are also frugal innovations. Further, in such frugal innovations, the cost of regulation is handled by using a network of sophisticated knowledge and complying with ISO/FDA approval/CE mark standards to develop enormous market opportunities, both within developed and emerging markets. In line with expanded market opportunities, the present research also confirms the claim that frugal innovation could create entirely new markets (Lim & Fujimoto, 2019; Winterhalter et al., 2017), which is evident from the example of the 'Company C' case study in that their product could enable mobile operation theatres.

Thus, the present research highlights the practices through which developed market firms minimise the cost of complying with these standards and achieve sophisticated technological products. This finding of the present research also complements prior studies suggesting that a low-cost product does not necessarily mean low-tech, and that frugal innovation can be developed by combining sophisticated science, knowledge and technology (Arocena, 2019; Bound & Thornton, 2012; Rao, 2017). Further, such frugal innovations can get patented considering that they are not just downsizing an existing solution, and involve extensive engineering work and novel technical solutions (Altgilbers et al., 2020). The 'Company B' 'Project B' in the present research is the best example of such frugal innovation. The present research findings not only reveal the incorporation of sophisticated science and technology to develop a patentable frugal solution, they also suggest that developed market firms put extra emphasis on the sustainability aspects of the solution. These findings align with frugal innovation studies that have explored frugal innovation in relation to sustainability and suggest a positive relationship (e.g., Albert, 2019; Bas, 2017; Bianchi et al., 2017; Brem & Ivens, 2013;

Hassani et al., 2019; Molina-Maturano et al., 2020; Rao, 2017; Rodríguez & Cunha, 2017; Rosca et al., 2017; von Janda et al., 2020, 2020).

In terms of project-level general and type-specific knowledge integration activities, the present research findings are in line with a recent study on knowledge integration and frugal innovation (Dost et al., 2019) that suggests significant effects for internal and external sources of knowledge on frugal innovation, and for facilitating frugal innovation in the midst of moderate market and technology turbulence. Other frugal innovation studies also confirm that the combination of internal and external knowledge expertise facilitates frugal innovation (Bhatti, 2012).

Nevertheless, the present research also reveals some interesting new insights related to collaborative R&D and knowledge integration activities for doing frugal innovation. Traditionally, offshoring R&D and other outsourcing activities are considered cost reduction practices (Nieto & Rodríguez, 2011). Also, the frugal innovation literature on emerging markets suggests that developed market firms operating within emerging markets opt for collaborative partnerships and outsource (missing low-cost competencies) when they lack critical frugal competencies, as building those capabilities within the firm is costly (Winterhalter et al., 2017). While the present research agrees with these claims regarding the emerging market context, the present research also suggests that developed market firms doing frugal innovation opt for collaborative partnership for two reasons: 1) To integrate the firm's internal knowledge with the capabilities and knowledge of collaborative partners in order to build new frugal competencies; 2) To exploit the superior knowledge base and sophisticated technology available within the developed market context. It is also another core reason developed market firms opt for virtual R&D apart from resource flexibility and cost minimisation. From the perspective of the broader innovation literature, these practices align with the open innovation concept, see for example H. Chesbrough, Vanhaverbeke, and West (2014) which emphasises efficient and effective innovation through integrating internal and external knowledge bases. The present research findings therefore suggest that big investment in R&D is not necessary for developed market firms to achieve improved performance of the product at low cost, as suggested otherwise in Lim and Fujimoto (2019).

From the product design and technological knowledge perspective, the present research findings suggest that a modular design architecture coupled with new technological knowledge could enable complex frugal innovation products that meet first-world quality standards. These findings relate to Lim and Fujimoto's (2019) suggestion that "frugal innovation can be treated from traditional viewpoint of technological product innovation, in the sense that it may be

improving the performance of the product deliverable by creating new technological knowledge”. Lim and Fujimoto (2019) also suggest that modular architecture and mixing and matching low-cost standard parts may not achieve minimum quality standards in heavy and complex machines. However, the present research findings suggest that minimal adaptation and modification of low-cost standard parts to make them fit for purpose coupled with the development of new technological knowledge could result in a good quality complex frugal innovation product. The ‘Company B’ ‘Project B’ can be considered a great example of modular design architecture coupled with new technological knowledge.

Synthesising the findings for developed market firms’ motivation and the general and type-specific firm-level and project-level activities leads to a revised and extended conceptual model (see Figure 6). This model advances various aspects. First, it presents a typology of developed market firm motivation to engage in frugal innovation. Second, it presents a multi-level, theory-driven exploration of the common and type-specific activities that underpin capabilities for frugal innovation. Third, it suggests common distinct capabilities built by developed market firms to do frugal innovation. Identifying and understanding the distinct capabilities of developed market firms for frugal innovation is important, as this facilitates differentiating the activities that enable capabilities for frugal innovation in developed market firms from those in emerging market firms. This model, therefore, broadens the existing knowledge and understanding of capabilities for doing frugal innovation by presenting it from the perspective of developed market firms.

6.3. Practical implications

From a practical perspective, the empirical insights offer important lessons for developed market firms pursuing frugal innovation. More specifically, the present research highlights certain firm-level strategic decision activities and project-level knowledge integration-related activities within the new product development process that can develop capabilities for frugal innovation. Awareness of the firm-level and project-level activities that enable capabilities for doing frugal innovation has value for top management, innovators, developers, and R&D professionals in developed market firms by arming them to tackle the low-cost competition from emerging market firms and enabling them to be sustainable in the face of global competition.

The literature review for the present research shows that frugal innovation is not only relevant for the emerging market context, but that scholars identify it as equally relevant to an amplifying segment of budget-oriented, value for money customers in developed markets

(Cunha et al., 2014; Radjou & Prabhu, 2015a; Zeschky et al., 2011). Taking a further step, the present research suggests that developed market firms in their early growth stage are involved in frugal innovation for various motivational reasons. These motivations are shaped by their degree of interest in profits and levels of social empathy towards emerging market needs, which range from high, to moderate, or low. However, socio-empathic motives play a vital role in enabling developed market firms to overcome the high risks and challenges associated with developing frugal innovation solutions. The present research therefore provides guidelines for firms with philanthropic drive and minimal resources to adopt the Philanthro-Capitalist approach, which will instil vision in these social enterprises within developed market contexts towards achieving a win-win.

The present research also suggests that to be involved in frugal innovation projects, developed market firms need to build distinct capabilities both at the firm level and project level. Knowing these distinct capabilities is particularly important because they are unique to the firms operating in the developed market context, which is considered different to the emerging market context. These firm-level distinct capabilities could provide guidance to top management on how they can encourage and facilitate the activities of frugal innovation within their firm. For instance, developed market firms could organise and manage virtual and flat R&D structures, and adopt a “moral strategy” to identify and onboard stakeholders with shared values and beliefs so as to leverage the sophisticated technology and expert knowledge base available through maintaining proximity to developed markets. Similarly, the project-level distinct capabilities could also provide guidelines to product innovators seeking to minimise resources without compromising on quality. For instance, to develop capabilities for frugal innovation, developed market firms can adopt a clean slate approach of forgetting the known and being open to new learning to understand the customer in resource-constrained environment, and thereby develop a frugal mindset that focuses on cost minimisation and value maximisation from consumer’s perspective. Thus, the firm-level strategic decisions identified in the present research provide guidelines to top management on how to encourage and facilitate the activities of frugal innovation within developed market firms.

At the project level, the activities identified in the present research provide guidelines for product innovators within developed market firms seeking to minimise resources without compromising on quality. Identifying these activities is especially important for all types of firms as they seek production efficiency, reduced use of resources and other related cost control mechanisms. Since these project-level activities are process-based, they are therefore less explicit and so difficult for competitors to imitate, thus help in combating global market

competition. Additionally, the present research provides valuable and timely guidance to managers involved in frugal innovation projects in particular, as well as other managers of small and medium enterprises, for identifying, approaching and accessing the sources of external knowledge and integrating the external knowledge with the firm's internal knowledge in a purposeful manner so as to achieve the cost minimisation objective without compromising on quality.

6.4. Limitations and future research

The present research comes with some limitations that bring forth some fruitful opportunities for future work. Firstly, the present research examines extreme cases to reveal new insights into theory and management. Due to challenges associated with identifying and accessing extreme cases, the present research could only access four cases and incorporates a retrospective approach. The retrospective approach comes with the issues of recalling historical data and post hoc explanation, which raises validity issues for this type of research design. Therefore, triangulation is used to inform the issues associated with the retrospective approach. Nevertheless, having only four cases implies limitations to this research. Also, four extreme cases do not facilitate generalisability despite providing detailed and thick description. Although, generalisable research is appreciated by and considered more valuable among scholars, the novelty of the frugal innovation concept and the scarcity of scholarly studies on frugal innovation call for theory expansion and new insights from contexts that have never been studied systematically before. The primary purpose of this research is therefore theory building, not empirical generalisation to the whole developed market context.

Even though four in-depth case studies are considered sufficient for a cross-case analysis (Eisenhardt, 1989a), a larger sample could nonetheless facilitate a broader and deeper understanding of how developed market firms build capability for doing frugal innovation. Since all four cases are located in the Asia Pacific region due to primary focus of this research and associated constraints such as time, budget, and accessibility, therefore additional fruitful insight into theory might emerge if similar studies are conducted in other developed markets, such as Europe, the USA, and Canada. One could also select cases from all these geographical regions, which would not only enable a larger sample to improve generalisability, but any institutional, socio-economic and cultural differences might reveal new exciting insights into capability building processes for doing frugal innovation.

Secondly, all the cases within the present research are small and young firms in the early growth stage, therefore the ability to draw implications for established firms is limited, and the findings are entrepreneurial in nature and may fall within the social innovation area. Thus,

future research could explore established firms within the developed market context to establish broader implications.

Thirdly, the cases presented in the current research do not include unsuccessful frugal innovation cases. Comparing both successful and unsuccessful frugal innovation cases within developed markets would also be a useful future research avenue to reveal best practices and potential barriers for frugal innovation capability within developed market firms.

Finally, the typology of firm motivation for frugal innovation within developed market firms is tentative. Hence, quantitative research could be conducted in future to validate the suggested typology.

6.5. Concluding remarks

In summary, this research entails new insights and contributes to the emerging research on frugal innovation. To the best of researcher's knowledge, this present research is the first to fill this gap in the inadequate literature on frugal innovation, where there are anecdotal examples of frugal innovation within developed market firms but a lack of literature and thus understanding about the activities that enable capabilities for doing frugal innovation within developed market firms. As almost all the frugal innovation research so far has focused on activities within emerging markets, the present research emphasises the importance of frugal innovation activities in developed markets. It brings forward fruitful insights that challenge preconceived notions about developed market firms not being able to do frugal innovation. It not only empirically identifies the distinct capabilities built by developed market firms for doing frugal innovation, but also highlights the underlying activities that enable those capabilities.

Appendix A. Participant Information Sheet & Consent Form (Organisations)

Department of Management & International Business
The University of Auckland
Private Bag 92019
Auckland, New Zealand
Telephone + 64 220785801,
Email: f.subhan@auckland.ac.nz

Participant information sheet for organisations

Title: Capability Building for doing Frugal Innovation within Developed Markets

Dear {Participant},

My name is Fasiha Subhan. I am a PhD student in the Department of Management & International Business at the Business School of University of Auckland New Zealand. I am conducting my PhD research on capability building process for doing frugal innovation within developed market firms under the supervision of Prof. Kenneth Husted, based at University of Auckland, New Zealand and Prof. Cornelius Herstatt, based at TUHH, Germany. The research will be used for my PhD thesis, and eventually for conference papers and publications.

Your organisation is invited to participate in my research, and I would appreciate any assistance you can offer me. As part of my research, I want to conduct a case study on your organisation and want to develop theoretical insights into the activities of organisations similar to yours, with particular emphasis on the process of capability building for doing frugal innovation within developed market firms. Your organisation has consented to this research.

I would like to interview appropriate people in your organisation, but no-one is under any obligation at all to participate. I would greatly appreciate a list of individuals within your organisation who might be appropriate for this research. Each such individual will be interviewed or observed only after they sign a form giving consent for the interview.

You will need to confirm that participation or non-participation in this research will not affect anyone's employment or relation with the firm. Each interview would take about 1–1½ hours and would be during work time. Participants can withdraw their information any time up to 14 working days after being interviewed or observed. To ensure accurate collection of information, I would like to make audio recordings of the meetings. If the recording is undertaken, participants may request that it stops at any time. Furthermore, participants may request a copy of the transcription of their interviews. The transcription may be done by a professional third-party operating under a confidentiality agreement.

All information provided to me is treated in a confidential manner, and the names of respondents, or your organisation, will not be used; nevertheless, it is possible that others may correctly guess the identity of those participating in this research. **Any information that participants indicate is commercially sensitive will not be disclosed** and will be used only to provide background context for the researchers, and it will not be reported. My

study of your organisation might build the foundation for a long-term research project (after I finish my PhD). Therefore, data collected in the present project may be used for future research in that broad line of inquiry and will be stored for a minimum of six years. All data collected will be securely stored on password-protected and backed-up on the server.

If you agree to be interviewed, please let me know by filling in the attached *Participant Consent Form*. Thank you very much for your time and help in making this study possible. If you have any queries or wish to know more, please email me, phone me, or write to me at the address above.

Fasiha Subhan, Department of Management and International Business, The University of Auckland Business School, Level 4, Room 416, Private Bag 92019, AUCKLAND, Telephone 923 5762, Email: f.subhan@auckland.ac.nz.

Below are the contact details of my supervisor:

Prof. Kenneth Husted, Department of Management and International Business; The University of Auckland Business School, Private Bag 92019, Auckland; Telephone 923 6829, Email: k.husted@auckland.ac.nz,

You can also contact my Head of Department at the address below:

Professor Rod B McNaughton, Department of Management and International Business; The University of Auckland Business School, Private Bag 92019, Auckland; Telephone 923 7524

For any concerns regarding ethical issues you may contact:

The Chair, the University of Auckland Human Participants Ethics Committee, at the University of Auckland, Research Office, Private Bag 92019, Auckland 1142. Telephone 09 373-7599 ext. 83711. Email: ro-ethics@auckland.ac.nz

Approved by the University of Auckland Human Participants Ethics Committee on 20th March 2017 for one year and two months, Reference number 014190

Participant consent form for organisations

This consent form will be held for a period of six years

Title: Capability Building for doing Frugal Innovation within Developed Markets

Researcher: Fasiha Subhan

As the principal representative/contact for this research within my organisation, I have been given and have understood an explanation of this research project. I have had an opportunity to ask questions and have them answered.

I understand that all those who are participating in the study may be interviewed or observed only after they give formal consent on consent forms. I understand that individual participants can withdraw their participation and any information traceable to them at any time up to 5 working days after their respective interviews without giving a reason.

I understand that audio recordings may be made of interviews and that participants may request that the recorder be turned off at any time.

I understand that participants may request copies of the transcription of their interviews and that transcriptions may be done by a professional third-party operating under a confidentiality agreement.

I understand that the present research project might build the foundation for a long-term research project. Therefore, data collected in the present project may be used for future research in that broad line of inquiry.

I confirm that participation or non-participation in this research will not affect anyone's employment or relation with the firm.

I agree for my organisation to take part in this research.

Name of Organisation: _____

Name of the representative/ Contact within the organisation (Please print clearly): _____

Signature of the representative/ Contact within the organisation: _____

Date Signed: _____

Approved by the University of Auckland Human Participants Ethics Committee on 20th March 2017 for one year and two months, Reference number 014190

Appendix B. Participant Information Sheet & Consent Form

(Individuals)

Department of Management & International Business
The University of Auckland
Private Bag 92019
Auckland, New Zealand
Telephone + 64 220785801,
Email: f.subhan@auckland.ac.nz

Participant information sheet for individuals

Title: Capability Building for doing Frugal Innovation within Developed Markets

Dear {Participant},

My name is Fasiha Subhan. I am a PhD student in the Department of Management & International Business at the University of Auckland Business School. I am conducting my PhD research on capability building process for doing frugal innovation within developed market firms under the supervision of Prof. Kenneth Husted, based at University of Auckland, New Zealand and Prof. Dr Cornelius Herstatt, based at TUHH, Germany. The research will be used as the basis for my PhD thesis, and eventually for conference papers and publications.

You are invited to participate in my research, and I would appreciate any assistance you can offer me. As part of my research, I am conducting a case study with your organisation and want to develop theoretical insights into the activities of organisations similar to yours, with particular emphasis on the process of capability building for doing frugal innovation within developed market firms. Your organisation has consented to this research.

I would like to interview you – but you are under no obligation at all to be interviewed. The interview would take about 1–1½ hours and would be during work time. You can withdraw your information any time up to 14 working days after being either interviewed. Your CEO has given an assurance that participation or non-participation in this research should not affect your employment or relationship with this organisation.

To ensure accurate collection of information, I would like to make audio recordings of our meetings. You may request that the recording stops at any time. You may also request a copy of the transcript of the recording. Transcriptions may be done by a professional third-party operating under a confidentiality agreement.

All information provided to me is treated in a confidential manner, and the names of respondents, or your organisation, will not be used; nevertheless, it is possible that others may correctly guess the identity of those participating in this research. Thus, you should assume that any information given by you may be directly identifiable as being provided by you. **Any information you indicate as being commercially sensitive, will not be disclosed**, and only used to provide background context for the researcher; it will not be reported. If you agree to participate, please let me know by filling in the attached Participant Consent Form.

My study of your organisation might build the foundation for a long-term research project (after I finish my PhD). Therefore, data collected in this project may be used for future research in that broad line of inquiry and will be stored for a minimum of six years. All data collected will be securely stored on password-protected and backed-

up on the server. Thank you very much for your time and help in making this study possible. If you have any queries or wish to know more, please email me, phone me, or write to me at the address above.

Fasiha Subhan, Department of Management and International Business, The University of Auckland Business School, Level 4, Room 416, Private Bag 92019, AUCKLAND, Telephone 923 5762, Email: f.subhan@auckland.ac.nz,

Below are the contact details of my supervisor:

Prof. Kenneth Husted, Department of Management and International Business; The University of Auckland Business School, Private Bag 92019, Auckland; Telephone 923 6829, Email: k.husted@auckland.ac.nz,

You can also contact my Head of Department at the address below:

Professor Rod B McNaughton, Department of Management and International Business; The University of Auckland Business School, Private Bag 92019, Auckland; Telephone 923 7524

For any concerns regarding ethical issues you may contact:

The Chair, the University of Auckland Human Participants Ethics Committee, at the University of Auckland, Research Office, Private Bag 92019, Auckland 1142. Telephone 09 373-7599 ext. 83711. Email: ro-ethics@auckland.ac.nz

Approved by the University of Auckland Human Participants Ethics Committee on 20th March 2017 for one year and two months, Reference number 014190

Participant consent form for individuals

This consent form will be held for a period of six years

Title: Capability Building for doing Frugal Innovation within Developed Markets

Researcher: Fasiha Subhan.

I have been given and have understood an explanation of this research project. I have had an opportunity to ask questions and have them answered.

I understand that I may withdraw myself or any information traceable to me at any time up to five working days after being interviewed or observed without giving any reason. I also understand that none of the information I offer will be communicated within the organisation without my explicit consent.

I understand that audio recordings may be made of interviews, and I may request the recorder may be turned off at any time.

I understand that copies of my transcriptions will be made available to me if I request them.

I understand that the present research project might build the foundation for a long-term research project. Therefore, data collected in the present project may be used for future research in that broad line of inquiry.

I agree to take part in this research.

I agree/disagree to being recorded.

Name of Organisation: _____

Name of the Participant
(Please print clearly) _____

Signature of Participant: _____

Date Signed: _____

Approved by the University of Auckland Human Participants Ethics Committee on 20th March 2017 for one year and two months, Reference number 014190

Appendix C. Interview Schedule

Department of Management & International Business

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Interview Schedule

Prompts for semi-structured interviews

1. Which competencies (knowledge, skills, and experiences) you already possess that you think had contributed in achieving the objective of this project?
2. Which competencies did you need to build to achieve the objective of this project?
3. Which types of activities were related/or lead to building to those competencies?
4. How those certain type of activities contributed to/constitute those competencies
5. In your opinion, what enabled this product innovation to be successful and how?
6. Which of those capabilities are essential without which the success of the project could have been doubtful?
Please give an example of an incident in which firm's certain capabilities played a key role in the success of this project
7. What role strategic decision making played in the success of this project. (please answer in light of particular incidences)
8. What role knowledge integration (both within and outside the firm) play in the success of this project. (please answer in light of particular incidences)
9. Which capabilities were build from this project which then applied to the next product innovations project?
10. How were those capabilities built?
11. How did the project team co-develop the new product with foreign partners, suppliers, vendors, distributors and customers within this project? (What external knowledge has been acquired/seemed useful in achieving the objective of the projective? Who provided that knowledge? And how?)
12. To what extent and how the external knowledge applied within this project? / What role the external knowledge integration and integration mechanism played in completing this project?
13. How did the external knowledge communicated and coordinated within the firm? (Please give an example)
14. How did your functional department coordinate with other functional departments for co-development of the new product within this project?
15. How was the external knowledge combined with firms existing knowledge?
16. What were the new learning outcomes from integrating external knowledge with firm's internal knowledge?
17. What did people in different functions learn within this project?

Approved by the University of Auckland Human Participants Ethics Committee on 20th March 2017 for one year and two months, Reference number 014190

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Follow up Interview Schedule

Prompts for semi-structured interviews

18. What is the current status of [Name of the company] and the [Name of the project]?
19. What is the current motivation of the [Name of the company] (IF CHANGED) in terms of developing [Name of the project]?
20. What are the new strategic decisions made (IF ANY) in the past couple of years in terms of product development, manufacturing, marketing, target customers, pricing, and so on? And what is the impact of those strategic decisions on firms and the product?
21. What new capabilities are built (IF ANY) from those changes, new strategic decisions and related change in product?

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