A Microfoundational View: How is Open Innovation Related to Dynamic Capabilities and Strategic Agility?

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Declaration

This thesis has not been submitted in substantially the same form for the award of a higher degree elsewhere. It is the author's own work and does not include content developed in collaboration unless specified. Consistent with the Lancaster University Postgraduate Research Regulations, this thesis contains three chapters that include papers that have been submitted or published as follows:

Title	**Authors**	**Published/Submitted**
How does Open Innovation Contribute to a Firm's Dynamic Capabilities?	Steven Hutton Robert Demir Stephen Eldridge	Technovation (Published) *** An earlier version of this paper was submitted and presented to the British Academy of Management Conference (2019) *****
A Microfoundational View of Resource and Capability Creation through Open Innovation.	Steven Hutton Robert Demir Stephen Eldridge	Journal of Product Innovation Management (Under Review)
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Abstract

This thesis examines how open innovation is related to dynamic capabilities and strategic agility using an empirical approach. By adopting a microfoundations lens and examining open innovation processes, first, I develop a model to explain how open innovation is related to sensing and seizing abilities of the dynamic capability framework. Next, by considering resource bundling and individuals' activities alongside broader organisational conditions and activities, I develop a framework to further explain the relationship between open innovation and a firm's dynamic capability. Finally, to address the omission of speed from the dynamic capability literature and the development of resources and capabilities, I develop a framework to explain the interplay between open innovation and a firm's strategic agility. In doing so, this thesis advances our understanding of the open innovation concept by linking open innovation to strategic firm-level concepts. Furthermore, this thesis contributes to our understanding of the multi-level nature of open innovation by uncovering microfoundations that underlie the relationship between open innovation and strategic firm-level concepts.

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List of Abbreviations

C: Cognition

COO: Chief Operating Officer

DC: Dynamic Capabilities

HRM: Human Resource Management

HC: Human Capital

IT: Information Technology

NPD: New Product Development

OI: Open Innovation

R&D: Research and Development

SA: Strategic Agility

SC: Social Capital

SME: Small to Medium Enterprise

UK: United Kingdom

Chapter 1: Introduction and Background

This thesis consists of five chapters. Chapter 1 provides an overview of the overarching research problem and justification. Within this chapter is also the theoretical background associated with the research problem, and the research questions and methodology used to address the research problem. Chapter 2 consists of the first research paper that examines the relationship between open innovation and a firm's dynamic capabilities by focusing on the open innovation process and using a microfoundations lens. An earlier version of this paper was presented at the British Academy of Management Conference where the authors were awarded the best paper of the innovation track. The revised version included in this thesis was published in Technovation journal in 2021. Chapter 3 consists of the second research paper that builds on our understanding of open innovation and a firm's dynamic capabilities by using a microfoundations lens to examine open innovation processes alongside organizational supporting conditions and mechanisms. This paper is currently under review by The Journal of Product Innovation Management. Chapter 4 consists of the third and final research paper that examines the interplay between open innovation and a firm's strategic agility using a microfoundations lens. Adopting a similar approach to paper two, the third paper also considers open innovation processes alongside organizational supporting conditions and mechanisms. In doing so, paper three helps to shed light on how open innovation can impact the speed of resource and capability creation. This paper is currently under review by Long Range Planning. Chapter 5 concludes the thesis and outlines the theoretical and managerial implications.

1.1 Problem Statement and Justification for Research

Innovation is a key outcome for firms looking to create and maintain a competitive advantage by developing new products and capabilities. Consistent with Crossan and Apaydin (2010:

p1155), innovation refers to the "production or adoption, assimilation, and exploitation of a value-added novelty in economic and social spheres; renewal and enlargement of products, services, and markets; development of new methods of production; and establishment of new management systems. It is both a process and an outcome". Open innovation is an approach to innovation management that places an emphasis on the use of knowledge resources situated outside a firm's boundaries (West and Bogers, 2014; Bogers et al., 2018a). Through the use of inbound and outbound knowledge flows (Dahlander and Gann, 2010), firms that pursue an open innovation approach can enhance their internal innovation activities with external knowledge resources (Vanhaverbeke and Chesbrough, 2014; Bogers et al., 2018a). This requires firms to integrate new to the firm knowledge with existing knowledge to innovate new products, services, processes, and practices (Vanhaverbeke and Cloodt, 2014). Owing to its influential impact on accelerating innovation, open innovation has become an important topic in the innovation literature (Bogers et al., 2017; Bogers et al., 2018a).

However, there are two areas of existing open innovation literature that call for further research. First, existing open innovation literature is unclear about how the open innovation concept is related to other firm concepts despite uniting around a common goal of innovation (Vanhaverbeke and Cloodt, 2014). For example, the dynamic capabilities framework (Teece, 2007; Teece, 2014), which expands the resource-based view of the firm (Barney, 1991) places an emphasis on innovation in pursuit of difficult to replicate firm resources as a source of competitive advantage (Teece et al. 1997). A dynamic capability refers to "the capacity of an organization to purposefully create, extend, or modify its resource base" (Helfat et al., 2007: p4). Firms that have developed a dynamic capability are able to enact purposeful changes to firm resources to drive innovation activities (Teece, 2016). These capabilities reside in organisational processes that are impacted by a firm's history and are used to derive innovation outcomes (Teece, 2023). Alternatively, strategic agility is a capability that enables

firms to rapidly respond to changes in the external environment (Doz, 2020). Firms can exhibit strategic agility by continually adapting the innovation portfolio in response to technological opportunities in alignment with the changing needs and requirements of customers (Kester et al., 2011; Doz, 2013). Open innovation thus, has the potential to contribute to a firm's dynamic capabilities and strategic agility, through product innovation that can be used to grow existing business areas and target new business areas (Vanhaverbeke and Cloodt, 2014).

Second, the greatest proportion of open innovation studies have considered the firm as the object of study (West et al., 2014; Bogers et al., 2017). However, considering the firm as the object of study has the potential to mask important differences within firms such as those associated with individuals or projects that can affect open innovation outcomes (Dahlander et al., 2021). Consequently, the open innovation literature would also benefit from a greater proportion of studies that consider how the open innovation process can impact organizational resources and capabilities. Indeed, configuring open innovation in pursuit of resource and capability renewal has not been sufficiently addressed in prior studies (Vanhaverbeke and Cloodt, 2014).

Taken collectively, these research gaps pose a challenge to scholars, since firm's that turn to open innovation in contexts that require dynamic capabilities and strategic agility are yet to understand how these concepts are related. However, if scholars are to understand how to organise for open innovation in pursuit of dynamic capabilities and strategic agility, it is vital to understand how the concepts are related. Indeed, research has revealed that open innovation processes and outcomes can be influenced by internal firm practices (Du et al., 2015) and individuals' knowledge and experience (Bogers et al., 2018b). To understand how open innovation relates to dynamic capabilities and strategic agility requires research to examine the intra-organisational conditions and activities that occur within the firm. Such

conditions and activities that have the potential to impact innovation outcomes can be addressed through microfoundational studies (Felin and Foss, 2005; Felin et al., 2012). Microfoundational studies are concerned with "locating (theoretically and empirically) the proximate causes of a phenomenon (or explanations of an outcome) at a level of analysis lower than that of the phenomenon itself" (Felin et al., 2015: p586). Clearly, the literature would benefit from empirical research that explores the relationship between these concepts at a microfoundational level to understand how they are related.

Consequently, the overarching objective of this thesis is to develop an understanding of the relationship between open innovation and the concepts of dynamic capabilities and strategic agility using a microfoundational lens. Initially, this thesis explores the process through which open innovation contributes to dynamic capabilities through resource and capability creation. Next, this is complemented by an exploration of the process through which individuals bundle new to the firm resources with existing resources in support of resource and capability creation. Finally, the issue of speed is addressed, which appears to be an important omission from the dynamic capabilities literature to explain the interplay between open innovation and a firm's strategic agility.

1.2 Theoretical Background

This section provides the theoretical background of the concepts and key constructs that form the basis of this thesis. Initially, the concept of open innovation is considered, followed by dynamic capabilities and strategic agility. The section concludes with an overview of the microfoundations view.

1.2.1 Open Innovation

Open innovation is an innovation management approach that places an emphasis on the use of knowledge resources situated outside the firm boundary to enhance innovation activities

(Chesbrough, 2003; Chesbrough, 2006). Chesbrough and Bogers, (2014: p17) define open innovation as a "distributed innovation process based on purposively managed knowledge flows across organisational boundaries". As such, open innovation has family resemblance with network-based innovation, albeit with the explicit focus on inter-organisational relationships (Chesborough and Bogers, 2014). Implicit in the definition of open innovation is the movement of knowledge across a permeable firm boundary. Dahlander and Gann, (2010) classified these knowledge flows across two dimensions corresponding with the mode of interaction and the logic of exchange. When a firm exchanges knowledge in the outside-in direction, the mode of interaction is inbound. In contrast, when a firm exchanges knowledge in the inside-out direction, the mode of interaction is outbound. The logic of exchange may be either pecuniary or non-pecuniary with the former representing a monetised exchange and the latter representing an unmonetized exchange. In their literature review, Stanko et al., (2017: p545-546) grouped the distinct types of inbound, outbound and coupled mechanisms of open innovation as follows:

Table 1: Mechanisms of Open Innovation

Inbound	**Outbound**	**Coupled**
Beta Testing	Innovation Providers	Alliances
Contracting/Outsourcing	Licensing	Innovation Ecosystems
Crowdsourcing/Ideation	Spinoffs	Inter-organisational
Innovation Contests		collaboration
Lead Users		Networks
Open Search		
Supplier Integration		
Third-Party Intermediaries		
Toolkits		

University Partnerships

User Communities

This thesis focuses on non-pecuniary inbound and outbound knowledge flows that occur during innovation activities. Such an approach is consistent with the resource-based view of the firm, which sees competitive advantage residing in bundles of resources that are valuable, rare, inimitable, and not substitutable (Barney, 1991), and that a firm "need not own a resource or capability for it to comprise part of the resource base" (Helfat et al., 2007: p4). In contrast, while I consider pecuniary outbound knowledge flows such as patents and licencing that are sold for commercial purposes as key characteristics of open innovation, these mechanisms of open innovation do not form part of this study. Moreover, I consider new product development as the central activity through which firm innovations occur. Indeed, in-house R&D and open innovation can be thought of as complements (Bogers et al., 2019), while the literature has established the benefits of open innovation in support of new product development (Mishra and Shah, 2009; Bahemia et al., 2017). Under these circumstances, non-pecuniary inbound and outbound knowledge flows are consistent with the view that firms can function as both receivers and providers of knowledge resources (Tranekjer and Knudsen, 2012). These knowledge flows correspond with exchanges between innovating firms and external actors such as customers and suppliers.

In addition to distinct mechanisms of open innovation, the literature has also established multiple levels through which the concept of open innovation can be studied (see Table 2). Consistent with historical and current open innovation definitions, the greatest proportion of open innovation research considers the firm as the object of study (Chesbrough, 2003; Chesbrough, 2006; Chesbrough and Bogers, 2014). However, while focusing on the firm as the object of study can provide useful insights into open innovation at the level of the

firm, the underlying architecture that contributes to open innovation related firm outcomes is often overlooked (Bogers et al., 2017). For example, in their firm-level study, Foss et al. (2013) establish a relationship between external knowledge sources and strategic opportunities. However, the conditions and activities through which external knowledge sources lead to the identification of strategic opportunities, and how this relationship is positioned within the broader open innovation process remains to be explored. The open innovation microfoundations literature complements firm-level studies by considering individual and project-level factors. This literature stream has explored the relationship between an individual's background and their propensity to openness (Bogers et al., 2018b) and how an individual's openness impacts ideation performance (Salter et al., 2015). Both of which highlight factors associated with individuals and the impact on open innovation activities. Additionally, in their project-level study, Du et al., (2014) established a relationship between the project management approach, partner type and the project's financial performance. However, while these studies provide useful individual and project-level insights, studies that consider the open innovation process as the object of study remain scant. Such a focus has the potential to shed light on the range of activities that underlie open innovation processes and further advance our understanding of the open innovation concept (Bogers et al., 2017). Consequently, this thesis considers individuals, groups, projects, and functions involved in open innovation processes.

Table 2: Open Innovation – Levels of Analysis and Research Objects

Level of Analysis	***Research Objects***
Intra-organizational	Individual, Group/Team, Project, Functional area, Business unit

Organizational	Firm, Other (non-firm) organization, Strategy, Business model
Extra-organizational	External stakeholders: individual, community, organization
Inter-organizational	Alliance, Network, Ecosystem,
Industry	Industry development, Inter-industry differences
Regional innovation systems	Local region, Nation, Supra-national institution
Society	Citizens, Public policy

Adapted from: Chesbrough and Bogers (2014: p27)

The open innovation concept has grown in popularity through the literature since it was established. However, because the open innovation concept emerged from observations of changing innovation management approaches from closed to open (Chesbrough, 2003; Chesbrough 2006), open innovation has not yet been strongly linked to other domains of management research (Vanhaverbeke and Cloodt, 2014). Figure 1 depicts the dispersion of open innovation research, illustrating the concept has not yet been strongly linked to resource-based theories and dynamic capabilities. Further, where links do exist, they appear indirectly through the firm's business model, search strategies and absorptive capacity (Randhawa et al., 2016). Research that considers the direct relationship between open innovation and dynamic capabilities are either conceptual in nature (e.g., Teece 2007; Teece, 2016), or firm-level studies that attempt to establish capabilities for knowledge exchange (Lichtenthaler and Lichtenthaler, 2009) and strategic and operational reconfiguration (Ovuakporie et al., 2021). Following, I introduce the dynamic capabilities literature while considering areas of overlap with the open innovation concept.

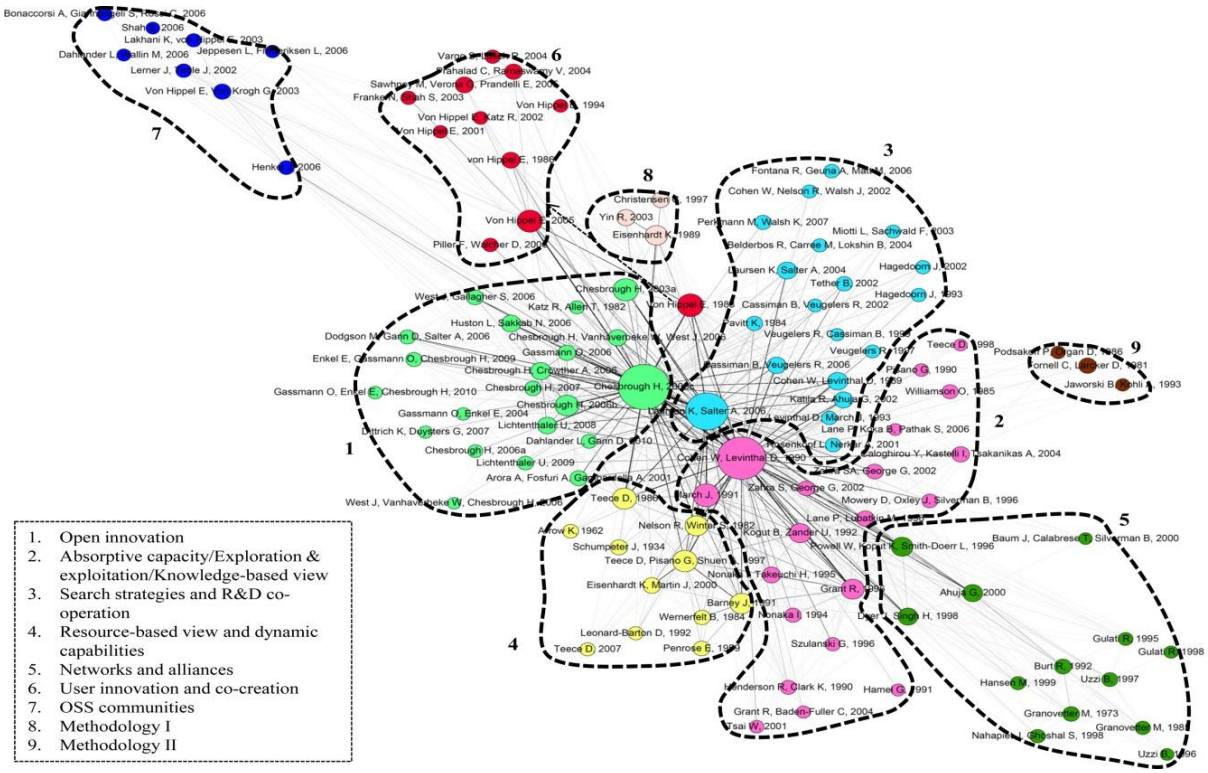

Figure 1: Dispersion of Open Innovation Concept

Source: Randhawa, K., Wilden, R., and Hohberger, J. 2016: p757.

1.2.2 Dynamic Capabilities

The concept of dynamic capabilities built on the central tenets of the resource-based view of the firm in that competitive advantage is a function of firm resources, and that firm resources, especially tacit knowledge-based resources are heterogeneous and not easily transferrable across firm boundaries (Barney, 1991). While the resource-based view placed an emphasis on firm resources as a source of competitive advantage, dynamic capabilities attempt to address the static nature of the resource-based view by considering purposeful change to the firm's resource base. Dynamic capabilities were thus defined as "the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments" (Teece et al., 1997: p516) and were said to reside in managerial and organisational processes that correspond with three roles: coordination, learning and reconfiguration. Subsequent to this, Eisenhardt and Martin (2000) challenged the

conceptualisation of dynamic capabilities by delimiting the boundary conditions in which dynamic capabilities apply. In high velocity markets, dynamic capabilities were said to be experiential and based on simple rules rendering them unstable, whereas in medium velocity markets, dynamic capabilities were based on routines. Later research by Zollo and Winter (2002: p340) further emphasised the relationship between dynamic capabilities and a firm's competitive environment, arguing that dynamic capabilities apply to firms that compete in "environments subject to lower rates of change".

More recently, Teece (2007) built on their conceptualisation of dynamic capabilities by associating dynamic capabilities with organisational capacities for sensing, seizing and transformation. These capacities refer to the identification and assessment of opportunities relative to customer needs (sensing), the mobilisation of resources in response to new opportunities (seizing) and reconfiguration to continually align resources and capabilities with market requirements (transformation) (Teece, 2014). I adopt sensing, seizing and transformation capacities as a framework to group dynamic capabilities throughout this thesis and consider dynamic capabilities to refer to "the capacity of an organization to purposefully create, extend, or modify its resource base" (Helfat et al., 2007: p4). Consistent with Helfat et al., (2007: p4), I consider the resource base of the firm to include "tangible, intangible, and human assets (or resources) as well as capabilities which the organization owns, controls, or has access to on a preferential basis", while a capacity refers to "the ability to perform a task in at least a minimally acceptable manner" which is distinct from *ad hoc* problem solving.

Early research associated dynamic capabilities with an organisation or firm (Teece et al, 1997; Teece, 2007; Helfat et al., 2007). Consequently, and similar to the OI literature, scholars treated dynamic capabilities as a firm-level concept. Thus, resulting in a high proportion of studies exploring dynamic capabilities at the level of the firm. However, the

behaviours and activities of managers will undoubtably influence the resources that a firm owns and controls including their deployment and reconfiguration.

In trying to understand how individuals and groups can impact dynamic capabilities, the literature has recently experienced an increase in studies at the individual and group levels (Schilke et al., 2018). For instance, Helfat and Peteraf, (2015) linked the organisational capacities for sensing, seizing and transformation to managerial abilities represented by human capital, social capital, and cognition. In such contexts, human capital refers to an individual's knowledge and expertise, social capital refers an individual's social relationships that enable knowledge resources to exchange through social networks, while cognition refers to an individual's mental models, beliefs, values and emotions that form the knowledge structures through which decision making occurs (Adner and Helfat, 2003; Helfat and Martin, 2015). This research stream suggests each of these abilities are developed and influenced through prior experience giving rise to dynamic managerial capabilities.

While the dynamic capabilities literature has explored firm-level and individual-level antecedents and outcomes of dynamic capabilities (Schilke et al., 2018), one aspect of the dynamic capabilities literature where there remains a paucity of research is associated with the link between an organisation's innovation process and its dynamic capabilities. More specifically, we still have a limited understanding of the process through which existing firm resources are deployed to address market opportunities and threats and the process that results in the creation of new resources and capabilities. This is surprising because a firm's new product development process that can lead to product innovations is considered a type of dynamic capability (Helfat and Winter, 2011).

Open innovation has the potential to impact a firm's existing resources and lead to resource and capability creation. Indeed, open innovation has been conceptually linked with a

firm's dynamic capabilities. For instance, Teece (2007) suggested that firms can support their product innovation processes by engaging in search activities to obtain knowledge resources from the periphery of the organisation. This requires managers to develop a strong internal and external orientation allowing them to combine knowledge from internal and external sources (Teece, 2014). However, when firms engage in innovation activities, they face multiple challenges based on the modularity, decomposability and specificity of the knowledge components to be recombined to generate novelty and usefulness (Xiao et al., 2021). This process is exacerbated when firms engage in open innovation, as resources rooted in different social settings, historical contingencies, and causal ambiguities (Barney, 1991) present firms with multiplied challenges adding to the existing complexity of resource creation.

Further, directing resources towards non-routine open innovation processes seems like a daunting task for managers attempting to combine knowledge from internal and external sources in pursuit of new resources and capabilities. Yet, little consideration has been given to the conditions and activities through which open innovation contributes to a firm's dynamic capabilities. Consequently, the dynamic capabilities literature would benefit from process or activity-level studies (Johnson et al., 2003) that have the potential to shed light on the relationship between these firm-level concepts by revealing the mechanisms through which open innovation impacts a firm's dynamic capabilities.

Another important omission in the existing dynamic capabilities literature is associated with the speed at which firms transform existing resources into new resources and capabilities. Indeed, speed is important to firms looking to take advantage of new opportunities (Vecchiato, 2015). The literature has suggested that open innovation processes can speed up a firm's product innovation process placing firms in a stronger position to act on new opportunities (Teece, 2016). However, open innovation relies on purposeful knowledge

exchanges across firm boundaries (Chesbrough and Bogers 2014). This requires firms to engage in search activities that can be costly in pursuit of knowledge resources (Laursen and Salter, 2006; Salge et al., 2013). Further, knowledge resources situated outside the firm boundary are nested in complex social relationships that require trust and cooperation to be productive (Phelps, 2010). Both considerations are potentially problematic to firms looking to adopt open innovation processes in pursuit of dynamic capabilities. Further, existing literature is unclear about the relationship between open innovation, the organisational capacities for sensing, seizing and transformation and the speed at which new resources and capabilities are created. Following, I turn to the concept of strategic agility that has the potential to address some of the challenges associated with open innovation and the speed of resource and capability creation.

1.2.3 Strategic Agility

The literature has highlighted the importance for firms to develop capabilities to cope with increasingly rapid markets and the rate of technological change. Research has established the beneficial role of agility in supply chain management and within manufacturing strategies (Pinho et al., 2022). However, strategic agility has recently emerged as a firm-level capability that enables organisations to rapidly respond to changes in their external environment through strategic initiatives (Doz, 2008; Doz, 2020). This capability is rooted in two key activities: i) sensing the need for change and ii) implementing the appropriate strategic action (Weber and Tarba, 2014). Consequently, strategic agility has been defined as the ability "to exploit, or create to one's advantage changing patterns of resource deployment in a thoughtful and purposeful but also fast and nimble way rather than remain hostage to stable pre-set plans and existing business models" (Doz and Kosonen, 2007; cf. Doz, 2020: p1). I use this definition throughout this thesis due to its focus on resource deployment and, thus, its proximity to the dynamic capabilities view.

In attempting to understand how firms can develop strategic agility, studies have considered antecedents and outcomes of strategic agility. Broadly, the antecedents can be grouped into two perspectives: digitization (Ciampi et al., 2022) and human resource management (HRM) (Doz, 2020), while outcomes are concentrated around firm performance. The central tenet of the HRM perspective is that strategic agility is a function of leadership (Lewis et al., 2014) and managerial actions that correspond with strategic sensitivity, resource fluidity and collective commitment (Doz, 2020). In this context, strategic sensitivity refers to a sensemaking ability that is impacted by managerial awareness and attention to strategic situations as they develop (Doz, and Kosonen, 2008; Doz and Kosonen, 2010; Doz 2020). Indeed, the literature has established a relationship between individuals' attention and the recognition of strategic opportunities (Eklund and Mannor, 2021). Resource fluidity refers to the capacity for management to "free resources from existing activities and redeploy them rapidly toward new growth opportunities" (Doz, 2020: p2). While strategic sensitivity and resource fluidity share similarities with the sensing and seizing capacities associated with dynamic capabilities (Teece, 2007), the greatest divergence is associated with the omission of a transformation capacity and instead, suggesting collective commitment as an essential component of strategic agility. Collective commitment refers to the capacity for managers to quickly agree on strategic decisions and begin the process of implementation once new strategic opportunities have been identified.

Firms are increasingly adopting product innovations as a strategy to address technological change. In support of strategic agility, firms can develop new products and innovations to address opportunities and threats that arise from markets experiencing technological change (Helfat and Winter, 2011). Thus, highlighting the importance of the activities that constitute the implementation of new products and innovations to a firm's strategic agility. In attempting to understand the relationship between product innovations

and a firm's agility, Kock and Gemunden, (2016) investigated how senior managers can impact the decision-making quality of innovation projects. Their research offered a useful insight into antecedents of organisational agility by focusing on decision-making relative to a firm's innovation project selection, prioritisation, and termination. However, the speed of new technological innovations is also vital to firms looking to respond to changes in their external environment through product innovations (Teece et al., 2016; Prange, 2021). Thus, highlighting the importance of decision-making quality that occurs during innovation project activities. Consequently, the strategic agility literature would benefit from an implementation perspective that considers the activities through which firm's develop new products and innovations alongside the broader organisational factors that have the potential to impact the firm's strategic agility.

Existing literature has suggested that open innovation processes can speed up a firm's product innovation process resulting in greater levels of strategic agility (Teece, 2016). In support of strategic agility, open innovation can provide firms with information concerning the needs of customers and solutions to address the changing needs of organisations' innovation activities (Salge et al., 2013). One example is through inbound mechanisms such as crowdsourcing and ideation that can provide managers with valuable market knowledge, resulting in fresh ideas for innovations (Gatzweiler et al., 2017). Further, suppliers can provide technical knowledge that has the potential to speed up product developments by avoiding unproductive paths (Tavani et al., 2013). However, leveraging customer and supplier knowledge can also negatively impact the performance of product developments. For instance, the process of obtaining customer and supplier knowledge requires individuals to embark on a decision-making process that concern where and how to search for information which can be costly to firms (Laursen and Salter, 2006; Salge et al., 2013; Lopez-Vega et al., 2016). Research has also highlighted that the ability for firms to make use of external

knowledge is impacted by intra-firm mechanisms such as communication and the decision-making autonomy of individuals (Foss et al., 2011), and the knowledge and experience of managers (Du et al., 2014). For firms to be effective at sourcing the relevant external knowledge, it is essential to develop internal knowledge and experience (Grigoriou and Rothaermel, 2017).

Given the potential for the mechanisms that exist within firms to impact the performance of open innovation processes positively or negatively, it is vital that we develop a more complete understanding about the relationship between open innovation and a firm's strategic agility. If firms are to adopt open innovation as a tool in support of strategic agility, the literature requires a more complete understanding of the architecture that underlies the implementation of strategic initiatives through open innovation processes. This includes the conditions and activities that occur within the firm as well as the supporting structures that enable open innovation to be leveraged in support of strategic agility. Following, I turn to microfoundations view that has the potential to help address some of the gaps in the literature concerning the relationship between open innovation and the concepts of dynamic capabilities and strategic agility.

1.2.4 Microfoundations

Early research by Coleman (1990) distinguished between two methods of explanation in social sciences. On the one hand, a system may be characterised by examining factors *external* to the system, which is referred to as a *macro* perspective. On the other hand, a system may be characterised by examining factors *internal* to the system, which is referred to as a *micro* perspective. The resulting perspective is a method of explanation that is multi-level in nature, building up from individuals. The benefit of adopting a multi-level perspective can be illustrated by considering the advantages of linking a firm's strategy and

environment at one level and considering how a firm formulates and implements a strategy at a more micro level (Hitt et al., 2007).

The microfoundations perspective builds on Coleman's (1990) view, highlighting the advantages of examining the constituent components of a firm's routines and capabilities to better understand sources of firm heterogeneity (Felin and Foss, 2005; Felin et al., 2012). Broadly, there are two conceptually distinct interpretations of microfoundations, one considers individuals as primacy for explanatory purposes, while the alternative considers microfoundations as levels (Felin et al., 2015). Consistent with the view of microfoundations as levels, I consider firm-level concepts such as dynamic capabilities, strategic agility, and open innovation as concepts that are multi-level in nature and can be unpacked to reveal the constituents that underlie the concepts as well as the relationships between them. These constituents may consist of individuals, processes, capacities, and structures, and reside at a lower level than the firm-level concept (Felin et al., 2015).

The microfoundational perspective has been applied in strategic management and innovation management literatures. For example, Teece (2007: p1319) conceptually distinguished microfoundations of dynamic capabilities by associating sensing, seizing and transformation capacities to "the distinct skills, processes, procedures, organizational structures, decision rules, and disciplines". More recently, Teece (2018: p364) suggested the microfoundations of dynamic capabilities include "lower-level dynamic capabilities such as processes for forming external partnerships or for developing new products". Thus, emphasising their relationship between the microfoundations of dynamic capabilities, open innovation processes, and strategic activities.

Further, the strategic agility literature has considered microfoundations that correspond with strategic sensitivity, resource fluidity and collective commitment (Doz, 2020). These microfoundations place an emphasis on the role of individual activities in support of a firm's

strategic agility. Finally, open innovation research has begun to establish isolated microfoundations that correspond with individuals' ideation (Salter et al., 2015), knowledge search (Dahlander et al., 2016), project management approach (Du et al., 2014) and human capital (Bogers et al., 2018b).

However, the greatest proportion of existing studies treat open innovation, dynamic capabilities, and strategic agility as independent firm-level concepts. Further there is a paucity of research that links open innovation to dynamic capabilities and strategic agility literature. Consequently, the literature would benefit from microfoundational studies that are empirical in nature and explore the relationships between these concepts. Such studies have the potential to develop our understanding of how open innovation, dynamic capabilities and strategic agility are related through micro activities.

1.3 Research Questions

The goal of this thesis is to theoretically develop the open innovation concept by empirically establishing how open innovation is related to other concepts including dynamic capabilities and strategic agility. As such, the overarching research question underlying this thesis is *"How does open innovation enable firms to develop new resources and capabilities?"*. To answer this question, research was conducted in three phases. In phase 1, this thesis establishes the relationship between open innovation and a firm's dynamic capabilities through examination of resource and capability creation. In phase 2, this thesis builds on our understanding of the open innovation – dynamic capabilities relationship by revealing how individuals bundle new to the firm resources with existing resources to give rise to new resources and capabilities. Finally, in phase 3, this thesis examines the interplay between open innovation and a firm's strategic agility. Each phase corresponds with a separate research paper that answers the following research questions:

- "How do open innovation activities contribute to a firm's dynamic capabilities by supporting the creation of firm resources?"
- "How, during open innovation processes, do individuals bundle resources to give rise to new resources and capabilities?"
- "What are the underlying microfoundations that support the interplay between open innovation and strategic agility?"

Following, I provide the research methodology that was used to answer the proposed research questions.

1.4 Research Methodology

The theoretical background to this thesis highlighted the opportunity to develop our understanding of the relationship between open innovation, dynamic capabilities and strategic agility. Following, I reveal my approach to reasoning, before introducing the methodological approach adopted in studying these relationships.

The process of researching the underlying mechanisms that relate open innovation to other firm-level concepts requires a form of reasoning that allows the researcher to draw specific conclusions about these concepts. The literature has classified forms of reasoning as deduction, induction, and abduction. Deduction begins with a general rule and an explanation to derive a specific outcome (Mantere and Ketokivi, 2013). With deduction, the outcome must follow from the rule and explanation to be logically consistent. In contrast, induction begins with an outcome and explanation to infer a specific rule (Mantere and Ketokivi, 2013). However, with induction, while the outcome and explanation provide a degree of support to the rule, the outcome and explanation do not offer a complete account of the rule. Finally, abduction begins with an outcome and a rule, to infer an explanation (Mantere and Ketokivi, 2013). Through abduction, it is possible to develop plausible explanations about a specific

outcome and generate knowledge claims that can be continuously revised (Behfar and Okhuysen, 2018). As such, the abductive approach to reasoning supports the researcher's aim of understanding the relationships between open innovation and other firm-level concepts. This was achieved through a variety of methods and data types that are subsequently disclosed.

The research questions in this thesis require an in-depth observation to understand how, during open innovation processes, new firm resources emerge, how individuals bundle resources and the interplay between open innovation and a firm's strategic agility. As such, a case-study approach was adopted which is an in-depth empirical inquiry into a contemporary phenomenon in its real-world setting (Yin, 2014: p16). The case is a UK SME manufacturer that has been established for over 90 years operating in the chemical industry. Firms within the chemical industry are increasingly subjected to regulatory pressures associated with a reliance on feedstocks derived from coal and oil resulting in a tendency to source more sustainable products. This requires the firm to continually adapt and respond to such environmental changes. The firm also pride themselves on developing tailored products across a variety of industries by working alongside their customer base. In support of this, open innovation has become deeply embedded within the firm's innovation strategy over the last two decades by leveraging knowledge from external actors. Throughout this thesis, the researcher was employed by the firm which provided unusually rich and opportunistic access to data across a four-year period.

Consistent with the explanatory nature of the research questions, all three papers were abductive in nature combining a range of different data collection and analysis methods. As my understanding of the research questions developed and I received feedback from the peer-review process and a conference, I continually refined my data collection and analysis to further shed light on the research questions. Throughout the four-year period, data collection

was initially approached from an outcome-driven narrative (Kouame and Langley, 2018) consistent with the requirement to understand the relationship between open innovation and other firm-level concepts. As such, I focused data collection around open innovation processes to establish the underlying activities through which outcomes of interest emerged. I adopted theoretical sampling (Eisenhardt and Graebner, 2007) to ensure open innovation projects selected were suitable for shedding light on the underlying activities of interest. This required sampling projects that resulted in new resources and capabilities, contained resource bundling activities and supported the firm's strategic agility. I complemented open innovation process data with a range of archive data, questionnaire data, informal discussions and interview data from key informants. Similar to Bingham and Eisenhardt (2011), I selected informants with the greatest insight into the open innovation projects which included that project leaders, product developers and sales representatives. Further, as my understanding of the underlying activities required broader contextual knowledge, I selected 'elite informants' who were considered "key decision makers who have extensive and exclusive information and the ability to influence important firm outcomes, either alone or jointly with others" (Aguinis and Solarino, 2019: p1293).

My analysis of NPD project data was consistent in documenting activities in the order in which they occurred alongside the type of activity, actors involved and resulting actions and outcomes. The analysis of textual data including questionnaire responses adopted grounded theory methods (Gioia et al., 2013), involving the identification of first-order codes (informant centric), then clustering of similar codes and removing duplicate codes (researcher centric), before identifying adaptive actions, interactions, and outcomes. At this stage, I aggregated codes and where relevant, related them to existing concepts in the literature. The coding techniques were adopted from Saldana (2021) and process theorising from Demir and Lychnell (2015).

Throughout this research, steps were taken to reduce bias. Abductive reasoning can occur at both individual and collective levels to generate the most plausible explanations (Sætre and Van de Ven, 2021). While individual insights can be considered partial and tentative, “utilizing multiple perspectives also produces requisite variety and guards against jumping to one conjecture prematurely” (Sætre and Van de Ven, 2021: p 694). As such, during data collection and analysis, opinions and criticisms were continually sought from two researchers (co-authors) external to the contextual setting and data collection activities. Data was continually triangulated by cross-referencing researcher interpretations and data sources and project data with the themes and concepts that emerged from analysis of textual data (Miles et al., 2020). Following is detailed overview of the data collection methods adopted through each phase of this thesis (Table 3).

Table 3: Summary of Data Collection Methods and Data Sources

Phase 1: How does OI Contribute to DC through Resource Development?			**Phase 2: During OI processes, how do individuals bundle resources to result in new resources and capabilities?**			**Phase 3: What are the Microfoundations that underlie OI and a firm's SA?**		
Data Type/Method	**Data Source**	**Objective**	**Data Type/Method**	**Data Source**	**Objective**	**Data Type/Method**	**Data Source**	**Objective**
NPD Project Data/Archival Data	Project / Technical Reports (22) Participant Emails (427) Meeting Minutes (10) Product Formulations (147)	Establish NPD projects & Identify engagements	NPD Project Data/Archival Data	Salesforce Project Emails (27)	Establish projects that resulted in new resources and capabilities Add depth to identified projects	Company Documents/ Archival Data	Marketing Reports (8) Technical Reports (12) Company Reports (11) Project Reports (4) Product Launch/Press Releases (4)	Establish industry conditions & strategic initiatives
Informal Meetings	R&D Staff (12) Sales Representatives (3) Sales Director Production Director Purchasing Manager Marketing Manager Managing Director	Validate project data & engagements	NPD Project Data/Archival Data	Participant Emails (61) Project Reports (4) Technical Bulletins (5) R&D Reports (6)	Establish knowledge bundling activities Add depth to knowledge bundling activities	Questionnaire	Senior Leadership Team (11 members)	Add depth to identified projects
Interviews	Project Leaders/Developers (2) Sales Representative (1)	Identify driving force of engagements	Interviews	Project Leaders (4)		Interviews	Sales Director (4) R&D Manager (4)	Establish knowledge bundling activities
Questionnaire	Project Leaders/ Developer (3)	Identify subsequent actions, significance & capabilities.	Informal Discussions	Project Participants (16)		Informal Discussions	Senior Leadership Team/ Senior Managers (27)	Add depth to knowledge bundling activities Establish product portfolio & open innovation knowledge network
Interviews	Project Leaders/Developer (1) Sales Representative (2) Supplier (2)	Shed light on emerging themes	Archival Data	Meeting Reports (2) Company Emails (10) Marketing Reports (8) Sales Reports (8) Documented Literature (44)	Establish product portfolio & open innovation knowledge network	Archival Data	IT Manager	
			Questionnaire	Sales Director Marketing Manager R&D Manager Chief Operations Officer		Informal Discussions	R&D Manager (1) IT Manager (1) Sales Director (1)	

Chapter 2: How does Open Innovation Contribute to a Firm's Dynamic Capabilities?

2.1 Abstract

A pressing management issue exists to understand how firms can develop dynamic capabilities (DC) through processes such as open innovation (OI). Our study aims to expand knowledge in this area by explicating the underlying mechanisms of OI that contribute to a firm's DC. Adopting a microfoundations perspective, we examined three separate new product development projects in a UK manufacturer over a period of two years. Our findings demonstrate that manufacturing firms can exploit technological and market-based knowledge resources during OI activities and we have developed a process model to reflect these findings. We were able to identify three underlying mechanisms of OI: realization, engagement, and appropriation, that contribute to the creation of firm resources and the firm's DC. Our study reveals that each mechanism links the process of OI to a firm's DC by sequentially and reciprocally altering the firm's abilities for sensing and seizing opportunities. This improved understanding of the microfoundations of OI enables us to explain how external knowledge search and the ensuing knowledge appropriation can correct misalignment between a firm's current capabilities and its future market opportunities, and, thus, enhance the firm's DC.

2.2 Introduction

Firms endowed with dynamic capabilities (DC) can quickly and purposefully modify and renew their resources to capitalise on market opportunities and secure competitive advantage (Teece et al., 1997; Teece, 2007). These firms develop sensing and seizing abilities that enable them to anticipate new market opportunities and then mobilize resources in response

to these opportunities (Teece, 2014). Both the sensing and seizing of these opportunities is supported by external search activities that occur during the process of new product development (Teece, 2007) since these search activities yield exploitable knowledge resources located in the supplier and customer knowledge domains. At the same time, exploiting knowledge resources from interrelated actors within the firm's external network to supplement internal innovation is seen as an important consequence of open innovation (OI) activities (Weber and Heidenreich, 2018). One conclusion that can be drawn from this apparent link is that OI is an effective route to enhancing a firm's DC (Ahn et al., 2018). Certainly, firms that successfully engage in OI are able to continue their pursuit of profits by targeting new markets with the ensuing innovation outputs (Chesbrough, 2003). Owing to its influential impact on innovation success (Chesbrough, 2003; Laursen and Salter, 2006), OI has emerged as an important topic in the innovation literature (Dahlander et al., 2021).

DC enable firms to cope with increasingly competitive dynamics and enhance performance (Vanhaverbeke and Cloodt, 2014; Teece, 2014) but, to develop these capabilities, firms need a comprehensive understanding of the underlying mechanisms or microfoundations that precede their development. Research into the microfoundations of OI is providing an emerging body of literature (Bogers et al., 2018b) that can help to shed light on lower-level mechanisms that result in firm-level capabilities (Lewin et al., 2011). For example, studies have examined the relationship between openness and new idea creation (Salter et al., 2015), and the organisational mechanisms that contribute to a crowdsourcing capability (Pollok et al., 2019). Our study aims to expand knowledge in this area by explicating the underlying mechanisms of OI that contribute to a firm's DC in order to answer the question: *"How do open innovation activities contribute to a firm's dynamic capabilities by supporting the creation of firm resources?"*

Our research adopts a microfoundations perspective (Felin et al., 2015) by examining how lower-level mechanisms of the OI process influence organisational outcomes through the creation of firm resources and capabilities. Adopting this perspective has the potential to improve our understanding of how OI can enhance firm-level performance (Vanhaverbeke et al., 2014). The underlying mechanisms of the OI process that contribute to a firm's DC were investigated using an embedded case study design featuring three separate cases of new product development (NPD) projects that took place within the firm over a period of two years that had led to the creation of new capabilities via OI activities.

By adopting a microfoundations perspective, we were able to empirically explicate lower-level mechanisms of OI that contributed to the firm's DC (Lewin et al., 2011). In doing so, we build upon earlier OI studies by revealing and theorising three mechanisms that link OI to DC: realization; engagement; and appropriation. Each mechanism has varying levels of interaction with each other and the sensing and seizing abilities of the DC framework. Importantly, our study reveals that OI activities lead to behaviour modifications that influence the product development process and contribute to a firm's DC. Further, building on the microfoundations approach, our study offers some initial steps towards advancing our understanding of the underlying relationships between the two concepts of OI and DC. Finally, these findings also have important implications for managers by providing them with insights into how OI practices can alter the resource base of a firm and instil behavioural changes in NPD projects.

The next section will explore the theoretical underpinnings of this study by reviewing the DC literature, prior to establishing the theoretical linkages that relate to OI practices. Subsequently, we move on to present the research site and methodological and analytical choices made before we move on to presenting our findings. Finally, we discuss the findings and conclude with some implications for theory and practice.

2.3 Theoretical Background

Researchers adopting the microfoundations perspective have established the importance of identifying and explicating lower-level mechanisms that drive firm-level outcomes. However, since its inception, different interpretations of microfoundations have emerged from the research. Some studies consider the role of individuals in contributing to firm-level outcomes (e.g., Grigoriou and Rothaermel, 2014), whereas other studies consider the role of organisational processes and activities (e.g., Teece, 2007). We adopt a microfoundations perspective consistent with Felin et al. (2015) that microfoundations are a proximate cause of a phenomenon that exist at a lower-level than the phenomenon itself and are not necessarily reducible to individuals. For example, this perspective has been used to identify metaroutines as sources of organizational absorptive capacity (Lewin and Massini, 2003) and highlights their importance for identifying external knowledge, learning from partners and absorbing knowledge back into the focal organisation (Lewin et al. 2011).

The microfoundations approach is a powerful approach to understanding lower-level phenomena that affect firm performance and innovation. However, while conceptually appealing, its explanatory power remains to be empirically explored. For example, Lewin et al. (2011) offer a conceptual model of microfoundations for knowledge absorption but, thus far, empirical studies of the microfoundations for firms' OI activities, in particular those that generate organisational level DC, remain scant. Thus, adopting a microfoundations perspective is a promising way to increase understanding of the mechanisms that contribute to a firm's DC through OI.

2.3.1 Dynamic Capabilities

Continual adjustment of a firm's resources is both critical to survival in competitive markets with high rates of technological change (Teece, 2007) and necessary to keep abreast of incremental changes to a firm's competitive environment. A firm with developed DC is able

to “purposefully create, extend, or modify its resource base” (Helfat et al., 2007: 4) in response to exogenous changes to its competitive environment. A firm’s resource base is comprised of tangible, intangible and human assets, and capabilities that the firm either owns, controls, or can access on a preferential basis (Barney, 1991). In firms endowed with DC, these resources are continually adjusted “to a reliable and at least minimally satisfactory manner” (Helfat and Winter, 2011: 1244). In other words, firms that have developed DC exhibit repeatable resource and capability creation, extension and modification. Under such circumstances, resource and capability creation does not occur by chance and, in agreement with Winter (2003) and Rothaermel and Hess (2007), we suggest that the DC construct can be disaggregated into interacting microfoundations that result in a firm-level capability. Developing our understanding of these microfoundations and how they interact will provide insight into how DC can develop to facilitate firm-level resource and capability creation and ensuing competitive advantage.

The microfoundations of DC enable firms to sense and seize opportunities through the reconfiguration of resources and capabilities. *Sensing* refers to a firm’s ability to identify and assess technological opportunities arising from unmet customer needs (Teece, 2014: p332). DC research has emphasised the role of individuals in contributing to a firm’s sensing ability when individuals understand customer needs and are able to recognise or develop new opportunities in response (Teece, 2007). This requires knowledge and information which is influenced by the individual’s capability and social network (Helfat and Martin, 2015). However, relying on individuals to facilitate sensing can leave firms vulnerable as the locus of the capability is embedded within the individual. To strengthen their sensing ability, firms can benefit from developing organisational processes such as sensemaking and scenario planning that embed scanning and monitoring activities (Teece, 2014). These processes provide firms with opportunities to anticipate external technological advances enabling them

to formulate appropriate responses and act on opportunities through the development of new products or processes. However, the role of organisational processes such as OI in contributing to a firm's DC remains unclear. This is significant, as new opportunities may also arise *during* the OI process when firms have access to knowledge resources situated outside the firm boundary. External knowledge resources provide firms with further opportunities through the identification of customer needs or preferences (Tether, 2002), or alternatively, increased awareness of supplier-developed innovations (Teece, 2007). Firms may exploit external knowledge to focus existing resources in pursuit of new resources or capabilities.

Seizing refers to a firm's ability to mobilise resources in response to a new opportunity (Teece, 2014) and is influenced by a firm's choice of actions, investments and resource deployment (Helfat and Martin, 2015). Resource mobilization that occurs during seizing is underpinned by lower-level activities and routines that enable firms to reduce capability gaps and to implement new business models through resource and capability creation and the successful development of new products and innovations (Teece, 2019). The decisions that precede these activities are influenced by managers and guided by the individuals' capabilities, network and social ties and educational background and experience (Helfat and Martin, 2015). These decisions may result in the structuring, bundling or leveraging of new resources in support of the firm's seizing ability (Sirmon et al., 2011). The mechanisms by which new products and technologies arise include the OI process that makes use of knowledge situated outside the firm boundary. During OI processes, individuals make decisions that influence what a firm *does* with its existing knowledge resources in pursuit of new resources. However, the role of the OI process in contributing to seizing remains unclear. Therefore, we need to consider the potential for the OI process to contribute to firm resources and DC.

2.3.2 Open Innovation

The OI process supports a focal firm's innovation activities by means of search, adaptation and adoption of external knowledge (Chesbrough, 2003; West and Bogers, 2014) and has been defined as *"a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organization's business model" (Chesbrough and Bogers, 2014: 1)*. The distributed nature of a firm's OI process features the inclusion of external actors in innovation activities such as suppliers, customers, industry experts and consultants. In these contexts, external actors are valuable knowledge resources that firms can exploit to supplement internal innovation activities (West and Bogers, 2014; Weber and Heidenreich, 2018).

New product development (NPD) is an organizational process that facilitates the seeking out and application of external knowledge and is central to adaptation and renewal at the firm level (Brown and Eisenhardt, 1995). External knowledge sought during the NPD process can be classified as either market knowledge or technical knowledge (Cui and Xiao, 2019). Market knowledge refers to the expressed and latent needs of customers (Narver et al., 2004) and firms can best exploit it by closely aligning internal R&D, NPD activities and market requirements (Teece, 2018a). Alternatively, technical knowledge is knowledge of supplied components, materials, or products that influence the features, feasibility and application of a product (Laursen and Salter, 2006). The NPD process assimilates both market and technical knowledge (Danneels and Kleinschmidt, 2001), since the former sets the direction of the NPD, while the latter supports the actual development process.

How does OI contribute to Sensing?

Existing OI research has identified firm-level mechanisms that may have implications for a firm's sensing ability. When firms engage in the OI process, search activities enable firm to draw on knowledge and ideas from external sources (Laursen and Salter, 2006). These knowledge resources may be mobilised through inbound, outbound or coupled knowledge flows (Stanko et al., 2017). Our research is concerned with inbound knowledge flows that convey external knowledge resources to innovating firms both prior to and during NPD activities. In these contexts, search activities can provide firms with knowledge of customer needs and preferences (Laursen and Salter, 2006) and technological advances (Cousins et al., 2011). Firms may develop an astute awareness of environmental changes that over time generates DC (Helfat and Peteraf, 2003), putting them in a better position to sense new opportunities and threats (Danneels, 2011). To make best use of technical knowledge, firms must have developed capabilities to facilitate knowledge transfer (Naqshbandi and Jasimuddin, 2018). Such capabilities may be underpinned by structural, cultural or technical factors (Jasimuddin and Naqshbandi, 2019) and enhance a firm's ability to seek out and integrate external knowledge (Cohen and Levinthal, 1990). Moreover, firms that have access to a greater number of external knowledge sources can enhance incremental innovation performance (Garriga et al., 2013) and help developing new business models (Demir and Angwin, 2021). Consequently, inbound knowledge flows associated with the OI process may reduce a firm's proximity to external knowledge sources, placing firms in a better position to sense new opportunities.

Research into the OI microfoundations can be broadly classified into individual-level or project-level studies. At the individual-level, studies have established that individuals may have implications for a firm's sensing ability, as they play a role in contributing to the identification of new opportunities. When individuals are open to external sources, they are

exposed to knowledge variety and may become more alert to external information (Salter et al., 2015). Consequently, these individuals become more aware of environmental changes and are better positioned to identify new opportunities that firms can exploit to develop new resources and capabilities. Research at the project-level has examined the links between knowledge search and NPD project success (Salge et al., 2013) and identified different search mechanisms that can be adopted by firms depending on the type of OI project (Lopez-Vega et al., 2016). Overall, microfoundations research has uncovered various endogenous mechanisms that may contribute to a firm-level sensing ability. Thus, adopting a microfoundations lens is a promising way of increasing our understanding of how a firm can leverage OI to enhance its sensing ability.

How does OI contribute to Seizing?

Seizing opportunities in the marketplace, is an essential function of DC. Once a firm has identified a new opportunity, it can contribute to resource and capability creation (Helfat and Peteraf, 2003) by leveraging knowledge resources in support of developing new products or innovations (Teece, 2007). Firms that supplement their innovation activities with external knowledge resources have been found to experience higher levels of innovation performance (Laursen and Salter, 2006; Leiponen and Helfat, 2010; Weber and Heidenreich, 2018). However, these firms must also develop capabilities to integrate external knowledge with their internal organisational processes (Cohen and Levinthal, 1990; Lane et al., 2006). Thus, implicating endogenous factors such as NPD in facilitating resource and capability creation when firms mobilize resources in response to new opportunities.

During NPD, a firm may turn to OI to exploit external knowledge resources in support of resource and capability creation. Once technological opportunities have been identified, individuals that engage in the NPD process develop new knowledge by drawing on prior learning, experience and their social networks (Grigoriou and Rothaermel, 2014).

Overall, we suggest firms may leverage OI during NPD in support of new resource and capability creation. However, researchers are unclear about the mechanisms of OI that contribute to new resource and capability creation.

Research on OI microfoundations has, however, identified both individual-level and project-level factors affecting a firm's seizing ability. At the individual-level, Dahlander et al. (2016) found that when individuals build relationships with external actors, they are better able to absorb external ideas and develop new knowledge. Bogers et al. (2018) found that individuals' educational diversity had a positive relationship with their ability to access external knowledge. Yet others have found that during OI, individual R&D technicians' creativity and problem solving is enhanced when they operate in informal roles, which enables risk taking, experimentation and learning (Pollock et al., 2019). At the project-level, Du et al., (2014) found that adopting formal or informal project management approaches can impact the performance of OI projects, depending on whether external actors are science-based or market-based. Overall, these earlier studies suggest that mechanisms at a lower-level than the firm may impact a firm-level seizing ability. Although Teece (2016) has suggested firms may leverage OI in support of a seizing ability, the mechanisms of the OI process that contribute to a firm's seizing ability remains unclear. These prior studies have established the importance of OI for seizing opportunities in the marketplace. However, while prior studies have established some important *relationships* between OI and seizing—an essential function of DC—they have not explicated the microfoundational *mechanisms* by which OI contributes to new resource and capability creation.

Linking OI and DC Theory

Although existing literature has associated OI with the firm's DC (Teece, 2016; Randhawa et al., 2016; Ahn et al., 2018), there is still a lack of consensus regarding *how* DC are developed, which is a critical concern to firms wishing to create a competitive advantage. While the microfoundations literature has addressed individual-level and project-level aspects of OI, theoretical insight into the process-level mechanisms by which OI can contribute to a firm's DC has not yet been extensively developed. Indeed, Ambrosini and Bowman (2009: p44) suggest that *"it must be feasible to identify discrete processes inside the firm that can be unambiguously causally linked to resource creation"*. Consequently, integrating OI research with that of the DC framework (Chesbrough, 2014: 3) provides an opportunity to explain how process-level activities may result in resource and capability creation. Within the OI domain, the NPD process focuses on activities that require competence in extracting market and technological knowledge (Danneels, 2016). Consequently, our study will focus on the microfoundations of OI through careful examination of the NPD process to identify OI process-level mechanisms that contribute to the development of a firm's DC.

2.4 Research Design and Methodology

Given the paucity in research on how OI can contribute to a firm's DC, we adopted a process-level outlook (Randhawa et al., 2016) by conducting an embedded case study approach of how OI activities help generating knowledge-based resources that contribute to new capabilities. This is an appropriate approach because it offered an in-depth inquiry into a specific and complex phenomenon (Eisenhardt, 2021), set within its real-world context, and yet allowing replication where each case can serve to confirm and disconfirm inferences drawn from the other (Eisenhardt, 1989). Our embedded case study consisted of three separate NPD projects using OI activities over a period of two years and had resulted in the

development of new capabilities. Drawing on embedded units of analysis typically generates more robust and generalisable findings than single cases (Yin, 2018). This progressive approach enabled the identification of links between process-level activities that took place within the organisation over time and phenomena at the firm-level by adopting an outcome-driven narrative (Kouamé and Langley, 2018). This approach enabled us to track closely the actions performed by organisational actors across several functions and hierarchical levels and engaged external actors in the focal firm's innovation activities in pursuit of developing new capabilities. Hence, using multiple NPD cases not only helped us finding strong patterns of OI enabled resource alteration patterns, but also establishing some of the building blocks for building theory (Eisenhardt and Graebner, 2007) on the development of DC. Our level of analysis was at the process-level, which provided a detailed account of how OI activities had contributed to the development of new capabilities. Our unit of analysis was the NPD activities taking place within the observed projects, both internal and those extending beyond the organisation's boundaries.

2.4.1 Research Setting

Our research setting was an established UK small- and medium sized enterprise (SME) in the manufacturing sector. We selected an organisation that has over 80 years' experience developing innovative and market leading products. These products cover a wide variety of market sectors ranging from specialist toy and hobby markets to more general industrial and defence markets, with each market varying in size. Consequently, the organisation has a broad customer-base served by a national sales function focused on gaining new business by gathering information on external development opportunities and market movements. The broad customer base corresponds with a diverse supply network that is used collaboratively to support the organisation's OI activities. Consequently, most of the organisation's NPD projects consist of input from a wide range of external actors, mainly customers and suppliers

but also technology experts. This setting is, therefore, an ideal context for researching OI, both in terms of the activities and the actors involved (Chesbrough and Bogers, 2014). We identified the mechanisms by which OI activities contributed to the organisation's DC through careful examination of NPD processes for a period of two years. During 2017 and 2018, the organisation completed 197 and 196 development projects respectively, with 28.6% of the projects leading to sales revenues. In 2019, 54.3% of the organisation's sales revenues were attributable to products introduced during the previous five years. The continually evolving portfolio underpinned by successful NPD projects demonstrates continued support to the organisation's DC through OI activities.

2.4.2 Case Selection

We selected three NPD projects that began with varying levels of market demand for the products under development and had therefore been assigned different resource allocations. To identify relevant NPDs, we selected a cross section of projects using theoretical sampling (Eisenhardt, 1989) to meet the following criteria: 1) projects were recent; 2) had disparate driving forces; 3) included significant input from external actors; and 4) had resulted in an established and revenue generating product in the organisation's portfolio. Our criteria ensured that OI activities were performed throughout the NPD process and that the development had concluded. Thus, we ensured all the possible engagements with external actors had been captured and the projects had resulted in new capabilities.

The first NPD project had been initiated within the organisation in response to a loss of business to competitors, owing to the organisation's inferior product offerings in the market. This NPD illustrated a capability gap and competitive disadvantage concerning the organisation's offerings and its market requirements. The second and third NPD projects had arisen from external market drivers. The second NPD was in response to a requirement for a product that would enable a specific customer (i.e., an external actor) to compete in its

existing markets at lower cost, providing a competitive advantage for its business. The third NPD was initiated following a new potential customer's concern that its existing supplier was using process technologies that were no longer appropriate for the product it was supplying. Both the customer and the current supplier had experienced technical and manufacturing issues, and both were seeking to exit the relationship in a satisfactory manner. This set of three cases provided contrast between the disparate forces driving innovation in the sense that it features initiation by internal forces and clear external/market forces. This is an appropriate method for sampling multiple cases in pursuit of theory development (Eisenhardt and Graebner, 2007) as it provides insight into a variety of factors driving the need for new capability development and how this was achieved.

2.4.3 Data Collection

Our primary data collection was conducted by the lead author, a researcher-practitioner who was employed by the organisation in a senior technical role throughout the duration of the projects. This enabled access to project reports and all communications recorded during each product development. Furthermore, he had easy access to all the organisation's functions that participated in the developments, as well as participating in a technical evaluation and quality control role throughout the research duration. His familiarity with the organisation and its data sources and terminology enabled an unusually rich and focused approach to data collection. Both co-authors were independent of the organisation. They participated and advised during the data collection process to ensure we collected all available contemporaneous archival data relating to each product development. These data included: preliminary costing and technical requirements; project activities; project reports; and notes from any meetings held between internal staff and external actors.

We obtained all recorded communications associated with the corresponding NPDs from within the organization (Table 4). These comprised emails between internal staff

revealing any attempt to gain knowledge from the existing knowledge source and emails between internal and external staff revealing any attempts to gain knowledge from an external knowledge source. Meeting minutes and reports ranged from brief summaries to more comprehensive multiple page documents. These data enabled us to construct a data collection framework for each of the three NPDs, whereby depth could be added through subsequent qualitative data capture from available actors that had participated in the projects.

Table 4: Amount and Type Data Obtained for each NPD

DATA SOURCE		**NPD One**	**NPD Two**	**NPD Three**
Emails	*Pages (amount obtained/total available)*	231/231	92/92	104/104
Meeting Minutes	*Documents (amount obtained/pages)*	5/27	3/17	2/2
Reports	*Documents (amount obtained/pages)*	16/25	2/28	4/18
Informal Discussions	*Total / Duration (Hours)*	7/3.5	6/4	7/3
Semi Structured Interviews (*Internal/External Actors)*	*Total / Duration (Hours)*	2/2	3/3	3/3

Following this, we held informal meetings with all the available internal actors that had been involved in the NPDs (i.e., project leaders, developers, production and sales staff) to review and validate the data captured. All actors involved in this research were "key" (Yin, 2018) or "elite informants" (Aguinis and Solarino, 2019: 3) who were selected because they had deep knowledge of the projects (Miles and Huberman, 1994) and "extensive and exclusive information and the ability to influence important firm outcomes, either alone or jointly with others" (Aguinis and Solarino, 2019: 3). Such informants are often rare and

provide crucial information that is central to the research question (Miles and Huberman, 1994). Hence, similar to Bingham and Eisenhardt (2011), we chose these informants as they were considered "innovators" and had the most insight on the entire NPD process and helped generating specific and salient data.

Next, we conducted semi-structured interviews with project leaders and any internal staff that participated in the NPDs. The interviews lasted a duration of six hours in total and each included an opportunity for an open discussion. During the interviews, participants had been asked to identify the driving forces behind all engagements of each project where external knowledge had been sought. Following these interviews, we asked participants to identify any actions arising because of the OI engagement and to score the significance of the contribution of each OI engagement to the overall project. To capture this data, we developed a questionnaire using a Likert-type scale with descriptions rating from "*no influence on the success of the development*" to "*absolutely critical to the success of the development*." This discovery process revealed the factors that influenced decisions to obtain external input and, more importantly, revealed how OI inputs had influenced the NPD through knowledge flows and had resulted in new capabilities. Some of the questions posed during the interview process included 1) *"What reasons, if any, led you to seek information from an external organization?"*, and 2) *"In what ways, if any, did external input change your actions or behaviour during this interaction?"*. During the subsequent data analysis, we conducted a further round of semi-structured interviews with the project leaders to shed light on the key themes that were emerging from the data. The interviews lasted two hours in total. During these interviews, project leaders were asked about the extent to which new processes or routines had been deployed in future interactions with external actors. These findings were supplemented with telephone interviews with external actors who had been identified as having a substantial contribution to the NPD process. Interviews that were relevant to the

research question were selectively transcribed, resulting in 27 pages of raw data. The commercial sensitivities associated with NPD Three limited our access to the external actors involved. This was compensated for during the internal interviews and discussions and additional data was sought from notes in internal documents, meeting minutes, email exchanges and other sources.

2.4.4 Data Analysis

We conducted our analysis in four stages and combined case analysis (Eisenhardt and Graebner, 2007) with grounded theory procedures (Corley and Gioia, 2004) to produce a deep insight into our objects of study. Our data analysis was performed in concert with our data collection to enable the continual refinement of data capture based on emerging themes, the relevant literature and the data (Corley and Gioia, 2004).

During stage one, we established a grounding of the phenomenon being studied by developing a timeline of each NPD project using the archival data. We mapped out the number of interactions that had occurred during each project and inserted a summary of the activity that had taken place into the timeline, alongside a corresponding timestamp. Following this, we reviewed all email dialogues obtained from each project with the project leader, and manually coded these dialogues using in-vivo codes representing the actor that participated in the communication, the type of communication, and a brief summary of the communication. Similarly, we inserted this data into the corresponding NPD timeline in date order, alongside a timestamp. This provided a preliminary overview of the frequency and type of communications between actors operating internally with external actors throughout each NPD.

During stage two, we inserted the driving force behind all engagements with external actors into each NPD timeline. This had the effect of associating the ‘why’ behind the OI

engagement with the corresponding activity and revealing what knowledge had been sought from external actors. To understand better both the nature of the engagement and how the external actors had influenced the NPD, we also inserted into the NPD timelines the resulting input and any activities associated with each step of the NPD project. Then, we inductively generated themes concerning inputs and activities in correspondence with the project leaders that were refined iteratively during the subsequent interviews and discussions that were conducted for each NPD.

During stage three, we inserted the significance and contribution of external inputs to the completion of the overall project into the NPD timelines. We asked the project leaders during the subsequent interviews to elaborate on the reasons behind the scoring and how the activities had influenced the overall project. This helped provide a deeper understanding of why certain activities had greater significance. Importantly, it revealed comprehensively how external actors had influenced the NPD project and the firm by highlighting potentially significant capability gaps that had been bridged during the project.

During stage four, we further analysed the textual data, interview transcripts, project reports and email exchanges. This was usually completed in the sequence they were conducted, although sometimes simultaneously and in different activity sites (Demir and Lychnell, 2015) to develop an understanding of the OI activities underpinning the alteration of DC. Following Gioia et al. (2013), the analysis was accomplished in three steps by reading and rereading the data, coding events, actions and activities associated with OI until a categorical scheme was developed (see Figure 2).

During our analysis, we triangulated our data by continually comparing the textual data with the NPD timeline and revisiting the actors involved to resolve any inconsistencies. In the first round of this analysis, we stayed close to our data, coding terms used by our informants

and in documents into first-order concepts. Then, we revisited the first-order concepts and assessed whether they had captured enough detail and could serve as plausible accounts of OI activities. This step further involved matching and grouping concepts based on their similarity and compatibility into second-order themes. Finally, we aggregated second-order themes into three analytical dimensions representing how OI contributes to the firms' DC.

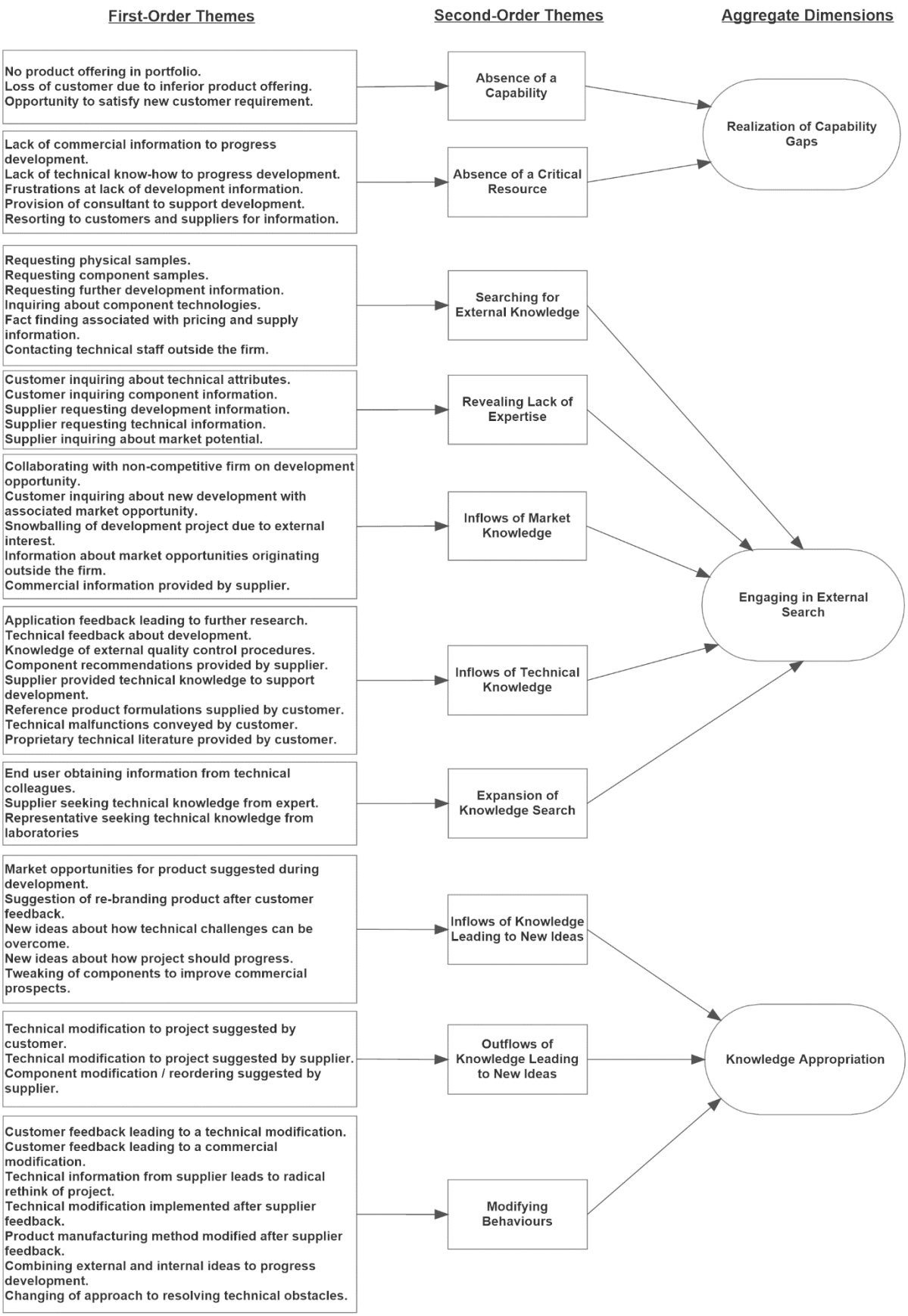

Figure 2: First-Order Themes, Second-Order Themes and Aggregate Dimensions

2.5 Findings

We present our results in four sections. Initially, we present three higher-order concepts and their microfoundations that we distilled from our analysis of the three NPD cases. Subsequently, we consider the process-level outputs that result from the interactions between these concepts. In this section, we refer to the organisation responsible for the NPD projects as Alpha. Similarly, we reference specific external actors with pseudonyms to protect their anonymity. Following is an overview of each NPD project and the number of individual engagements that we discuss throughout this section (Table 5).

Table 5: External Inputs that Impacted Each NPD

	NPD One	**NPD Two**	**NPD Three**
Total Quantity of Individual Engagements	154	29	73
Purpose Types (Rationale Behind OI engagement)	27 Product Characteristics 5 Product Features 16 Market Potential	10 Product Characteristics 3 Product Features 3 Market Potential	7 Product Characteristics 3 Product Features 3 Feasibility of Product 2 Market Potential
External Actors Involved	11 Supplier	4 Customer 1 Supplier	5 Customer 3 Supplier
Engagement Types (Means and types of engagement)	43 Information Sharing	11 Information Sharing	14 Information Sharing
Resulting Inputs	27 Technical 13 Component Costing 3 Supply	8 Technical 1 Component Costing 3 New Collaboration Opportunity	11 Technical 5 Component Costing 2 New Collaboration Opportunity

		1 Physical Sample	1 Physical Sample 1 Supply
Behaviour Modification	28 Changes of base component. 5 Changes of component ratios. 1 Modification to Component Ordering 2 Changes to Internal Actors Thinking 2 Fundamental Product Changes 6 Attempts to gather more Information	4 Change of Component 2 Modification to component order 2 Change to Internal Actors Thinking 1 Information Gathering	3 Change of Component 1 Modification to Component Order 2 Information Gathering 2 Modification to Manufacturing Process 1 Fundamental Product Change 2 Change to Product Specifications

2.5.1 Realization of Capability Gaps

At Alpha, NPDs are normally initiated in response to a market opportunity, either identified internally or prompted by an external actor. The initiation of NPDs inevitably revealed a knowledge gap in the firm rather than knowledge availability. Conceptually, the *realization of capability gaps* preceded resource or capability creation and is underpinned by the initial recognition of an *absence of a capability*, followed by a condition where the focal firm had *an absence of a critical resource* required to develop the product (Table 6).

Table 6: Realization of Capability Gaps – Conceptual Descriptions and Empirical Examples

Second Order Theme	Conceptual Description	Empirical Example

Absence of a Capability	When an innovating firm recognises a market opportunity that has the potential to support growth of the focal firm.	"he's not got anything to go up against this [competitors] product, and he can't get in there on price" "they travelled to [customer] where they were told [customer] would not be renewing the [product] contract in favour of [competitor] citing a loss of gloss as the main reason for the move" "[beta] contacted us with an opportunity to supply these two [products] they were making for [gamma]"
Absence of a Critical Resource	Represents a lack of knowledge within the focal firm required to develop a new product.	"This leaves me in a difficult situation, because I feel like I've exhausted all the 'tricks of the trade' with the current [components]. I know there is something not quite right… please let me know your thoughts" "We were utilising [consultant] on this project due to his contacts and knowledge of the [component] industry." "We have manufactured somewhere in the region of 60 [products] and not achieved a product we deem suitable for end use"

Absence of a Capability

In all three developments, the recognition of a capability gap was the driving force behind establishing the requirement for a new capability. This manifested itself as the lack of a

product offering to satisfy a market requirement and, in each instance, the awareness of such a gap originated from an external knowledge source. During NPD One, Alpha had been called to visit a key customer (C1) who were regularly purchasing one of Alpha's established products. During the meeting, Alpha were informed that C1 *"would not be renewing the [product] contract in favour of a [competitor]" (Director).* This was a consequence of long-standing technological problems and the associated *"lower quality finish of the end product." (Project report).* To have a chance of gaining back the lost business, Alpha would need to develop a product that was technically comparable to the competitor's but surpassed it in quality.

NPD Two was initiated after one of Alpha's representatives paid a cold call visit to a prospective customer. The visit was motivated by Alpha targeting increased sales in a familiar market. During the visit, the customer made the representative aware of a competitor's product that they were using in substantial volumes. However, at this time, Alpha did not have a comparable substitute: *"he's [representative] not got anything to go up against this [competitors] product and he can't get in there on price" (Project Leader)*. Unfortunately, Alpha's nearest substitute was too expensive to be a viable option. At this stage, Alpha recognised the requirement for a new, more competitive product.

NPD Three was initiated when a collaborating firm's (Beta) Managing Director established contact with Alpha's Laboratory Manager to query the possibility of toll manufacturing a product for Beta's customer (Gamma). Both Beta and Gamma were trading in a market that was unfamiliar to Alpha. However, the product shared similarities with an existing product in Alpha's portfolio that Alpha manufactured using different equipment. At this stage, it was not clear whether Alpha could manufacture the product with their equipment. This created a circumstance where Alpha would *"need to develop the capability*

to manufacture a novel product, using our equipment that would conform to [Gamma's] requirements" (Project leader).

Absence of a Critical Resource

In these three examples, access to external knowledge led to Alpha identifying capability gaps, which subsequently led to the initiation of NPDs. During the initial stages of these NPDs, Alpha realised it lacked critical knowledge resources to progress the NPDs and began knowledge searching activities.

In NPD One, Alpha had historically failed to develop a competitive product. This was a cause of concern as Alpha *"lacked the technical ability to develop a product that could be traded" (Industrial Sales Manager)* and was seen to be falling behind competitors. Initially, Alpha searched for knowledge on component technologies and manufacturing methods using industry leading suppliers' websites and engaged an external consultant to gain expert knowledge of one of the product's components. However, this did not provide the necessary solutions as Alpha lacked the technical knowledge and capability to progress the development: *"we have manufactured somewhere in the region of 60 [products] and not achieved a product we deem suitable for end use" (Project Developer)*. It appeared Alpha had used a trial and error approach to achieve a product with the desired properties but had been unsuccessful thus far.

In NPD Two, Alpha *"had a product that would go through [processing method]" (Project Leader)*, but Alpha was not aware how the cost of the existing product (P) could be reduced to achieve the price level required by the market. Similarly, Alpha searched supplier websites for information about component technologies that could be used. However, the information was limited to basic component families and properties, which did not provide a

solution. Consequently, Alpha needed to obtain knowledge of component technologies and recommendations for reducing costs from its suppliers.

In NPD Three, Beta *"had been experiencing technical frustrations and challenges with the product that were leading to defects and a high rejection rate" (Project Leader).* Initially, Alpha's development team were unsure how, or even whether, Alpha could manufacture the products on its equipment despite its familiarity with the component technologies. At this stage, it was also unclear whether Alpha could resolve the technical issues Gamma was experiencing. Consequently, Alpha required information about the existing manufacturing equipment, product formulations and defects, and quality control specifications and procedures.

While all three NPD projects were not similar in size and scope, they all lacked the requisite knowledge resources to progress the development.

2.5.2 Engaging in External Search

As Alpha's knowledge gaps were exposed and demonstrated their lack of capability in pursuing the NPDs, they began engaging in external search to bridge these knowledge gaps. As illustrated in Table 5, NPD One involved the largest amount of external engagements (154 occasions), which is indicative of its large knowledge gap relative the other NPDs. This project was also the most complex, involving at least eleven external actors. Engaging in external search (Table 7) was underpinned by five lower-level mechanisms: *searching for external knowledge*; *revealing a lack of expertise; inflows of market knowledge; inflows of technical knowledge;* and *expansion of knowledge search*.

Table 7: Engaging in External Search - Conceptual Descriptions and Empirical Examples

Second Order Theme	Conceptual Description	Empirical Example

Searching for external knowledge	Searching for knowledge outside the firm to support new product development.	"I asked for some wet samples off the customer because I wanted something to look at. We also got some of the [component]." "There was a requirement to get some external input in i.e., from supplier in terms of what have you got that is going to enable us to do this." "Hi [Supplier], this is a bit of a long shot, but are you aware of any [components] that are good for stabilizing [component] in [product type] systems?" "We visited some development chemists at [supplier] and are working closely with them to resolve these challenges."
Revealing Lack of Expertise	A customer or supplier demonstrating a lack of knowledge about the new product development.	"The customer was asking whether this product that has been developed will go through [application method]." "she was asking us whether we could go [component] free and I said yes that's an option." "The result with [component a] and [component b] is very strange, as this never usually gives any problem…. Do you what temperature the [products] are getting to?"
Inflows of market knowledge	New market opportunities presented during the development process.	"On an unrelated note we're looking for [new product type] – is this something you can offer?"

		"[customer] shared information on some customers that he's had that will be interested in this product" "it sort of snowballed from one customer with one colour to this is a saviour of cheap [product type]. We knew at that point there was going to be other customers involved."
Inflows of Technical Knowledge	Technical knowledge from outside the organisation being communicated to the innovating firm.	"it was the [product] feedback with the [aesthetic property] which was obviously a little set back...we've made a decision to do a bit more research if you like." "In your [product] system, I'd look to replace [component a] and [component b] with [component c] as this is a better for [components] like [component type]." "I have enclosed TDS for you to review and presentations on the influence of the [property] of [component a] on the effectiveness of [component b] and [component c]."
Expansion of Knowledge Search	Technical knowledge outside the firm being provided by an extension of the original recipient.	"I have been in touch with a company [company name], to give me some recommendations for newer, efficient [component types] to try, that

	have a better tox profile and I am just awaiting delivery of samples."
	"Please can you suggest anything for [Alpha], I was thinking [component], but also are there further questions from [development chemist] that needs answering to suggest the possible cause of the [technical issue]?"
	"The Auto lab commented your [component] should not be a problem to stabilise in, and recommended [various components]"

Searching for External Knowledge

In NPD One, Alpha lacked technical knowledge about interactions between component technologies, the sequencing of components and component ratios. Consequently, Alpha resorted to knowledge searching activities with suppliers where Alpha shared detailed information about technical issues. For example, during the early stages of the NPD, Alpha provided detailed feedback to one supplier regarding difficulties stabilising the product components stating *"I would be interested in your comments and recommendations for stabilising the [product]…" (Project Leader).* However, as the project progressed and Alpha evaluated new components, further obstacles became evident: *"I'm disappointed that the [component a1] causes* adhesion *issues, as the [products] had zero float and were perfect in terms of rheology, cost etc. This represents a major setback for us" (Project Leader).* This resulted in a sustained level of supplier involvement despite retaining the external consultant throughout the project. Alpha contacted additional suppliers for ideas about how to overcome this issue: *"This is a bit of a long shot, but are you aware of any [component a] that are good*

for stabilizing [component b] in [component c]? I've tried [component a1] (this works but poor adhesion), [component a2] seems very floaty and flocculates when [component d] is added." (Project Leader). Unfortunately, the consultant's expertise was limited to a single component, but the product consisted of multiple components that interacted with each other in diverse ways with the potential for any combination of components affecting the technical properties of the product.

In NPD Two, initially Alpha sought supplier knowledge to understand how to develop a product at a specified cost, whilst offering specific application and aesthetic properties. At this time, Alpha was not aware of how this could be achieved so it contacted a supplier to obtain knowledge of component technologies: *"You may remember we briefly spoke just before Christmas regarding an alternative to [component name], as you have a [component type] with lower hydroxyl functionality that could work for us…to get nearer as an equivalent and also drive our costs down a bit I would be interested in this [component type] for this new development. If you have any further information, I would be very interested, also we would need samples, but the important thing is that I can use the [component type] for airless application" (Project Leader).* As the development progressed, Alpha manufactured product samples using the recommended components. However, Alpha had to obtain customer knowledge because they lacked understanding of how the novel product would perform using this component: *"they'll know (supplier) about the product because of the track record of who they've sold it in the past. We sprayed some out airlessly, but smallish panels, and we've relied on providing samples and getting feedback from the customer" (Project Leader).* Unfortunately, the feedback revealed new technical challenges concerning the aesthetic properties of the product. This led to continual customer involvement during the later stages of the project.

In NPD Three, Alpha engaged in knowledge searching activities for several reasons. At the beginning of the development, Alpha had limited knowledge of the product Beta were manufacturing for Gamma. Beta had supplied Alpha with *"rudimentary product formulations consisting of components, ratios and a processing method" (Project Leader)* but it had still been necessary for Alpha to visit Beta: *"it's not a straightforward cut and dry, here's a formula, just fit into the way you do things…I asked for retained samples because although we had the formulas, I wanted to actually look at some of the [product]."* During the visit to Beta, Alpha used the opportunity to observe its manufacturing equipment and engage with its technicians to gather further information about the development. Alpha also sought information about the product components as *"there were a few [components] that we [Alpha] weren't familiar with" (Project Leader).* As the development progressed, Alpha sought further knowledge of Gamma's QC testing procedures due to inconsistencies that led to technical issues: *"it passed the QC specs as provided, but they came up with this other thing they do called the evil cam" (Project Leader).* Throughout this development, it had been necessary for Alpha to obtain further information about technical issues Gamma was experiencing in order to make product improvements that would overcome these issues.

Revealing Lack of Expertise

Once Alpha had engaged in knowledge searching activities, it found that its suppliers lacked expertise resulting in reciprocal knowledge searching activities. In NPD One, a supplier requested information about the product under development and its associated market potential. This type of knowledge was required for the supplier to commit resources to the development: *"All technical projects are entered in project management system ranked by commercial success and technical success. Net Present Value is our preferred method for budget decisions and choosing between and prioritizing technical projects" (Supplier).* Throughout the duration of the project, suppliers requested technical feedback: *"Do you*

know what temperature the [products] are getting to?" (Supplier) and further knowledge about the project. This was a strategy used by suppliers to help eliminate technical issues. During this process, it had been necessary for Alpha to support knowledge transfer with specially developed tangible graphical illustrations of the issues experienced.

In NPD Two, once Alpha engaged in knowledge searching activities, the supplier sought knowledge of the type of product being developed and whether Alpha was aiming to switch to a higher value component. The prospect of Alpha switching the component was a major cause of concern to the supplier, which manifested itself as a reluctance to share information. However, after some reassurance from Alpha, the supplier agreed to support the development: *"I will order both samples and see if [manufacturer] can give any further price support as it's additional business rather than a cannibalisation of the [component] business" (Supplier).* During this development, one customer demonstrated interest in the development and, to generate product sales, requested further information about the product: *"You were to get back to me with info on all aspects of the new [products] but not seen anything. Can you update me." (Customer).*

In NPD Three, Gamma sought information from Alpha about the component technologies used in the product formulation and technical information about component interactions and behaviours in the product: *"The TDS [technical data sheet] does offer some recommendations for using [component type], but like I say, we would look to move away from [component type] for any new developments/modifications. I'd be really happy to receive any recommendations of materials to try, if you have any" (Technician, Gamma).* This request demonstrated a lack of technical expertise to achieve the desired product modifications, despite Gamma's ownership of the formulation. During this development, Gamma also enquired about Alpha's knowledge of a specific and unrelated product type and appetite for further collaboration: *"I am looking for an [product type] for one of our new*

[product systems]" (Technician, Gamma). This appeared to arise from the positive experience associated with the initial development and learning about Alpha's technological capabilities.

Inflows of Market Knowledge

Following knowledge searching activities, reciprocal inflows of market knowledge occurred in two projects. In NPD Two, a customer had appeared willing to provide market-related opportunities to Alpha: *"first and foremost the development was for [customer] and since then it has snowballed" (Project Leader).* As the project progressed, two additional customers showed interest in the product, one of which shared information about further prospects: *"(C1) shared information on some customers that he's had that will be interested in this product".* This appeared to be a consequence of the mutual benefit gained from succeeding with the development and would later enable Alpha to target previously unknown market opportunities with the product.

During NPD Three, towards the later stages of the development project, Gamma inquired about an opportunity for collaboration on a new project: *"I was hoping we may be able to have a conference call tomorrow afternoon to discuss a new project we may have for you." (Technician, Gamma).* The initial knowledge exchanges identified a three-month timeframe and, at this time, Gamma stated *"we would be looking for stock in August (the sooner the better to be honest)" (Technician, Gamma).* The new opportunity appeared to arise due to the positive experience associated with the project timescale and technical success of the project. When Gamma conveyed the requirements for the new project, they stated, *"this is urgent, and we will need this on a quick turnaround" (Technician, Gamma).* Thus, indicating the importance of project turnaround to capitalise on the opportunity.

Inflows of Technical Knowledge

Following knowledge searching activities by Alpha, our research revealed reciprocal inflows of technical knowledge occurred. During NPD One, there were 43 instances of inflows of knowledge. The main type of knowledge inflow was technical (27), followed by cost (13) and supply (3). In general, knowledge inflows were in response to a knowledge gap that existed within Alpha, manifesting as a technical obstacle that was preventing NPD progress. For example, a supplier technician was asked *"Have you any idea how I might increase compatibility between [supplier components] and this [product system]?" (Developer)* to which they responded *"There are a few options here, have you tried adding [component] in a small amount (1.5% by weight) as the [products] are mixing in the base? This is known to help reduce [product defect]". (Supplier Technician).* After this, Alpha implemented the suppliers' recommendations which led to further questions and reciprocal knowledge inflows. Compared to the other NPDs, Alpha had the widest knowledge gap to bridge in order to complete this development: *"we have exhausted all of [suppliers] recommendations" (Project Leader)*.

During NPD Two, there were 13 instances of inflows of knowledge. Most knowledge inflows were technical (8), followed by physical inputs (1) and cost inputs (1). Prior to this project, the prospective customer provided Alpha with knowledge of product requirements (e.g., aesthetics, target costing, application properties) in descriptive format, and samples of a competitor's product. Alpha's knowledge gap associated with its customer requirements led to the recommendation of a component with similar properties to one Alpha currently used, but at a lower cost: *"[component name] is a much more economical option of 2 fronts, it has a lower OH value so less isocyanate and also the buying price is lower. It is a good standard GI grade but not as high spec (more in terms of weathering) than the [existing component] – I think this would be ideal for your needs" (Supplier).* However, as the product required

multiple components that had the potential to interact with each other, it was necessary to develop some physical samples in the laboratories prior to drawing on customer input to validate the product. Subsequently, the customer provided vital feedback that enabled the project leader to *"get a feel for how the product was performing" (Project Leader)*, leading to further ideas and minor adjustments to the product.

During NPD Three, there were 20 instances of inflows of knowledge. Most knowledge inflows were technical (11), followed by physical inputs (1), cost inputs (1) and supply inputs (1). At the beginning of the development, Beta supplied *"rudimentary product formulations consisting of components, ratios and a processing method" (Project Leader)*. Alpha also requested tangible samples of the existing product, in addition to a product component: *"They supplied wet samples because they were requested at the meeting, and Danny took a drum of [component] in his car and brought that into our place" (Project Leader).* During the later stages of the project, Alpha manufactured physical samples to Gamma for trials with their end user to check the feasibility of the product. Upon initially submitting the samples, several unanticipated and unrelated technical issues had occurred: *"Attached are some photos of glass slides we have dipped into the [product] and cured. They show some [defect], so just needed to chat to you guys about this, as we cannot send this to our customers in this form. We'll talk you through this later." (Technician, Gamma).* At this stage, Alpha requested the quality checks performed by Gamma prior to releasing the product, to enable Alpha to gain a deeper understanding of the technical issues Gamma wase experiencing and how to overcome them.

Expansion of Knowledge Search

The external actors that Alpha initially contacted did not always possess the knowledge required to overcome the technical issues experienced during the NPD projects. Under such circumstances, external actors sometimes initiated an expansion of knowledge search that

resulted in further inflows of knowledge. In NPD One, a supplier used this technique to request input from their satellite laboratories owing to a lack of technical knowledge relating to an issue*: "The Auto lab commented your [component] should not be a problem to stabilise in and recommended [various components]" (Sales Manager, Supplier)*. Another supplier used the same technique through an upstream component supplier: *"Please can you suggest anything for [Alpha], I was thinking [component], but also are there further questions from [development chemist] that needs answering to suggest the possible cause of the [technical issue]?" (Technical Service Manager, Supplier).* In both instances, this reciprocal activity facilitated knowledge inflows from previously unknown or directly inaccessible knowledge domain. During NPD Three, Gamma contacted a component supplier to gain further technical information to make further product improvements: *"I have been in touch with a company [company name], to give me some recommendations for newer, efficient [component types] to try, that have a better tox profile and I am just awaiting delivery of samples."* (*Technician, email).*

2.5.3 Knowledge Appropriation

At Alpha, successful NPD teams demonstrated appropriation of externally sourced technical or market-related knowledge. Conceptually, *knowledge appropriation* (Table 8) consists of *inflows of knowledge leading to new ideas*, *outflows of knowledge leading to new ideas* and *modifying behaviours*. We observed these knowledge resource creating processes throughout each example.

Table 8: Knowledge Appropriation - Conceptual Descriptions and Empirical Examples

Conceptual Description	Second Order Theme	Empirical Example

Inflows of Knowledge Leading to New Ideas	External knowledge input that stimulated a new idea inside the firm to support the product development.	"The customer said it was really good and it actually it feels like a more expensive [product], so I thought, do you re-label it as something else and sell it to a different market to a different customer" "we get in the [competitor] products, and we say, aha it's actually quite a different mixing ratio, so straight away there's a limit with your [component type a] which is the other side of the equation. So, when I spoke to [supplier], I said look we need something like [component type b], it must go through [processing method], but it must have a lower [component type a] demand."
Outflows of Knowledge Leading to New Ideas	Internal knowledge output that stimulated an idea outside the firm to support the product development.	"Or adjust the order of addition? Adding some [component a] before [component b] can help to prevent issues with gelation." "I think that a polymeric 'grinding medium' could eventually be a better choice for the [component type]"
Modifying Behaviours	Internal behaviour modification following external knowledge input.	"The biggest change to the product has been from the feedback on the down glossing...what we did, we took out the [component a] because it tends to leave an oily residue and swapped it for [component b]." (after supplier recommended trying a different component) "We had a meeting with [supplier] to discuss one of their [components] that is

	compatible with a range of [product families] I intend to begin formulating some [products] using this [component] and hope to have a range of prototype [products] next month."
	"they [customer] were saying we're suffering from [defect] is there something you can do, and we said yeah we can look at it. When we started looking at the formula, we had a quick look and I wanted to try something. I thought we could also try a bit of [component] in the [product a] and the same [component] that's in the [product b] and see what that's like."

Inflows of Knowledge Leading to New Ideas

During NPD One, Alpha sought supplier knowledge about components and component ordering due to experiencing technical issues during the development process. After an extended knowledge search, a supplier made a recommendation to substitute a component in the product. The component in question was novel to Alpha and used a different technology that had the potential to resolve various technical issues. This initially changed Alpha's thought process by stimulating a new idea: *"I'm thinking we can perhaps grind [component a] into this [new component] and operate a system similar to [existing product system]. This would allow us to develop [new products] around the [new system] and give us some flexibility there." (Developer).* This resulted in a change of behaviour by the developer that would enable the new product to be modularised, opening further opportunities to develop supporting products. Alpha subsequently adopted this technology which led to the approval

of a programme of work by the R&D laboratory to develop 12 new supporting products targeting new markets.

During NPD Two, Alpha sought knowledge of how the product was performing in relation to customer expectations, despite differences in the processing methods used by Alpha and the customer. Initially, Alpha received feedback the product *"was really good and it actually feels like a more expensive [product]" (Representative).* This market-related knowledge led Alpha to consider whether to *"re-label it as something else and sell it to a different market to a different customer" (Project Leader),* creating further market opportunities. During this development, knowledge inflows conveyed the customer's application techniques, that were cross-fertilized with internal knowledge to stimulate new ideas and considerations: *"The last lot of feedback from the spray trials, I had [development chemist] looking at it again… he's come up with something else that's really good – I'm really impressed and it's cured it (technical defect) and it's made it cheaper" (Project Leader).* The feedback and associated modification of the product resulted in unexpected cost savings that were crucial to the success of the product.

During NPD Three, Gamma had experienced technical issues that caused defects in the end-product. These defects were costly to Gamma and had the potential to place the business under threat. The receipt of the initial formulations and knowledge associated with defects stimulated a new idea that resulted in a behaviour modification: *"rather than introducing too many new [components]… I thought we will also try a bit of [component] in the black that's the same [component] that's in the red and see what that's like" (Project Leader).* This contrasted with an alternative option where Alpha would have used a familiar component to overcome the issue.

Outflows of Knowledge Leading to New Ideas

Our research also revealed outflows of knowledge resulted in the creation of new ideas externally that influenced the direction of two NPD projects. The suppliers and customers developed an understanding of product related technical obstacles and Alpha's capabilities that preceded to the creation of new ideas. During NPD One, various suppliers made recommendations to eliminate technical product defects. After exhausting all recommendations, an idea to substitute a core component within the product originated externally: *"I think that a polymeric 'grinding medium' could eventually be a better choice for the [component type]" (Supplier).* This external idea resulted in a behaviour modification by offering Alpha a previously unknown alternative option that eliminated the associated technical issue. Subsequently, Alpha adopted the idea which contributed to the success of the development.

During NPD Three, after seeking Alpha's knowledge about component technologies, the customer suggested a component modification that would make the product more sustainable by enhancing the product's toxicology profile. This was perhaps due to the customer having a high level of interest in the development, since their existing supplier no longer wanted to manufacture the product. In doing so, however, the development made a significant leap towards completion.

Modifying Behaviours

Throughout each NPD, behaviour modifications occurred following internal knowledge flows and ideas created both internally and externally. The type of behaviour modifications differed between the projects. Some included intangible differences such as changing the way the project leader had thought about approaching an issue: *"you might have an idea of how you going to achieve something, start along that line, and then you get some outside information and it makes you change what you thought you were going to do" (Project Leader, NPD*

Two). Others included tangible changes such as changing components, component ratios, the steps components were added, or more fundamentally, the type of product being developed: *"We held a meeting to discuss the direction of the [project] after evaluating a range of options that include [Option a] and several [Option B]" (Project Leader, NPD One).* Overall, the most significant contributions to the success of the projects were of a technical, tangible nature.

During NPD One, there were 44 internal behaviour modifications following external inputs. Each modification influenced the direction of the development with differing levels of importance, but the most significant contribution had been a complete change of approach to developing the product. This change, however, corresponded with a supplier-related knowledge inflow after an expansion of knowledge search. In this circumstance, email discussions that eventually led to a face-to-face meeting facilitated the initial knowledge transfer that led to the behaviour modification. This change resulted in a product system that was more flexible than the original intended product and supported the development of twelve new products.

During NPD Two, knowledge inflows resulted in nine internal behaviour modifications that had influenced the direction of the development. Knowledge of competitor product offerings enabled Alpha to adjust its approach to meet the cost requirements, whilst matching the application properties of the competitor's materials using physical samples that had been provided. However, the most significant behaviour modifications followed customer feedback: *"The biggest change to the product has been from the feedback on the down glossing...what we did, we took out the [component a] because it tends to leave an oily residue and swapped it for [component b]" (Project Leader)*. Once Alpha manufactured initial product samples, the customer participated in physical trials that consisted of *"a customer feedback loop where we send in a sample, and they gave us some nice feedback,*

then we made some improvements and developed another sample" (Project Leader). This feedback loop facilitated an incremental refinement of the product that led to the perfect balance of technological properties whilst achieving the cost requirements of the product.

During NPD Three, knowledge inflows had resulted in eleven behaviour modifications that had influenced the direction of the development. The most significant behaviour modification occurred once Alpha had learnt about the full extent of the product and the products application in practice: *"myself and Danny thought that we could do the final products for them rather than making the concentrate and then further mixing it" (Project Leader).* Alpha's direct contact with the customer facilitated knowledge of the full extent of processing. This led to the amalgamation of two manufacturing steps into a single process. Consequently, Alpha experienced greater efficiency and cost savings. Other behaviour modifications included the alignment of Alpha's QC procedures with those of Gamma, resulting in a more tightly controlled product. Finally, as the development progressed, Alpha combined existing technical knowledge of a component, with the knowledge inflows of product and market requirements from Beta and Gamma, resulting in the development of a product free of technical defects.

2.5.4 NPD Success and New Capability Development

Engaging in OI activities during the NPD process supported Alpha in its pursuit of new capabilities to close a technological gap between it, as the focal firm, and its competitive environment. The mechanisms by which OI activities contribute to new capabilities consist of the *realization of a capability gap*, *engaging in external search* and *knowledge appropriation*. These mechanisms work in sequence, and each mechanism interacts with DC sensing and seizing abilities.

The realisation of a capability gap occurred once Alpha became aware of a market opportunity and a lack of critical resources to act on the opportunity. This realisation constitutes a sensing mechanism and, in our examples, was triggered by external engagements. Once the requirement for a capability and critical resources had been established, Alpha used OI activities to leverage external knowledge resources situated in supplier and customer knowledge domains. These external engagements led to reciprocal knowledge sharing that sometimes triggered further sensing of market opportunities.

Knowledge appropriation occurred subsequent to market and technical knowledge inflows and represented a seizing mechanism. Knowledge appropriation was observed through the creation of new ideas and behaviour modifications that also led to further sensing of market opportunities. Knowledge appropriation influenced the course and direction of NPDs and eventually contributed to their success. Thus, contributing to the renewal of the firm's existing resource base through the creation of new resources and capabilities (Table 9). Interestingly, the process of gaining new capabilities appeared to result in additional capabilities, not associated with the original requirement of the NPD that Alpha could exploit in the future.

Table 9: New Capabilities Developed Subsequent to OI Process

	NPD One	**NPD Two**	**NPD Three**
Capability Realised	Development of a new product (formulation & production routine) enabling the firm to sell a system of components that can be used to manufacture high-quality	Development of a new product (formulation & production routine) enabling the firm to sell a product to low-cost markets, whilst achieving a specific application property.	Development of a new product (formulation & production routine) enabling the firm to sell a product into a previously unknown market.

	products and sold to various novel markets.		
Auxiliary Capability	Drawing on the expertise of an external consultant to obtain knowledge of a component technology resulting in increased linkages with external actors. Developed expertise in recent component technologies that can be applied under different circumstances to capitalise on future market opportunities.	Developed expertise in the application of component technologies that could satisfy specific application requirements whilst reducing cost. Developed ability to manipulate the application properties of a product family without affecting the aesthetic properties of the product.	Developed the ability to convert a product formulation using specific machinery to more modern manufacturing machinery utilised by the focal firm. N/A

2.6 Discussion

The aim of our study was to answer the research question *"How can open innovation activities contribute to a firm's dynamic capabilities by supporting the creation of firm resources?"* Our study reveals that the OI process consists of three lower-level mechanisms and that OI activities have varying degrees of interaction with each of these mechanisms. Our analyses lead us to suggest that these three mechanisms can be integrated in a process that explains how these mechanisms interact giving rise to firm-level abilities (Figure 3).

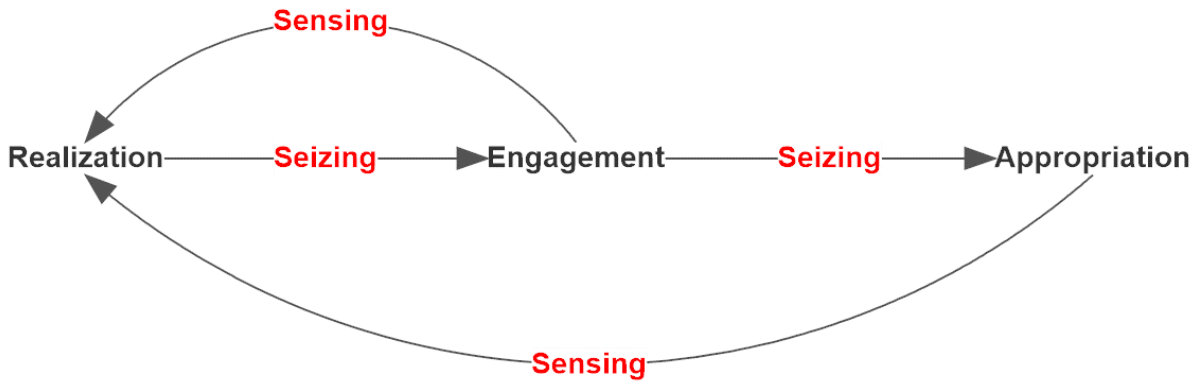

Figure 3: Mechanisms of OI that Contribute to a Firm's DC

Our process model demonstrates that firms are able to use OI to build new capabilities through a sequential or reciprocal process determined by three underlying mechanisms. Initially, *realization* must occur, when a firm becomes aware of the requirement for a new capability that it can address through the process of NPD. Realization is a sensing mechanism that may be initiated internally or externally and occurs when previously unknown market-related knowledge is brought to the firm's attention, giving rise to awareness of a new opportunity to create value. This market-related knowledge may be conveyed and facilitated by the firm's social network or external engagements that occur subsequent to the scanning activities. However, firms may also experience realization subsequent to customer engagements, which suggests that the OI process facilitates this mechanism by retaining open communication channels with customers that enable innovating firms to learn about customer needs and preferences.

Prior studies highlight that ideas for future NPD projects may arise subsequent to knowledge search activities (Salge et al., 2013) and that resource and capability creation may occur once firms recognise the value of new opportunities (Teece, 2007; Teece, 2014). However, we argue that realization extends the role of search activities. Our findings demonstrate that the necessary conditions to trigger realization occur both *prior* to the

initiation of an OI process and also *during* an OI process. This suggests OI engagements increase the likelihood of a firm identifying new opportunities by reducing the firm's proximity to external actors who may hold valuable market-related insights (Tether, 2002). These market-related insights may then contribute market knowledge, which firms can leverage to identify capability gaps and ideas for new innovations. Consequently, we posit that the OI process enhances realization, and that a firm with proficiency in realization may experience a greater ability to sense new opportunities in support of its DC.

Once firms experience realization, they may choose to act on a newly identified opportunity through *engagement* when they gain technical awareness of a knowledge or capability gap. A knowledge gap may be market-based or technical in nature and manifest as a lack of product or process knowledge. Engagement is an iterative process that combines externally sourced knowledge with internal knowledge stock in search for new knowledge and solutions. Under such circumstances, firms may obtain both market-based and/or technical knowledge from external actors such as suppliers and customers (Laursen and Salter, 2006). During engagement, when external actors lack the required knowledge or understanding, reciprocal knowledge search may occur. Thus, representing a learning process that may grant firms access to an extended knowledge network when external actors do not possess the required knowledge or understanding. Our study demonstrates that during engagement, a firm can benefit from new market-knowledge inflows when external actors develop a greater understanding of the firm's capabilities, triggering further realization.

Prior OI studies have established inbound and outbound knowledge flows as firm-level mechanisms of OI that grant access for the firm to knowledge resources situated outside the firm boundary (Dahlander and Gann, 2010; West and Bogers, 2014; Stanko et al., 2017). However, our findings extend the contribution of these studies by revealing that the OI process embeds inbound and outbound knowledge searching mechanisms, and these

mechanisms can occur as part of a cumulative learning process that builds on reciprocal knowledge and extended knowledge networks. Therefore, echoing Caner et al. (2014), we suggest firms that engage in high levels of inbound and outbound knowledge transfer may experience higher levels of innovation outputs. Furthermore, existing research has associated a firm's knowledge recombination ability with increased innovation performance (Carnabuci and Operti, 2013) and considered outcomes of knowledge search such as ideation (e.g., Salter er al., 2015) and performance (Dahlander et al., 2016) in isolation. However, our study offers a longitudinal insight into the dynamic process by which micro-level mechanisms interact within OI activities over time, resulting in technical knowledge recombination and the recognition of new market opportunities. Consequently, we argue that OI engagement supports a firm's DC by contributing to the firm's seizing ability and may lead to further realization giving support to the firm's sensing ability.

We refer to the final element of our process model as *appropriation*, which is the process by which a firm makes knowledge and capabilities its own. Appropriation occurs subsequent to engagement and requires knowledge inflows to impact the course or direction of the OI project. Appropriation is preceded by a mutual understanding of project requirements and may occur directly or indirectly as a consequence of a knowledge creation process preceded by knowledge inflows. Direct appropriation occurs when market or technical knowledge inflows trigger an internal idea that leads to opportunity creation (Alvarez and Barney, 2007). In contrast, indirect appropriation results from the interplay between a new idea and behaviour modifications that occur at the process-level. The interplay between a new idea and behaviour modifications is bi-directional, as demonstrated by our findings that a new idea may precede a behaviour modification or, alternatively, a behaviour modification may precede a new idea. Behaviour modifications affect the direction of the project and lead to new experiences and changes in approach. Moreover, our study

demonstrates that this knowledge creation process may occur in both internal and external knowledge domains subsequent to a knowledge flow.

Existing OI research has established various factors that influence idea creation. Salter et al., (2015) established the optimum number of external knowledge sources to facilitate individuals' ideation, while Dahlander et al., (2016) suggest that individuals that build relationships with external actors are more likely to access new ideas. We contribute to this research stream by revealing that the OI process embeds a knowledge creation process that may lead to new ideas in support of firm innovations. This knowledge creation process can result in new technical knowledge by triggering behaviour modifications that impact the course or direction of OI process, or new market-related knowledge that can trigger the realization of new opportunities. Moreover, Hunter et al. (2012) suggest that individuals' creative behaviour is positively influenced by connecting to remote networks. Our research demonstrates that the OI process can provide individuals access to extended knowledge networks that contribute to product innovations via a knowledge creation process. Consequently, we argue that appropriation contributes to a firm's DC by enhancing the firm's sensing and seizing abilities through this knowledge creation process.

Implications for OI Microfoundations Research

Our initial contribution to microfoundations research relates to our empirical elucidation of the dynamic process by which OI leads to new resource and capability creation and we establish three mechanisms - realization, engagement, appropriation, that contribute to a firm's sensing and seizing abilities. In doing so, we extend the general understanding of the microfoundations of organisational capabilities (Felin et al., 2015) and OI (Bogers et al., 2017). Research in this domain has identified separately project-level factors (Salge et al., 2013; Du et al., 2014; Lopez-Vega et al., 2016) and individual-level factors (e.g., Salter et al., 2015; Dahlander et al., 2016; Rangus and Černe 2019, Bogers et al., 2018b) that may affect

firm-level innovations, and studies have recognized the need to better understand the multi-level nature of OI (Bogers et al., 2017). We complement this stream by empirically establishing process-level mechanisms of OI that contribute to a firms' DC. By offering a process-level perspective on OI microfoundations, this opens new avenues for research such as exploring how project-level factors, such as the management approach to OI projects (Du et al., 2014), or individual-level factors, such as relationships with external actors (Dahlander et al., 2016), may or may not affect process-level mechanisms. Interesting questions remain concerning how a formal or informal management approach might impact the innovation process that occurs during appropriation and how this impacts realization. Moreover, while not central to our study, our findings have prompted us to consider how relationship building could affect the speed at which external actors can understand requirements. This might provide firms with indications about how to accelerate engagement and appropriation and contribute to quicker resource and capability renewal. Hence, an interesting avenue for further research is to explore the microfoundational mechanisms that set the right pace in OI collaborations in pursuit of capability renewal.

Implications for OI and DC Research

Our research also has implications for both OI and DC research. Prior research has suggested that DC are vital to firms in markets with high rates of technological change (Teece, 2007). In these contexts, firms with DC identify new technological opportunities through the development of scanning and monitoring competencies that manifest as sensing abilities (Teece, 2014). However, our study reveals that it may also be beneficial to view DC as a strategy for firms to cope with incremental change. From this perspective, OI becomes a bundle of mechanisms that enable the firm to renew their existing capabilities by leveraging external knowledge resources. These mechanisms and their interactions represent inter-firm heterogeneity in their ability to operationalise sensing and seizing abilities that lead to DC.

As such, a firm should strive to develop OI capabilities that contribute to firm-level sensing and seizing abilities and therefore, the firm's DC.

We extend earlier research on the relationship between OI and DC (Ahn et al., 2018) by offering a more fundamental perspective through the microfoundations lens when compared those studies that examine the relationship between these concepts at the firm-level. As such, our study captures the relationship between mechanisms previously examined at the firm-level (e.g., inbound/outbound knowledge flows) by shifting the perspective to consider how these mechanisms interact from within the OI process at the micro-level, giving rise to firm-level abilities. Consequently, our research shifts the emphasis away from examining such mechanisms in isolation to a dynamic process whereby multiple micro-level mechanisms interact over time.

Implications for Absorptive Capacity Research

Finally, although not central to our study, our findings provide insight into several process-level mechanisms that facilitate the integration of knowledge resources during OI. Existing research has established mechanisms linking OI to a firm's absorptive capacity (Zobel, 2017). Our study empirically demonstrates that OI is an important vehicle for mobilizing knowledge across firm boundaries and, therefore, plays a role in altering the absorptive capacity of firms (Cohen and Levinthal, 1990). Indeed, our findings reveal that realization, engagement and appropriation are critical micro-level mechanisms that trigger the firm's absorptive capacity through an intricate process and enable it to learn and bring new knowledge from external sources into the organisation. In this respect, our empirical study has brought some important micro-foundational elements to the conceptual understanding of how firm level capabilities develop from microfoundations (Lewin et al. 2011).

Moreover, prior studies of absorptive capacity have highlighted the role of individuals' perspectives adopted in contributing to the creation of new and innovative ideas prior to innovation activities (Distel, 2019). We extend this understanding by establishing a knowledge creation process that underlies new idea creation *during* NPD. This process is guided by changes to an individual's thought processes that manifest as behaviour modifications that influence the way that individuals choose to approach part of a NPD.

Limitations and Future Research

Although we made every effort to conduct a rigorous study, our paper is not without limitations. The data from this study were obtained from a single manufacturing organisation operating within a specific industry sector. Therefore, it is entirely possible that the firm has some unique characteristics. Future studies could elaborate on the relationships between the mechanisms we identified, or groups of elements of our model in other settings. For example, these could include: non-SMEs; non-manufacturing firms; firms that operate in different industry sectors; and firms that have other governance and ownership structures. We identified several relationships, such as the relationship between inbound knowledge flows, new idea creation, behaviour modifications and outbound knowledge flows. These appear to operate in sequential or reciprocal relationships. Examining these relationships further will help to shed light on those behaviours that are likely to lead to a more favourable outcome and those that may lead to failure.

Our research has focused on an essential organisational process, namely that of NPD. However, other distinct mechanisms of inbound, outbound and coupled OI exist and all of these can potentially contribute to the firm's DC in diverse ways. As such, future research could explore the relationships between these different OI mechanisms to investigate further microfoundations that link OI to the firm's DC.

2.7 Conclusion

The aim of our study was to answer the question of how OI can contribute to a firm's DC. By adopting a microfoundations perspective and examining the process of NPD in a rich research setting, we were able to identify three underlying mechanisms of OI —realization, engagement, appropriation—that contribute to the creation of firm resources and the firm's DC. To our knowledge, this is the first attempt to uncover microfoundations underlying the renewal of firm resources through OI activities. Our study reveals that each mechanism links the process of OI to a firm's DC by sequentially and reciprocally altering the firm's abilities for sensing and seizing opportunities. Sensing and seizing abilities can help address previously ignored market domains that were not accounted for in a firm's current strategy. Thus, supporting incremental capability and resource creation through fundamental activities that underpin the DC framework. The implication of using OI activities during the NPD process was a reorientation of the liability of ownership and control of resources, to one of inclusion and participation (Hautz et al., 2017). Under these circumstances, OI shifts the focus of the DC framework from the internal perspective of applying resources that firms own, to relational resources that the firm can exploit. Consequently, OI enriches firm capability development with external knowledge resources, contributing to a firm's DC.

Chapter 3: A Microfoundational View of Resource and Capability Creation through Open Innovation

3.1 Abstract

Firms that have developed dynamic capabilities are better positioned to respond to exogenous changes and threats to their environment through the creation, extension and modification of firm resources. Earlier studies have suggested firms can leverage open innovation in support of their dynamic capabilities by developing firm resources. However, open innovation is a practice rooted in complex social relationships, which makes adopting open innovation in pursuit of dynamic capabilities a daunting task in this context. These difficulties are compounded when consideration is given to the complexities associated with combining external resources with internal resources to generate new resources and capabilities. Consequently, the mechanisms within a firm that link dynamic capabilities development with the adoption of open innovation remain unclear. Our study attempts to shed light on this issue through a case study that closely examines five open innovation projects within a SME UK manufacturer. Our findings revealed seven microfoundations that underpin the relationship between the open innovation process and the firm's dynamic capabilities: environmental alertness, exposure to knowledge variety, outwards projection, cultivating relationships, resource accumulation, knowledge fluidity and resource bundling. Furthermore, our study suggests that these microfoundations can also influence the speed at which firms can accumulate new resources and capabilities, which is an often overlooked factor in earlier open innovation and dynamic capabilities studies.

3.2 Introduction

The open innovation (OI) literature places an emphasis on the use of external knowledge resources to supplement a firm's product innovation process (Chesbrough, 2003). Throughout

OI processes, firms engage in search activities to acquire new knowledge resources (West and Bogers, 2014) that are subsequently bundled with variably familiar resources to address new opportunities. As such, product innovations are considered non-routine activities that consume firm resources without guaranteed outcomes. While the OI literature focuses on the use of external knowledge resources in pursuit of new product innovations, the dynamic capabilities (DC) literature places an emphasis on addressing new opportunities through sensing, seizing and reconfiguration abilities (Teece, 2007). Research has suggested these abilities may be impacted by managerial actions (Helfat and Martin, 2015) that encompass the creation, modification, and extension of firm resources to give rise to new resources and capabilities (Helfat et al., 2007). In common with the OI literature, the DC literature places an emphasis on non-routine activities that lead to new products and process innovations (Teece, 2014). Indeed, earlier studies have suggested links between a firm's OI processes and its DC (Teece, 2016; Hutton et al., 2021).

The development of DC builds upon the resource-based view of the firm, which places an emphasis on developing difficult-to-imitate resources in pursuit of competitive advantage (Barney, 1991). This presents a challenge for researchers when firms attempt to leverage OI in pursuit of DC, as the process by which firms develop difficult-to-imitate resources is unclear owing to their causal ambiguity. Some attempts have been made to resolve this quandary by associating organisational behaviours and practices that embed sensing and seizing mechanisms with firms that exhibit DC (Teece, 2007; Teece, 2014). However, the conditions and process of bundling existing resources with novel resources present particularly complex and unresolved challenges. When firms engage in innovation activities, they face multiple challenges based on the modularity, decomposability and specificity of the knowledge components to be recombined to generate novelty and usefulness (Xiao et al., 2021). This process is exacerbated when firms engage in OI, as

resources rooted in different social settings, historical contingencies, and causal ambiguities present firms with multiplied challenges adding to the existing complexity of resource bundling. Further, how such knowledge resources and capabilities emerge throughout non-routine processes associated with OI seems like a daunting task for managers attempting to recombine resources in pursuit of renewing the resource base of the firm. Yet, little consideration has been given to the conditions and complexities of resource recombination during OI.

The purpose of this study is therefore, to build on the OI and DC literature by shedding light on how, during OI processes, individuals bundle existing resources with new to the firm resources, and how such resource bundling activities contribute to the firm's DC. To achieve our aims, we answer the following research question: *"How, during open innovation processes, do individuals bundle resources to give rise to new resources and capabilities?".* In answering this question, we establish the mechanisms by which OI can contribute to a firm's DC through the development of new resources and capabilities. Consistent with the DC perspective, we consider managerial actions to impact the creation, modification and extension of resources and capabilities (Helfat and Martin, 2015). However, we also consider the actions taken by individuals in non-managerial positions, as non-managerial actions impact decisions made before and during OI processes as well as the subsequent decisions to leverage new resources and capabilities emerging from OI. To achieve our ends, we turn our attention towards inbound knowledge flows (Dahlander and Gann, 2010), whereby individuals draw on social relationships and experience to enhance OI performance (Bogers et al., 2018b). We adopt the dynamic managerial capabilities (DMC) perspective (Helfat and Martin, 2015) to understand how, during OI processes, individuals bundle resources and how these resource bundling activities contribute to sensing, seizing and reconfiguration abilities of the DC framework (Teece, 2007). To establish the underlying

factors and conditions by which resource bundling activities give rise to new resources and capabilities, we combine a microfoundations lens (Felin et al., 2015) with an activity-level perspective. In alignment with Felin et al., (2015: p586), we consider microfoundations as 'levels', which refers to "locating the proximate causes of a phenomenon at a level of analysis lower than that of the phenomenon itself". Adopting this perspective offers a powerful approach to establishing the underlying factors and conditions that give rise new resources and capabilities.

By examining the actions of individuals that constitute resource bundling activities through a case study, our research establishes more clearly the relationship between OI and DC by revealing seven microfoundations that underpin the relationship: environmental alertness, exposure to knowledge variety, outwards projection, cultivating relationships, resource accumulation, knowledge fluidity and resource bundling. In doing so, we provide some needed insight into how OI can contribute to a firm's sensing, seizing and reconfiguration abilities and the speed at which firm resources and capabilities are accumulated.

3.3 Theoretical Background

3.3.1 Open Innovation

Open innovation is an organisational practise that emerged from observations of a change of approach towards innovation by firms from closed (in-house) to more open (Chesbrough, 2003; Chesbrough, 2006). OI is therefore considered "a distributed innovation process based on purposively managed knowledge flows across organisational boundaries" (Chesbrough and Bogers, 2014: p17). Drawing on knowledge resources situated outside a firm's boundaries (Dahlander and Gann, 2010), OI can enrich a firm's innovation activities enabling

firms to act on new opportunities. Firms that turn to OI often draw on inbound, outbound, and coupled modes of operation. Inbound modes are focused on the use of knowledge resources situated outside the firm boundary (Dahlander and Gann, 2010). In contrast, outbound modes are concerned with the transfer of internal knowledge and resources outside the firm boundary. Existing OI research has been conducted at firm-level and network-level of analysis (Chesbrough and Bogers, 2014). However, recently, OI literature has started to identify microfoundations (Du et al., 2014; Salter et al., 2015; Ahn et al., 2017; Bogers et al., 2018b; Rangus and Černe 2019) and how these may lead to the development of firm-level capabilities (Hutton et al., 2021).

3.3.2 Dynamic Capabilities

An alternative stream of research emerged from the resource-based view of the firm (Barney, 1991) to explain how firms can create a competitive advantage through the development of difficult to imitate resources. In pursuit of competitive advantage, a firm that has developed DC has the capacity to "purposefully create, modify or extend its resource base" (Helfat et al., 2007: p1) enabling them to take advantage of new opportunities. Such capabilities are enacted by firms to "deploy *Resources*, usually in combination, using organizational processes, to effect a desired end" (Amit & Shoemaker, 1993: p35, original emphasis). Firms may leverage resources that are tangible or intangible in nature (Helfat et al., 2007) and accumulated within the firm or acquired from outside the firm. In such contexts, these resources are subsequently bundled in a process that results in alterations to existing capabilities or the creation of new ones (Sirmon et al., 2007). These new capabilities are leveraged to take advantages of environmental opportunities in pursuit of competitive advantage.

While DC is considered a firm-level concept, Teece (2007) proposed and classified microfoundations of DC as sensing, seizing and reconfiguration abilities. These abilities

broadly encompass the structuring, bundling, and leveraging of resources (Sirmon et al., 2007). In understanding how firms develop DC, existing research has suggested DC are embedded in OI processes (Teece, 2012) and signature processes that emerge through historical experiences (Teece, 2014). However, only recently, in trying to understand how firms can develop DC, research has empirically established a relationship between a firm's DC and its OI process (Hutton et al., 2021). Managerial actions taken during non-routine activities such as those taken in formulating a response an opportunity also contribute to DC (Teece 2014: p338). Indeed, the ability of managers to effectively bundle resources determines the level of value created from such activities (Holcomb et al., 2009). In the context of DC, resource bundling activities require a collective of individuals' actions that result in unique combinations and configurations of resources to take advantage of such opportunities. Consequently, the knowledge, skill and experience of individuals situated within a specific context or environment underpin resource bundling activities. Indeed, managerial ability has been found to impact performance outcomes both positively and negatively through the bundling and deployment of resources (Holcomb et al., 2009). Despite this, it remains unclear from earlier studies how individuals' actions that occur during OI processes lead to the development of new resources and capabilities.

3.3.3 Dynamic Managerial Capabilities

To better understand how individuals' actions impact the development of new resources and capabilities, we turn our attention to Dynamic Managerial Capabilities (Helfat and Martin, 2015). DMC is a framework developed to understand the relationships between managerial actions and sensing, seizing and reconfiguration abilities that underpin DC. Managerial actions correspond with the search, selection and deployment of resources and capabilities and the structuring and bundling of resources (Sirmon et al., 2007). In the context of OI processes, individuals' actions have been found to affect outcomes positively and negatively

(Bogers et al., 2018b). Therefore, it is important to also consider individual-level non-managerial actions that can impact the search, selection and deployment of resources and capabilities (Helfat and Martin, 2015). Consistent with resource-based view of the firm (Barney, 1991) and how individuals' actions lead to resource and capability creation, we focus on inbound modes of OI that are frequently leveraged by individuals in pursuit of external knowledge resources (Chesbrough and Bogers, 2014). Moreover, we consider knowledge a key resource by which firm's drive innovations (Grant, 1996).

Conceptual research suggests DMC are characterised three microfoundations: human capital (HC), social capital (SC) and cognition (Adner and Helfat, 2003; Helfat and Martin, 2015). Considering these microfoundations in isolation, HC refers to the knowledge and expertise held by individuals, which are developed in a cumulative process by taking part in training and experiences. While some knowledge and expertise are firm and industry specific, others are generalisable and transferable to other settings (Adner and Helfat, 2003). During the process of sensing opportunities and threats to a firm, individuals leverage knowledge and experience to formulate the appropriate steps in response to these challenges (Teece, 2007; Di Stefano et al., 2014; Helfat and Martin, 2015). We suggest that by participating in OI processes, individuals develop knowledge and expertise, that contributes to the accumulation of HC in support of future DMC and OI processes.

Social capital refers to the relationships that individuals build with actors situated within and outside the firm, through which, knowledge resources are exchanged (Helfat and Martin, 2015). Within the firm, both formal and informal working relationships serve as information networks that convey knowledge resources (Adner and Helfat, 2003). Such resources may aid an individual's understanding of new opportunities and provide knowledge resources during non-routine resource bundling processes. Outside the firm, during OI processes, individuals develop social relationships with external actors (Chesbrough and

Bogers, 2014), that may hold generalisable or industry specific knowledge resources. Consequently, individuals may choose to bundle newly sourced knowledge resources to support innovation activities and contribute to the seizing of new opportunities.

Cognition refers to the knowledge structures that give rise to an individual's mental models, beliefs, values and emotions (Helfat and Martin, 2015). These factors form the frames of reference that underpin individuals' actions during non-routine resource bundling activities. Research has highlighted that individuals' actions are underpinned by controlled and automatic mental processes (Helfat and Peteraf, 2015). These processes correspond with deliberate actions encompassing the sensing, seizing and reconfiguration abilities (Teece, 2007) and adaptive processes emerging from an individual's non-cognitive substrate (Nayak et al., 2020). Drawing from the non-cognitive substrate, individuals may leverage past experiences to guide present actions and facilitate adaptation to environmental changes (Nayak et al., 2020). Hence, an individual's non-cognitive substrate may contribute to a response to exogenous changes, thereby contributing to the individual's sensing and seizing abilities. Both deliberate and adaptive actions taken by individuals will undoubtably have roots in historical, social, and internalised practices, all of which may be impacted by OI processes. In summary, cognition impacts sensing through perception and attention, seizing through reasoning and problem solving and reconfiguration through language, communication, and social skills (Helfat and Peteraf, 2015).

Each microfoundation of DMC are developed and influenced through prior experience (Helfat and Martin, 2015) and path dependent in nature (Helfat and Peteraf, 2015). However, the conditions and process by which these individual-level resources interact to give rise to new resources and capabilities remains to be seen (Helfat and Peteraf, 2015). This presents a challenge to firms looking to adopt OI practices in pursuit of DC, as our understanding of how OI influences the DMC microfoundations remains limited. This is

significant, as individuals' decisions taken both prior to and during OI projects result in resource bundling activities that may or may not give rise to the development of new resources and capabilities. This challenge is further exacerbated when consideration is given to the combination of internal and external knowledge resources embedded within OI processes. To shed light on this blind-spot, we introduce the OI microfoundations literature to establish links between OI processes and the DMC microfoundations.

3.3.4 Open Innovation Microfoundations

Existing OI research has considered HC from the perspective of project performance, while less consideration has been given to the antithesis, which considers how OI contributes to HC. For example, in their study of OI projects, Du et al., (2014) shed light on the role of HC by investigating how the knowledge and experience of managers impacted OI project performance. They found that when managers adopted a formal approach towards projects involving customers and suppliers, greater performance was experienced. Alternatively, when managers adopted an informal approach towards projects involving universities and knowledge institutes, greater performance was experienced. More recently, Bogers et al., (2018) revealed how an individual's educational diversity provides a greater knowledge foundation that positively impacts a firm's capability to use external knowledge resources. Moreover, an individuals' educational and work diversity across different industries enhances a firm's ability to leverage and integrate external knowledge.

Other research by Ahn et al., (2017) considered the role of cognition and HC on OI processes. Adopting a leadership perspective, they found that education helped individuals identify new technologies and opportunities. Moreover, positive reinforcements towards OI positively impacted OI adoption, while being patient with external partners positively impacted the OI process. Later research by Rangus and Cerne (2019) found that leadership was influential in building and assembling OI teams and facilitating openness, which

enhanced both creativity and ideation. Thus, having implications for the impact of OI processes on cognition and HC. Moreover, when individuals' social interactions exhibited help and consideration for others, it allowed them to build trust and further enhance their OI creativity and performance.

Although OI processes draw on external knowledge, the link between OI and social capital and the role of individuals and knowledge networks is underdeveloped (West et al., 2014). However, Salter et al. (2015) found that exposing individuals to a variety of different knowledge sources enhances the creativity and alertness of individuals in R&D settings (up to a certain level) during OI processes. Thus, having implications for the recognition of new opportunities and the creation of new ideas. Moreover, Dahlander et al., (2016) add to this by suggesting the accumulation of individual-level search leads to the discovery of new and innovative ideas. This research also reveals the relationship between an individuals' attention to internal and external knowledge sources contributes to project performance. Finally, research by Distel, (2019) established a link between cognition and OI performance by revealing an individual's ability to understand different viewpoints and perspectives enhanced their capability to identify and process internal and external knowledge. By enhancing individuals' creative behaviour when they acquire new knowledge, firms are better equipped to create value through innovation activities.

To conclude, the OI microfoundations literature has some overlap between the underlying abilities of DMC and OI performance, while less consideration has been given to the opposing role, that is how, during OI processes, individuals' actions contribute to a firm's DC. This paucity is further exacerbated by the lack of understanding of how the aggregation of individual's actions results in the development of new resources and capabilities during non-routine OI processes. This is a significant limitation in the existing literature as the future

success of the firm is determined by its ability to sense, seize, and reconfigure resources and capabilities to adapt to exogenous changes.

3.4 Research Design and Methodology

Our research question required a close examination of OI processes in a real-world setting over a period in conjunction with a deep analysis of data. As such, we adopted a case study approach that facilitated an up-close and in-depth investigation of a complex social phenomenon (Yin, 2014). Thus, enabling our study to elaborate on existing theory and generate new theoretical insights. We purposefully selected our case to facilitate deeper understanding of the relationships between OI processes and the underlying abilities of DC (Eisenhardt and Graebner, 2007). This also enabled us to track the activities through OI projects that had resulted in the development of new resources and capabilities. Our case, Alpha, is a SME UK manufacturer operating in the chemical industry. Alpha have been established for over 90 years and pride themselves on developing tailored products by working alongside customers. Over the last two decades, OI has become deeply embedded within Alpha's innovation strategy. Moreover, firms within the chemical industry are increasingly subjected to regulatory pressures associated with a reliance on feedstocks derived from coal and oil resulting in a tendency to source more sustainable products. As such, Alpha must continually keep abreast of environmental changes. The lead author was in the role of researcher-practitioner and had been employed by the organisation for over 20 years, as well as being involved in a variety of NPD activities. This enabled access to an array of data across different levels of analysis which is rare in research focusing on microfoundations. Alpha, therefore, offered an ideal setting for investigating the relationships between OI and the underlying abilities of DC.

3.4.1 Data Collection

Our approach to data collection was iterative following a cycle of data gathering then analysis to provide both depth and variation (Corbin and Strauss, 2015). In tracking NPD projects, Alpha had recently migrated from a manual project logging system to an integrated NPD management platform. Initially, we collected data from the integrated NPD platform that consisted of the project name, project type, project reference and status of 271 projects. Next, we theoretically sampled (Eisenhardt and Graebner, 2007) 12 NPD projects to ensure the projects were relevant to our research question. We sampled projects that were recent, grounded in OI processes, knowledge resources had been obtained and the project had resulted in the development of new resources and capabilities. The preliminary data on each project consisted of a selection of requirements and project information including technological objectives, baseline technologies, technological advancements required, technological uncertainties, qualifying activities and finally, the project manager. We complemented this preliminary data by collecting corresponding project emails, project reports, pictures, technical bulletins that had been logged on the NPD project system. This enabled us to gain a comprehensive overview of the types of projects as well as adding depth to each project.

Subsequent to this and in order to further enhance the depth and richness of our research question, we refined our understanding of 5 NPD projects through further data collection. Each of the 5 projects had comprehensively documented activities including corresponding emails, documented meeting minutes as well as good access to the project manager, thus, enabling us to rigorously track all the underlying activities that occurred throughout the OI process. Where possible, we sought convergence amongst multiple sources of evidence by performing semi-structured interviews with the lead developer of each project (Gioia, et al., 2013). Thus, allowing us to establish the activities by which knowledge

resources were sought and bundled with existing knowledge using both retrospective and real-time accounts. Our interview strategy was to perform a consistent line of inquiry by referring to a set of questions, while facilitating fluidity by allowing interview participants to elaborate and expand on any responses (Ruben and Ruben, 2011).

Our data collection and analysis were performed in tandem. As themes began to emerge, data was continually sought from "knowledgeable informants" (Eisenhardt and Graebner, 2007, p28) in the form of telephone calls, emails, and informal meetings to further enrich and expand on emergent themes. This data was integrated with existing data where clarification of understanding was sought or recorded as memos and notes alongside data where queries emerged. Moreover, as new concepts emerged, we added depth to our data by collecting company documents in the form of meeting minutes, marketing reports, sales reports, R&D reports, and documented literature such as archived industry specific reports. As our understanding of the relationship between the OI process and the emergence of new resources and capabilities developed, the board were seen to be highly influential in the emergence of new resources and capabilities. As such, we sought further understanding of our emergent themes and concepts by constructing and distributing a questionnaire to these "knowledgeable informants" (Eisenhardt and Graebner, 2007, p28). The questionnaires enabled us to add diverse perspectives from multiple levels of the organisation, while ensuring each recipient had input or involvement in the direction of and/or the knowledge used throughout the NPD projects. Our informants included the Sales Director, Marketing Manager, R&D Manager, and the Chief Operations Officer (COO). Following is an overview of the data sources and types obtained throughout our study.

Table 10: Overview of Data Sources and Types Sought

Data Source	***Type***	***Items***	***Pages (Hours)***

NPD Project Log.	Text, list	271	N/A
Project Emails	Text, emails	61	94
Project Reports	Text, report, images	4	25
Technical Bulletins	Text	5	12
R&D Reports	Text, report, presentation	6, 1	17, 72
Semi-Structured Interviews	Transcript	4	(8)
Telephone Calls	Text, record	10	(1)
Company emails	Text, emails	10	37
Informal Meetings	Text, record	6	2
Documented Literature	Text, reports, presentations	44, 2	234, 94
Meeting Reports	Text, reports, presentations	2, 2	15/90
Marketing Reports	Text, reports	8	96
Sales Reports	Text, reports	8	17
Questionnaire	Text, responses	5	17

3.4.2 Data Analysis

Our unit of analysis was open innovation practices with particular focus on resource bundling activities in the context of NPD. We began our analysis by reading project names, types, and references of all projects to gain an overview of project type and outcome. Subsequent to this, we read through the preliminary data from each of the 12 NPD projects, including goals, notes, customer visits, feedback, emails, pictures, requirements gathering, specifications, prioritisation and costings. This enabled us to establish the extent of knowledge inflows from external actors, including customer and suppliers that had resulted in the development of new resources and capabilities through OI processes.

As we refined our project analysis by focusing on projects that engaged OI and had comprehensively documented activities, we constructed a timeline of activities for the 5 projects to identify the activities that had occurred and the points at which knowledge flows had been leveraged. These timelines were assembled by extracting the recorded project data and associating with a time and date stamp—an initial temporal bracketing (Langley, 1999) of resource bundling activities. Once each NPD timeline had been constructed, we performed an in-depth analysis of all NPD emails, project comments, reports, and the interview transcripts, by manually coding each document using in-vivo "informant-centric" codes (Gioia, 2013, p18). At this stage, we inserted in-vivo summaries of each activity into the NPD timelines which corresponded with the timing of the email, project comment or report, briefly describing the activity that was taking place. We denoted the knowledge domains between which each knowledge flow had occurred and inserted the internal and external actors that had engaged in the knowledge exchange. Next, we derived first order concepts by clustering similar codes, removing redundant codes and adopting "researcher-centric" phrases (Gioia, 2013, p18), then performed analytic coding (Saldana, 2021) to identify adaptive actions, interactions, and outcomes (see Figure 4). Finally, we aggregated codes and concepts by and where relevant, identifying links with literature concepts such as managerial actions, knowledge flows, and resource bundling.

At this stage, we analysed the remainder of our data using the same process of in-vivo coding, clustering, removing, and aggregating. This consisted of data obtained from company reports including sales, marketing, meetings and documented literature, data on company emails, memos, and the questionnaire response data. Thus, allowing comparisons between NPD project concepts and themes and the concepts and themes from supporting data.

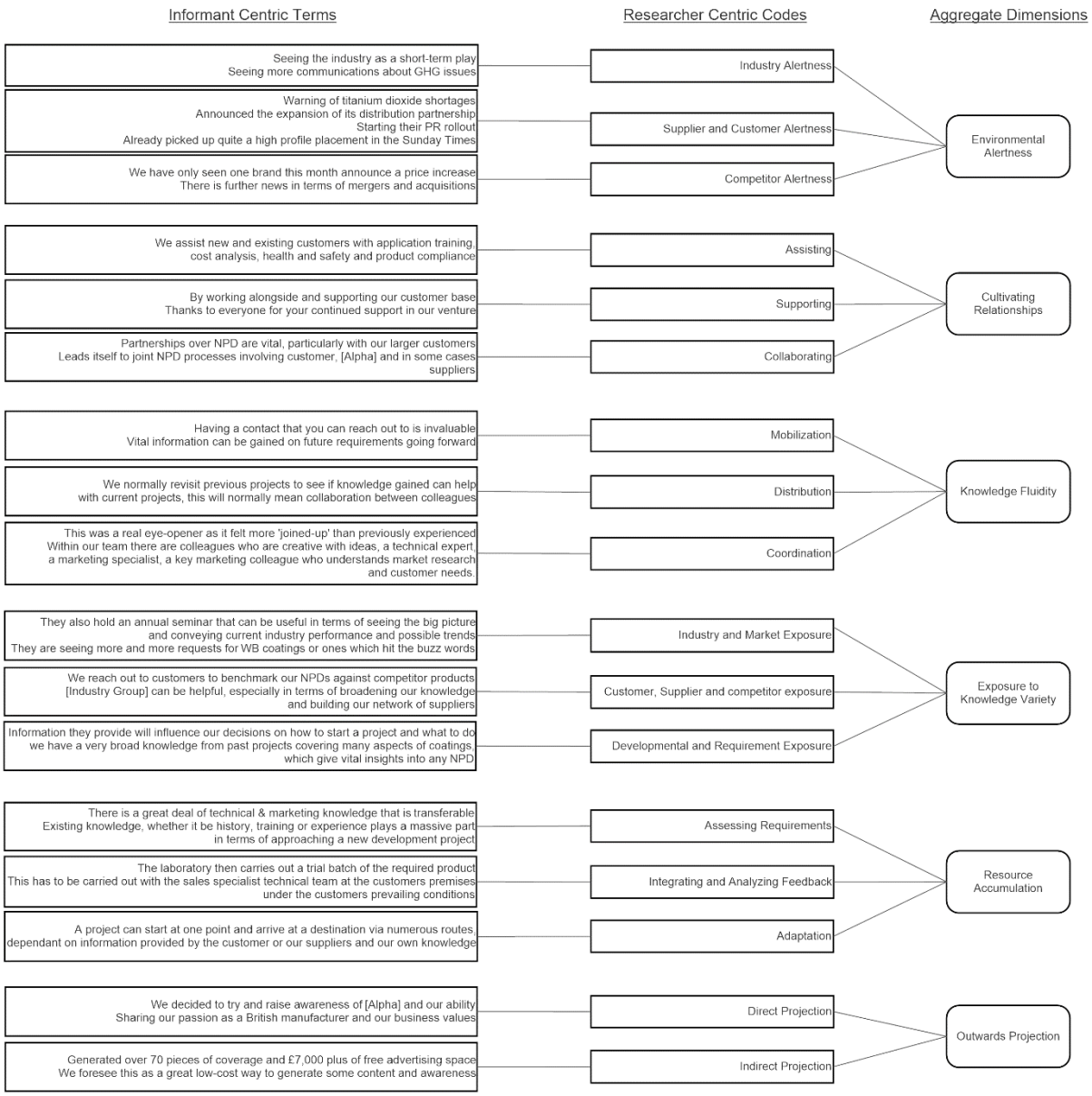

Figure 4: Informant Centric Terms, Researcher Centric Codes and Aggregate Dimensions

The final stage of our analysis consisted of explanation building by combining data of the NPD timelines with themes and concepts derived from company data, while associating relationships, triggers, and actions to construct a model representing the resource bundling process and supporting processes. In the subsequent section, we consider our models in conjunction with our themes and concepts to explain the background processes and resource bundling processes that occur.

3.5 Findings

Our data revealed resource bundling activities by which new resources and capabilities emerge and two innovation fields that were leveraged by Alpha during such activities: an internal innovation field and an external innovation field. The internal innovation field consisted of Alpha's management board, sales, marketing and R&D and is where OI NPD projects emerged. Alternatively, the external innovation field consisted of customers and suppliers directly involved in OI processes, competitors that serve as indirect knowledge resources, and organisations and industry groups situated in the broader business environment. We present our resource bundling model (Figure 5) that spans these innovation fields and the actors and microfoundations operating within the fields. Following, we present each microfoundation alongside our findings while later discussing how the microfoundations interact during resource bundling activities by which capability development unfolds.

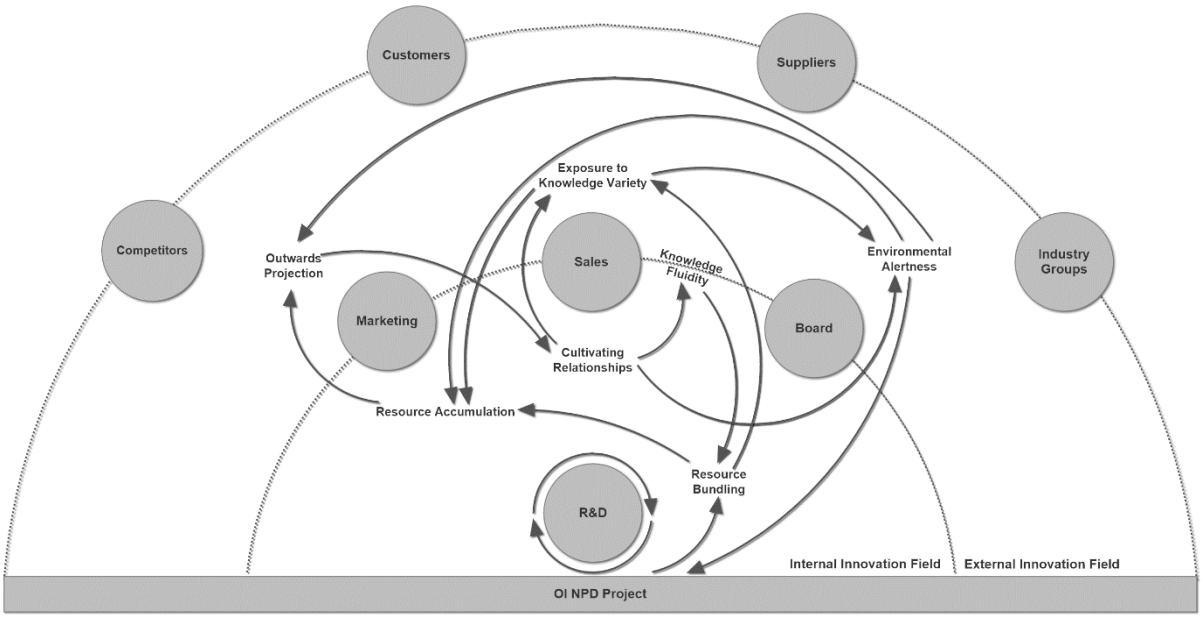

Figure 5: Resource Bundling Model

3.5.1 Environmental Alertness

Environmental alertness refers to the capability to be vigilant to act promptly on opportunities for renewal of knowledge about changes to the firm's business environment, resulting in alertness to environmental affordances (Nayak et al., 2020). By affordances we mean the multiple possibilities or opportunities offered by the environment to those capable of acting upon them (Gibson, 1977). A capability exhibits multiple shapes and forms of sensitivity to act upon information (Nayak et al., 2020), which we conceive as "messages, signs, and signals" (Gibson, 1977; Gibson, 2015: p56). Environmental alertness enabled Alpha to accurately direct R&D resources to respond to new opportunities through OI. Our data revealed environmental alertness occurs within different functions and levels of the organisation and can be disaggregated into five sub-types of alertness:

Individuals within the executive board exhibited *industry alertness* (1) facilitated by exposure to knowledge variety. Board members leveraged industry alertness to gain insight into products and raw materials such as price and supply, as well as regulatory and legislative changes that were likely to affect the industry, *"we have seen a considerable increase in tin pricing which will have an impact on us and also some potential White Label projects down the line"* (Marketing Manager, report). This knowledge and insight enabled board members to anticipate the impact of upcoming events and anticipate new product requirements.

Individuals within the board and R&D functions exhibited *supplier alertness* (2). Board members had insight into the supply network, as well as significant supplier activities including business expansion and mergers and acquisitions and new product innovations. R&D members shared an awareness of the supply network but had a greater insight into supplier product ranges and innovations, *"[supplier] have launched two new bio-renewable defoamers – [products] developed for printing inks and varnishes. [supplier] have also launched three new matting agents to its [product] range developed to offer deep-matting*

properties without sacrificing transparency" (Compliance Manager, report). Board members leveraged supplier alertness to anticipate new product requirements and potential supply issues. Alternatively, R&D members leveraged supply alertness to guide the selection of component technologies and knowledge flows before and during OI.

Individuals within the sales and marketing teams exhibited *customer alertness* (3). Customer alertness was used to gauge customer perceptions, preferences, product uses and requirements and future product plans, *"[customer] are introducing a new product named 'Chalk Based Furniture Paint' which is exactly the same product as their Chalk Paint but the wording works for certain markets they are entering in to. Their 2022 plans are to launch the new 250ml size, introduce more paint products as well as launch a paint brush range"* (Marketing Manager, report). Through customer alertness, individuals in sales and marketing were able to predict the needs and requirements of customers. This resulted in regular communication with the board and r&d, highlighting new opportunities and contributing to more efficient OI processes by increasing the accuracy of understanding customer requirements.

Board members also demonstrated *competitor alertness* (4). Competitor alertness consisted of knowledge of the firm's business environment, including competitors' mergers and acquisitions and business expansion, enabling the board to divert resources to any salient threats posed by competitors. Individuals within sales, marketing and R&D experienced competitor alertness associated with product developments, product combinations, features and capabilities and component technologies, *"[competitor] have launched its [new product range], specifically targeting the ACE market. The new technology apparently improves spraying efficiency and offers superior corrosion protection to various substrates. The product also claims wet on wet capabilities with no sacrifice of topcoat gloss"* (Compliance

Manager, report). This supported the product development process through benchmarking and product comparisons by understanding competitor offerings.

Taken collectively, Alpha leveraged environmental alertness to anticipate current and future product requirements, *"The new flavour of the month is ceiling paint in the professional painting and decorating world. With this in mind, we have had samples of some of the leading ceiling paints in for benchmarking in the lab against our current [product] and whether it needs slightly tweaking to be branded a ceiling paint."* (Marketing Manager, report). Our data revealed Alpha subsequently leveraged OI NPD projects to act on these newly identified opportunities.

3.5.2 Exposure to Knowledge Variety

Environmental Alertness was developed by individuals' *exposure to knowledge variety*, which concerns the frequency of interactions that encompassed purposeful knowledge exchanges between internal actors and external knowledge sources. Exposure to knowledge variety helped support OI processes: *"Many of my NPD's were able to be quickly turned around due to experience. This is a tacit knowledge of existing product portfolios but also exposure to suppliers, raw materials, application, testing, customers, and industry knowledge"* (COO). A variety of individuals throughout the organisation were exposed to knowledge variety that we discuss in the following sections.

Board members were purposefully exposed to a variety of knowledge about the business environment which enhanced industry alertness. Board members including the R&D Manager, Compliance Manager and COO participated in industry specific groups and journals and monitored publications and bulletins from feedstock suppliers. Moreover, conferences were attended yearly, while publications and bulletins were monitored on a weekly basis. By monitoring these knowledge sources, board members enhanced industry

alertness through knowledge about new suppliers, legislative changes, trends, and requirements as well as early warnings about supply related issues. *"I was proud to preside over a highly successful [industry exhibition] on the 7th and 8th of June, several laboratory team members and [board] members attended the exhibition and seminar sessions… I have had two supplier meetings and I have several face-to-face meetings lined up for July following meetings at [industry exhibition]"* (Compliance Manager).

Exposure to knowledge variety also enhanced board members competitor alertness. Through the same knowledge sources, board members gained information about competitors' mergers and acquisitions, production expansion, and new product launches. Board members shared knowledge with other board members and functions of the business on a weekly basis through reports, emails and face to face discussions allowing such knowledge to be leveraged prior to and during OI processes. This supported OI processes by providing individuals in sales, marketing and R&D with industry knowledge and competitor product offerings and packages and to eventually obtain competitor samples for benchmarking and evaluation.

Participating in industry specific groups, monitoring publications and attending exhibitions and trade shows also exposed board members to new and existing suppliers and customers. This enhanced supplier and customer alertness by offering vital sources of technical and market knowledge variety. Such knowledge was further enhanced when developers engaged in OI processes. For example, during OI processes, developers were continually exposed to supplier product knowledge, specialised technical knowledge and knowledge of suppliers. Observations of the NPD projects revealed examples of product developers' exposure to technical knowledge from suppliers *"Darren, please find below the comments from Deborah regarding the flash rusting issues we have been experiencing at [customer, product development] and it seems the [component] that we have may work, but*

the email below mentions keeping pH above 9, so this could be tried too" (Senior Developer, email).

Individuals within sales and marketing were frequently exposed to customer knowledge variety by engaging with customers prior to and during OI processes. Exposure occurred both in-person and remotely, enabling sales and marketing to gain knowledge about product sales, end user behaviours and information about competitors' products and prices *"We gather information from various avenues for example competitors' activities or by listening to application 'needs and wants' from our customer their management and painting teams"* (Sales Representative). Mechanisms in-person included visiting customers, observing behaviours, and obtaining competitor samples while remote mechanisms included monitoring emails, website requests, publications and linkbacks. R&D members were also exposed to a variety of customer related knowledge from engaging in OI processes. This occurred by engaging directly with customers or indirectly through sales representatives. This included knowledge of product requirements, application techniques and usage *"we've spent a lot of time talking to [customer] about how they apply these things, which has helped us to understand their application technique"* (Product Developer, interview). Developers used this knowledge to align product features more accurately with customer requirements.

In summary, Alpha's exposure to knowledge variety spanned internal and external innovation fields and their business environment, helping to increase environmental alertness. Knowledge exposure was enhanced by OI, when product developers directly sought customer, market, and technical knowledge from external actors and indirectly through sales and marketing. This exposed individuals within R&D, sales, and marketing staff to knowledge variety. The ensuing environmental alertness enabled individuals within Alpha's internal innovation field to leverage new knowledge and technologies both before and during OI projects. By combining industry and market knowledge with customer and supplier

knowledge, Alpha were more able to accurately assess environmental affordances, customer requirements and prospective solutions.

3.5.3 Outwards Projection

Our data revealed outwards projection was a technique used by individuals within marketing and sales to enhance value capture and success following OI processes. *Outwards projection* encompasses activities with the goal of increasing external awareness of Alpha and their products. The techniques by which individuals enacted outward projection occurred within the customer domain or remotely. Within *customer domains*, marketing and sales representatives engaged with distributor networks by sharing product promotions, campaigning, and showcasing new products to increase in-branch visibility. *Remotely*, marketing members used techniques such as emailing stakeholders and sharing data including product bulletins and promotional videos with customers *"our [new product range] strategy was rolled out across our distribution network and included seasonal promotions, product spotlight campaigns, sharing social media assets with distributors and product launches… during last year, [new customer] had spotted [Alpha] across social media with many posts and positive hype around [Alpha's new product range]"* (Marketing Manager). Other types of knowledge projected included knowledge about company values and abilities, as well as knowledge about product approvals, specifications, and benefits to increase brand appeal, coverage, and awareness. To ensure the knowledge projected was relevant, marketing members continually renewed and reoptimised the content using environmental alertness.

Our data revealed environmental alertness further supported outwards projection by highlighting the domains in which to project as well as the content to project. For example, in response to a new product launch, individuals in marketing accurately directed activities to increase awareness of new products and their features through developed awareness of customer needs and wants *"we're seeing more coverage and engagement on the [new*

product range] story released in January... Visits to alpha.com website [new product range] pages are 25% up on January and 69% up compared to November" (Marketing Report). Moreover, industry awareness also shaped outwards projections to increase new product sales through consideration of current and future trends. One example following BREXIT, was to project a Made in Britain marketing slogan to increase brand awareness *"certain markets we operate* in *are dominated by MNEs and imported products and being a true UK Manufacturer post-BREXIT is a USP to a lot of our customers"* (Marketing Manager), as post-BREXIT, marketing perceived the industry were receptive to sourcing British made materials.

3.5.4 Cultivating Relationships

Our data revealed board and R&D members cultivated relationships to maintain and enhance the number of external actors that could be leveraged during OI processes. We refer to *cultivating relationships* as building loyalty and trust between individuals within the internal and external innovation fields. The R&D Manager described this succinctly, *"loyalty and trust are very important attributes when it comes to our relationships with suppliers… Alpha are generally loyal to our suppliers as we have built up professional relationships with numerous suppliers spanning over 50 years"*. Members of the board and R&D cultivated relationships with suppliers to facilitate access to knowledge about industry movements and new technologies. Alternatively, individuals within sales and marketing cultivated relationships with customers and distributors. This enhanced access to current and accurate industry, customer and competitor knowledge that was later used during OI projects. Relationships were cultivated by assisting, supporting, collaborating, and formulating joint strategies with customers by helping to build mutual understandings and trust.

By cultivating relationships, individuals within Alpha's internal innovation field were able to reach out to customers and suppliers. This enhanced the speed at which OI projects

could be implemented, by eliminating unproductive courses of action *"by reaching out to customers and suppliers through personal face to face calling, email, appointments, or by telephone during each stage of the development of new products we may avoid pitfalls and further adjust the products to comply with the requirements of the market areas they are being introduced into"* (Sales Representative). Individuals in sales further enhanced relationships with customers through knowledge sharing, joint concept development and engaging in repeated collaborations over time.

Our data also revealed that cultivating relationships facilitated exposure to knowledge variety. By building and maintaining relationships with customers and suppliers, the same individuals were able to repeatedly leverage external knowledge during OI processes, exposing them to further knowledge variety. This repeated exposure to customers and suppliers and continual monitoring of the business environment increased the likelihood of individuals finding and extracting new and useful knowledge from customers and suppliers during OI processes. This process was helped by information sharing, frequent meetings and regular feedback from actors involved in OI processes. By increasing the likelihood of finding and extracting new and useful knowledge from customers and suppliers, this further enhanced the speed at which OI projects were completed and new resources and capabilities were developed.

Finally, our data revealed that cultivating relationships enhanced environmental alertness by facilitating R&D, sales, and board members exposure to knowledge variety. Ultimately, cultivating relationships enhanced the willingness of individuals within the external innovation field to share valuable knowledge and insights into industry and supplier innovations, and knowledge of customers and competitors. Consequently, successful OI product developments were a method used by Alpha to assist Alpha and their customers with value capture by enabling both to act on new opportunities.

3.5.5 Resource Accumulation

Resource accumulation refers to the accumulation of knowledge-based resources (Grant, 1996). Our data revealed that individuals in R&D, sales, and marketing accumulated resources during OI processes. Initially, resource accumulation required a process of assessing requirements to occur that was underpinned by four factors. Firstly, these individuals had a good *understanding* of customer requirements that emerged from an understanding of the customer environment and conditions required to collaborate as well as listening carefully to customer needs and wants. Secondly, individuals had good *experience* which emerged through training, homegrown staff, staff retention and experimentation. This enabled developers, sales staff, and board members to understand customer needs and wants more accurately. Thirdly, understanding and experience enabled individuals to make comparisons by *reassessing* existing technologies and searching for similar products by revisiting past developments. Finally, comparisons were enabled through *recollection* of existing products and technologies and past product developments and processes from Alpha's internal databank.

The process of integration and analysis of feedback consisted of two sub-processes: i) selecting and assembling and ii) evaluating. The *selecting and assembling* process was used by product developers to hypothesise an initial product makeup by carefully determining the components required and how such components fit together in practise *"every project has to have a start point – this could be looking at a similar product or revisiting other development work, or just knowing where to start in terms of raw material selection and how those raw materials will work together in practise"* (Product Developer). Customer knowledge supported the selection and assembly process by eliminating certain components technologies or anticipating potential challenges early in the development process *"during development, customers are useful in terms of eliminating possible chemistries, as we can draw on their*

experience with other products" (Product Developer). Moreover, supplier knowledge supported the selection and assembly process through component and technical knowledge when a developer's knowledge was lacking *"suppliers play a major role in terms of providing knowledge, especially at the start of a project when we have little or no knowledge of a component or requirement, and dependant on our own knowledge, suppliers can also be influential in terms of the direction of a project*" (Product Developer). Subsequent to selection and assembly, developers *evaluated* products by testing samples, performing trials and benchmarking. These activities served as vital feedback loops to confirm success or failure of the selection and assembly process, to result in resource accumulation.

The final process of resource accumulation was *adaptation*, which consisted of optimisation, recognising and adjusting sub-processes. The process of *optimisation* encompassed 'marrying up the variables' to eliminate investigations and certain courses of action and achieve optimum performance. Thus, enabling developers to increase focus and reduce development costs by enhancing the speed of turnaround and eliminating unproductive courses of action "*most development projects are problems, rather than puzzles – there are many solutions (or directions) to solve a problem, but only one solution (or direction) for a puzzle, so a project can start at one point and arrive at a destination via numerous routes, dependant on information provided by the customer or our suppliers and our own knowledge* (R&D Manager). Our data revealed that developers used the process of *recognising* and *adjusting* to identify new ideas and overcome obstacles and problems during OI projects. This facilitated adjustments and ensuing modifications to products or application methods. All developments were seen to have numerous routes and the recognition and adjustment process provided direction and future courses of action.

The processes of resource accumulation occurred alongside exposure to knowledge variety and therefore enhanced environmental alertness. Understanding customer

requirements required R&D, sales, and marketing members to be continually exposed to customer knowledge, enabling them to gather information about needs, preferences, and new opportunities. Similarly, gathering new technical knowledge about supplier technologies and innovations during development exposed individuals to supplier knowledge that could be leveraged during current and future OI projects. Thus, helping to fine tune adaptive activities and enhance the speed at which OI projects are completed.

3.5.6 Knowledge Fluidity

We use the term knowledge fluidity to describe a microfoundation by which Alpha facilitated the movement of knowledge between individuals, functions, and organisations prior to and during OI processes. Central to Alpha's internal innovation field was an R&D based project leader and diverse range of R&D staff, the management team, the sales and marketing teams and technical sales specialists. Alpha leveraged knowledge fluidity to tap into the accumulated knowledge and experience of individuals situated within their internal innovation field *"we've got 350 years of knowledge and experience from all sorts of different directions. We've all done various things, so everyone's got their own little ideas and things of what works…During developments, we talk a lot and share ideas about various things"* (Project Leader). As such, the internal innovation field served as a knowledge repository granting individuals access to accumulated industry, customer, supplier, product and contact knowledge. This increased the likelihood that individuals can quickly locate the required knowledge during OI projects. In contrast, Alpha's external innovation field was composed of actors from diverse backgrounds including customers, suppliers, industry groups and consultants. Our data revealed that in support of OI processes, knowledge fluidity facilitated the transfer of knowledge between a wide range of individuals within and across both fields. Following, we describe three sub-processes that constitute knowledge fluidity: mobilisation, distribution, and coordination.

Before knowledge could be leveraged from internal and external innovation fields, individuals involved directly in the NPD project such as R&D staff, or board members at the periphery of the NPD project used techniques to *mobilise* knowledge. The transfer of knowledge between internal and external actors was helped by cross-functional individuals. One example was the use of technical sales representatives who were employed in the field and had close working relationships with customers, while also having a technical background. These individuals were able to effectively articulate knowledge associated with product usability, application, and competitors' products to product developers *"experienced people like [Technical Sales Representative] have a unique understanding of customer requirements, competitive products and are able to articulate their thoughts and requirements to lab staff, as well as involve themselves in the process, particularly on the application side"* (COO). In support of this, individuals were frequently rotated to allow them to develop mutual understandings of different roles and requirements, which had the effect of creating multi-skilled employees throughout the business. As such, individuals from diverse backgrounds were better able to understand the requirements of others and offer help and support when needed.

Complementary to the mobilisation of knowledge, Alpha leveraged internal and external networks to support knowledge *distribution*. Internally, close relationships between managers supported knowledge distribution between functions during OI processes "*Alpha has always been a company with short management links, tends to be populated by 'home-grown staff' and as such most of us are involved in most NPDs to some degree*" (COO). Moreover, our data revealed that individuals' *willingness to share knowledge* internally, both within and between functions supported knowledge distribution. This sometimes involved less experienced developers seeking guidance from more experienced developers, or developers and sales representatives looking to colleagues for specialist knowledge during OI

projects. Through the external innovation field, *knowledge distribution* was achieved by cultivating relationships to build network contacts, trust, and loyalty and through OI engagements. As one project manager described *"The relationship [with customer] is managed by regular meetings, regular communication and most importantly the building of trust and a strong partnership. The very essence of our working relationship together is built upon a multichannel team that speaks together every day by phone, email, and physical meetings. This allows us to bring together the [technical] expertise from Alpha and the [usability] expertise from [customer] to collaboratively create the very best products possible. (Project Leader).*" Our data revealed each of the OI projects encompassed multiple knowledge distribution activities representing information sharing and knowledge acquisition. This included knowledge about new product requirements and trial feedback from customers that were distributed between developers, customers, suppliers and sales representatives. Knowledge distribution was also supported by Alpha's broader knowledge network and participation in industry groups "*I can't emphasise enough the usefulness of networks and contacts within our industry, therefore [Industry Groups] are fantastic opportunities to develop these"* (COO).

Finally, *knowledge coordination* refers to the ability to pull together distributed knowledge in coherent OI processes. As one informant described *"The whole NPD process can be boiled down to fulfilling customer's product requirements, and our skill lies in using our prior knowledge combined with seeking new knowledge to find the optimal combination of supplier raw materials, and our existing process technology to create a product that customers will purchase"* (R&D Manager). Knowledge coordination was facilitated by a joined-up NPD process that was internally driven. This was achieved through deployment of a project leader that controlled cost, resource allocation, and ensured projects were working to timelines.

3.5.7 Resource Bundling

Alpha leveraged OI processes to act on newly identified opportunities emerging from their exposure to knowledge variety and environmental awareness. To act on new opportunities, Alpha was actively bundling resources within and across internal and external knowledge domains both prior to, during, and following OI processes which resulted in the accumulation of new resources and capabilities. Following, we describe the *resource bundling* activities from the context of the development process while including wider organisational resource bundling activities that support OI processes.

After the identification of a new opportunity, members of the board, r&d and sales representatives determined whether to and how to act on a new opportunity through OI. This required bundling new opportunity and requirement knowledge with historical technical and commercial knowledge to consider the project from a feasibility perspective. This usually occurred amongst more senior staff owing to their experience with historical developments, while all projects were eventually signed off by the Sales Director and COO.

Once a project was initiated, the project leader would formulate a tentative hypothesis about how to address the newly identified opportunity. These activities required knowledge fluidity by involving different perspectives from board members, sales, marketing, and R&D. Some perspectives were sought, while others were offered in response to emails and discussions about the project *"Other business areas help during the process or initial information gathering, for instance Sales can help in determining customer requirements and commercial needs. Our COO and Chairman have development experience, so I would say they can be more influential in terms of approaching new projects"* (R&D Manager).

Our data revealed that initially, resource accumulation and knowledge fluidity worked together to enable individuals to assess similarities between new requirements and existing

products. This was enabled by considering historical projects and experience of product components and their usage in a selection and assembly process *"lessons learnt from previous developments help with new projects. Previous knowledge of a regulatory regime, or market requirements will help us approach new developments for a certain market. Knowledge in terms of how a product is used also helps with projects"* (R&D Manager). However, frequently individuals lacked knowledge of product requirements or technologies and therefore turned to OI. This is where, by cultivating relationships, individuals were able to reach out to customers, suppliers and other actors situated within the internal or external innovation fields for knowledge. In our example OI project, one email stated *"I have been working alongside [colleague] on a [product type] using the above [component]. I am having great difficulty finding a [component] that works. I have tried [list of components…] amongst others but still suffer from [defect] as shown in the picture below"* (Project Leader). In response, the supplier provided technical explanations and recommendations enabling the project leader to bundle new supplier knowledge with existing knowledge to move the development forward.

Once knowledge was sufficient to test a tentative hypothesis, a trial product was manufactured, allowing the trial to be evaluated against the required criteria to meet customer needs. Subsequent to this, a period of reflection occurred where the developer determined whether the trial was a success (meets criteria) or failure (doesn't meet criteria) *"the early trials all suffered many of the same defects; [list of defects] … several things were tried to fix these defects… despite all of the changes suggested above, the final product was still not performing well enough. After several failed attempts to reduce the [defects] in the final product and the sprayed panels, it was concluded that the [component] may have been a major factor"* (Project Leader). Our analysis of the project data revealed that knowledge of trial success or failure was subjected to a bundling process during evaluation, centred around

the question - was the outcome what we expected? This resulted in resource accumulation through three mechanisms that resulted in new knowledge: confirming the tentative hypothesis to be true; integrating further contextual factors that may or may not explain the reason for trial failure; or casting doubt on existing knowledge and experience resulting in a displacement of existing knowledge.

In the event of trail failure, an adaptation process begins, where the developer experimented iteratively, frequently obtaining knowledge from the internal and external innovation fields, then bundling new knowledge with existing knowledge leading to a further selection and assembly process *"After a period of re-testing, it was decided reformulation was the best course of action… A complete reformulation was performed this time, taking information from the manufacturer about which RMs we should use"* (Project Leader). Thus, resulting in resource accumulation. This knowledge bundling process continued to run in iterations, where a new hypothesis was formulated and tested until a trial batch met a viable criterion. At this point, a product was provided to the customer to trial in their environment. Subsequent to this, customer feedback was combined with developer knowledge and expectations in a bundling process *"Not good news regarding the [new product] trial, please see pictures below, looks like it's gone rusty overnight"* (Sales Representative, email), to which the project leader responded *"If you could give us as much information about how they applied and cured it that would help as we have panels at 250 hrs salt spray with no sign of the flash rusting"*, resulting in further resource accumulation. At this point, customer feedback was continually sought and bundled with existing knowledge in an adaptation process to gauge the project was moving in the right direction *"the primer sprayed out well, it has rusted in one place attachment 4 but [customer] believes this could have been some blast shot that wasn't brushed or blown from the substrate, he will do some other tests this morning but overall it looks like it went well"* (Sales Representative, email). This adaptation

process repeated, continually bundling customer knowledge with developer knowledge, accumulating resources throughout the process until customer requirements were eventually met *"please see attached pictures of the [new product] from my visit to [customer] last week. This has been left out in the elements since March next to where they jet wash everything so has had a good test and has been knocked about a fair bit. As you can see not much rust at all even in the pocket that has water laying in it… I am now being asked for this product on a regular basis"* (Sales representative, email). Once R&D had finalised the product development, marketing was seen to bundle knowledge of new products with existing marketing resources, leveraging outwards projection as a method of increasing value capture from the OI project.

To summarise, our data revealed the OI resource bundling process resulted in resource accumulation, exposure to knowledge variety and ensuing environmental alertness. Environmental alertness enhanced individuals' sensitivities to customer needs and wants, leading to opportunity identification; while exposure to knowledge variety during OI processes resulted in knowledge inflows, resource bundling and accumulation, which enhanced future opportunity identification and the efficiency of OI processes.

3.6 Discussion

To develop our understanding about how firms can leverage organisational practises to enhance their DC by developing new resources and capabilities, we studied resource bundling activities during OI. In contrast to existing research that suggests firms with DC are competent in the creation, extension, and modification of firm resources (Helfat et al., 2007), our findings demonstrate that engaging in OI processes contributes to DC through the accumulation of new resources and capabilities emerging from individual-level resource bundling activities. Equally important to our findings is that during OI processes, bundling new to the firm knowledge resources with existing knowledge also enhances DC by

developing individual-level HC. The process of enhancing individual-level HC is underpinned by microfoundations that allow individuals to accumulate resources through assessment, integration, analysis, and adaptation microprocesses that take place during OI. Existing literature has established relationships between managerial HC and OI performance (Du et al., 2014) and the use of external knowledge with educational and workplace diversity (Bogers et al., 2018b). Our findings complement this by establishing four microfoundations that contribute to the accumulation of resources and the development of HC. Moreover, we reveal a further microprocess, exposure to knowledge variety, that occurs both during and outside OI processes, leading to resource accumulation that can complement an individual's sensing abilities through HC. Consequently, we suggest firms that turn to OI benefit when board members seek knowledge of the business environment from diverse sources as a method of enhancing individual-level HC. Moreover, OI reenforces the development of HC through another microprocess, cultivating relationships, which helps firms to develop SC.

Through examination of OI processes, our findings also reveal a reciprocal relationship between OI and the microfoundation, cultivating relationships. While cultivating relationships is a necessary microfoundation that can enhance SC, by engaging in OI processes, firms can also enhance customer and supplier loyalty and trust. Existing research has identified factors that enhance OI outcomes, such as practicing patience when dealing with OI partners (Ahn et al., 2017). However, our research builds on this by revealing that repeatedly engaging in OI enhances loyalty and trust between internal and external actors, increasing the likelihood that external actors will collaborate and share more valuable knowledge during OI processes. Thus, cultivating relationships enhances a firm's DC by enabling individuals to accumulate resources during OI, as well as increasing individual's SC, resulting in increased HC. Moreover, by cultivating relationships, this enabled individuals to enhance the speed at which OI projects were successfully completed, by

facilitating access to external knowledge and increasing the likelihood of sourcing valuable knowledge.

Our findings revealed a microprocess, exposure to knowledge variety, that contributes to individuals' HC, SC and cognition. Broadly, this occurs through two mechanisms: First, environmental monitoring and participation activities, that exposes board members to previously unknown market and technical knowledge. Thus, placing board members in a stronger position to anticipate new opportunities or threats. Consequently, we argue environmental monitoring and participation activities enhances the sensing ability of DC. Second, continual engagement in OI processes leads to knowledge inflows from customers and suppliers. When individuals within sales and marketing and technical roles are repeatedly exposed to customer and supplier knowledge, those individuals are exposed to further market and technical knowledge variety, therefore enhancing their HC and cognition. While existing research has linked knowledge variety to cognition via creativity and alertness (Salter et al., 2015), our findings reveal this process is enhanced by cultivating relationships which enhances SC and facilitates access to valuable external knowledge resources during OI. Moreover, by engaging in OI processes, firms can enhance their external knowledge network accessible by individuals by cultivating relationships. Individuals can then leverage valuable external knowledge to stimulate further ideas and creativity during OI processes. Our findings are also consistent with Dahlander et al., (2016) that the accumulation of search activities leads to the discovery of new and innovative ideas.

We also identify knowledge fluidity as a microfoundation that facilitates the movement of knowledge between individuals, functions, and organisations during OI processes. Knowledge fluidity encompasses the mobilisation, distribution, and coordination of knowledge. Existing research has implicitly identified the impact of individuals' cognition on knowledge identification and absorption (Distel, 2019). By understanding different

viewpoints and perspectives, individuals can comprehend needs and motives and thus, stimulate creative ideas. However, our research complements this by revealing that firms require individuals to have developed a diverse understanding of roles, knowledge networks and a means to coordinate distributed knowledge through project leads. Consequently, we suggest knowledge fluidity enhances HC by enabling individuals to develop diverse understandings of different roles. Moreover, knowledge fluidity is an enabler of DC, by working in conjunction with cultivating relationships, since knowledge fluidity bridges the gap between SC, HC and cognition. By developing knowledge fluidity and cultivating relationships, individuals are therefore able to leverage SC and cognition during OI processes by building HC to support knowledge fluidity.

Finally, we demonstrate the resource bundling activities central to OI processes. Resource bundling activities occur from within OI projects and centre around whether and how a requirement or opportunity can be met. Consequently, we suggest firms that become proficient in resource bundling activities are better positioned to act on opportunities that can be addressed through OI. Existing research suggests that for firms to take advantage of new opportunities, they must have developed the capacity to modify the resource base repeatedly and purposefully (Helfat et al., 2007). Resource bundling activities underpin the creation of new resources and capabilities (Sirmon et al., 2007) and are dependent on the ability of managers to effectively bundle resources to create value from such activities (Holcomb, 2009). Our research reveals that during OI processes, existing knowledge is bundled with new to the firm knowledge which leads to resource accumulation. The accumulation of new knowledge and experience contributes to individual's non-cognitive substrates, in which, past activities are influential in anticipating future opportunities (Nayak et al., 2020). This knowledge and experience accumulation provides individuals with an ability to efficiently bundle resources during OI processes, in isolation and collectively. We argue this process is

facilitated by knowledge fluidity and enhanced by cultivating relationships and exposure to knowledge variety. As suggested by Leiponen and Helfat (2011: 225) "By accessing a greater number of knowledge sources, the firm improves the probability of obtaining knowledge that will lead to a valuable outcome". Although combining new knowledge with existing knowledge is central to OI processes and the creation of new resources and capabilities, we reveal that by engaging in OI projects, individuals are further exposed to knowledge variety which contributes to the development of their non-cognitive substrate (Nayak, 2020).

3.7 Conclusion

Our research has several theoretical implications. First, we contribute to the growing body of OI research conducted at intra-organisational levels of analysis, by considering the role of individuals in the development of new resources and capabilities when collaborating with external partners (Chesbrough and Bogers, 2014; Vanhaverbeke and Cloodt, 2014). While existing research has established theoretical linkages between OI and the firm's DC (Vanhaverbeke and Cloodt, 2014; Teece, 2016), through empirical analysis, we were able to establish various microfoundations that underpin the relationship between OI, individual-level activities and a firm's DC. An important finding from our study is the impact of OI on NPD project speed that has implications for the development of new resources and capabilities. While aligning OI with the firm's business model has been positively associated with NPD speed (Zhu et al., 2020) and NPD speed has been attributed to NPD success (Cankurtaran et al., 2013), if firms are to leverage OI in pursuit of DC, the added complexity of social relationships in the access and use of external knowledge will impact the speed at which firms can develop new resources and capabilities in pursuit of new product innovations.

Second, our research has implications for literature on DMC (Helfat and Martin, 2015) and DC (Teece, 2007; Teece, 2014). While managerial ability is considered important

to a firm's DC, and managerial HC, SC and cognition constitutes a vital part of managerial ability, we establish the impact of HC, SC and cognition from the perspective of individuals embedded within OI processes. By examining resource bundling activities, our research highlights the intricate relationship between OI and the HC, SC and cognition of individuals that contribute to OI processes, resulting from the accumulation of new resources and capabilities. We offer an alternative perspective on the underlying abilities of DMC, in the application of HC, SC and cognition to individuals embedded within organisational processes. In doing so, we establish the relationship between OI and the underlying sensing, seizing and reconfiguration abilities of DC more clearly.

Third, our study contributes to the growing body of research concerning the microfoundations of organisational practises (Felin et al., 2015). We applied the microfoundations as levels to the OI processes using an activity level perspective. In doing so, we were able to establish the underlying mechanisms by which OI can contribute to the firm's DC through the development of new resources and capabilities. As such, we complement the growing body of research on OI microfoundations that has been conducted at the individual level (Salter et al., 2015; Dahlander et al., 2016; Ahn et al., 2017; Bogers et al., 2018b; Rangus and Černe 2019), project level (Du et al., 2014) and process level (Hutton et al., 2021). However, while existing microfoundation literature is concentrated around individual behaviours and OI outcomes, we offer an alternative perspective of microfoundations as levels, while considering how individual activities embedded within the OI process give rise to a firm's DC. In addition, we also contribute to DC microfoundations literature. While existing studies concerning DC microfoundations are theoretical in nature, our empirical research establishes various microfoundations that relate OI to a firm's DC (Teece, 2007; Helfat and Martin, 2015; Nayak, 2020).

Limitations

While we made every attempt to develop a rigorous study, our study is not without limitations. Although the case-study offers an in-depth, longitudinal insight into a real-world phenomenon, we cannot claim our research setting to be representative of the complexity of disparate organisations functioning within a dynamic environment. The implications as such, is a model closely aligned with the inner workings of our research setting. However, our study facilitates relatability, by opening opportunities for our model to be tested in other organisations and settings. In doing so, we may begin to unearth more strongly, the complex relationship between organisational practises of OI and DC, thus helping firms to understand how they can leverage OI to develop DC. Another obvious limitation is the author acting as researcher practitioner. In order to mitigate this limitation, every effort has been made to eliminate bias. For example, during the data collection and interviewing process, both co-authors acted as external researchers and contributed to the formulation of questions and analysis of data. This helped the formation of basic questions that may have been overlooked. Moreover, the study used data triangulation where interview data with cross-referenced with archival records to aid the interpretation process.

Chapter 4: A Microfoundational View of the Interplay Between Open Innovation and a Firm's Strategic Agility

4.1 Abstract

Open innovation can complement firms looking to deploy strategic agility through product innovations during periods of market and technological change. However, existing research has examined open innovation and strategic agility in isolation, leaving the link between the two concepts empirically unexamined. Consequently, it remains unclear whether some open innovation activities can potentially help or hinder strategic agility. We address this gap by examining a firm's open innovation activities using an in-depth analysis of three new product development processes. Our analysis reveals that in response to changing market conditions, firms can leverage open innovation during NPD processes to drive technological innovations. Under such circumstances, open innovation enables firms to deploy strategic agility by continually developing the product portfolio. Our study reveals six mechanisms that underlie the relationship between open innovation and strategic agility: cohesive judgement, knowledge permeability, knowledge-base reappraisal, product portfolio elasticity, decisional precision and organizational adaptability. We theorise the interplay between these activities and how they give rise to a firm-level capability.

4.2 Introduction

Strategic agility (SA) is considered a firm-level capability that enables firms to rapidly respond to changes in its external environment (Doz, 2020). Firms that have developed SA may formulate plans to achieve consistent long-term goals, while remaining flexible and receptive to unexpected circumstances and new opportunities (Vecchiato, 2015). One method by which firms can deploy agility is by adapting the innovation portfolio in response

technological opportunities and the changing needs and requirements of customers (Kester et al., 2011). However, this can present challenges to firms, as innovation portfolio development requires resource allocation and may be costly without guaranteed outcomes. An alternative stream of research explains how firms can complement their innovation activities by leveraging knowledge resources outside the firm's boundaries (West and Bogers, 2014). Firms that turn to open innovation (OI) can target innovation portfolio development through new product development to create and capture value (Vanhaverbeke and Chesbrough, 2014). Consequently, OI can complement a firm's strategic agility "by enriching and speeding up new product development to meet nascent market opportunities." (Teece, et al., 2016: p25).

While existing research has focused on the relationship between OI and firm-level outcomes (West et al., 2014; Bogers et al., 2017), there is a paucity of research exploring the relationship between OI and firm-level SA. This is significant, as the adoption of OI is potentially problematic to firms looking to exhibit SA, given that OI can exacerbate challenges associated with resource allocation in pursuit of developing the innovation portfolio. Indeed, searching for external knowledge resources outside the firm boundary and nested within complex social relationships can be costly (Laursen and Salter, 2006; Salter et al., 2015; Bahemia et al., 2018). Similarly, firms that adopt OI may be reluctant to abandon projects in pursuit of new opportunities given the costs associated with resource investment, thereby having negative implications for the firm's strategic agility (Lill and Wald, 2021). Although OI has been considered a complement to SA (Doz, 2013; Teece et al., 2016) by potentially resolving various challenges associated with innovation portfolio development, we still have a limited understanding of how OI and SA interact, giving rise to firm-level outputs.

The aim of this study is, therefore, to begin to uncover the mechanisms that underlie the relationship between OI and SA to better understand the complementary nature of both

concepts. To achieve this end, our research adopts a microfoundations perspective, which focuses attention on the underlying mechanisms of a phenomenon (Felin et al., 2015). Given that OI emerged from observations of changing innovation management practices (Chesbrough, 2003) and SA emerged from observations of firms that were able to rapidly respond to changes in their environment (Doz and Kosonen, 2007), adopting a microfoundations perspective offers a powerful lens to establish a more granular understanding of the relationship between OI and SA.

In pursuit of our aim, we attempt to answer the research question *"What are the underlying microfoundations that support the interplay between OI and SA?"* To answer this question, we adopted a case study approach through an in-depth analysis of three new product development (NPD) processes in a manufacturing firm. Our case study revealed six mechanisms explaining the interplay between OI and SA giving rise to firm-level outputs. These are cohesive judgement, knowledge permeability, knowledge-base reappraisal, product portfolio elasticity, decisional precision and organizational adaptability. Each mechanism functions at the microfoundational level, spans the domains of OI, NPD and the firm's SA, and has varying levels of interaction. Our research makes a dual theoretical contribution to the OI and SA literatures by empirically establishing the mechanisms that underlie the relationship between OI and SA. As such, we respond to the growing body of OI microfoundation and multi-level research that seeks to develop our understanding of the interdependencies between lower-level factors and firm-level outcomes (Bogers et al., 2017).

4.3 Theoretical Background

4.3.1 Strategic Agility

This section introduces the concept and microfoundations that underlie strategic agility, while considering the challenges associated with firms' SA development. By microfoundations, we refer to the mechanisms that are the proximate cause of and exist at a lower level than SA (Felin et al., 2015).

Strategic agility is an organisational capability that refers to a firm's ability to anticipate future requirements, formulate appropriate plans and deploy resources while remaining flexible to unexpected changes and appropriately changing course or direction. As such, strategic agility has been defined as the ability *"to exploit, or create to one's advantage changing patterns of resource deployment in a thoughtful and purposeful but also fast and nimble way rather than remain hostage to stable pre-set plans and existing business models"* (Doz and Kosonen, 2007, cf Doz, 2020 : p1). When competitive environments change more rapidly, firms that develop strategic agility are better positioned to respond to such changes. Existing research has considered SA from the perspective of business transformation. However, we consider the alternative but equally important perspective, which relates to transforming a firm's resource portfolio through technological innovations. Through processes such as NPD and resulting technological innovations, firms can leverage new ideas to take advantage of nascent customer needs and requirements (Teece et al., 2016).

Attempts to understand how firms can develop strategic agility have established two key capabilities: sensing the need for change and implementing the appropriate strategic action (Weber and Tarba, 2014). These capabilities have been further disaggregated and refined into three microfoundations: strategic sensitivity, resource fluidity and collective commitment (Doz, 2020). Strategic sensitivity encompasses sensing the need for change, while resource fluidity and collective commitment are concerned with implementation. These

microfoundations are rooted in individuals' actions with a focus on senior management and, in combination, give rise to a firm-level capability. Moreover, the speed of new technological innovations is vital to firms looking to stay abreast of environmental changes (Teece et al, 2016). As such, we consider speed an important dimension that complements these microfoundations in giving rise to SA (Prange, 2021). Following, we discuss each of these microfoundations in isolation to understand how individual activities contribute to each in practice.

Strategic sensitivity is a sensemaking ability, that refers to the awareness and attention of senior managers to strategic situations as they develop (Doz, and Kosonen, 2008; Doz and Kosonen, 2010; Doz 2020). Firms that pursue technological innovations through NPD processes require strategic sensitivity to understand customer needs and wants and sense new opportunities that can be acted on before competitive rivals (Teece et al, 2016). In such contexts, research suggests that individuals can develop a sensitivity to customer needs and wants by being curious and open to internal and external actors (Doz, 2020). This is because firms that foster curiosity and openness equip individuals with the tools to stimulate innovative ideas, resulting in higher receptiveness and strategic intent to opportunities as they arise. Indeed, strategic intent is critical for agility as it moderates its effect on time to market (Demir et al., 2021). Further, by engaging in NPD processes that promote improvised actions and resulting experiences, individuals can increase their sensitivity to environmental opportunities (Nayak et al, 2020). However, strategic sensitivity is challenging to develop, as firm capabilities that underpin day-to-day activities promote stability, efficiency and repeatable processes that are rooted in best practices. Consequently, individuals operating within these environments can develop core rigidities, such as inefficient coordination mechanisms and as a result harming agility (Demir et al., 2021). In such environments, individuals tend to focus on exploiting and perfecting existing products or processes rather

than engaging in the exploration of new products or processes (Teece, 2018a). Thus, for individuals to develop strategic sensitivity, they must overcome the tensions associated with the exploitation and exploration of resources (March, 1991).

As strategic situations develop, *resource fluidity* is critical as this enables firms to rapidly free and reallocate resources in pursuit of new and developing opportunities (Doz, and Kosonen, 2008; Doz and Kosonen, 2010; Doz 2020). Consequently, resource reallocation requires firms to have developed strong dynamic capabilities that encompass the creation, extension, and modification of firm resources (Teece, 2014; Teece, 2018a). Research suggests individuals can enhance resource reallocation abilities through a combination of practices and experimentation that encompasses recombining and integrating resources during NPD processes (Teece, 2014). Alternatively, resource fluidity has been associated with adaptive learning processes centred around projects and teams (Doz, 2020). These projects and teams benefit from individuals with strong collaboration and negotiation skills that can successfully gain project support from executives and project team members operating within the organisation. In such contexts, individuals benefit from learning to trust colleagues by understanding what they can and cannot achieve and by engaging in flexible job designs (Doz, 2020). However, resource reallocation also entails a high level of risk. Given that the deployment of resources to act on new opportunities are non-routine NPD processes, firm resources are finite and positive outcomes from such activities are not guaranteed. As such, firms must engage in efficient resource deployment in response to strategic decisions. This can present challenges to firms looking to leverage OI in pursuit of NPD, as in some contexts, searching for external resources can be costly (Laursen and Salter, 2006; Bahemia et al., 2018). Further, resource fluidity may also be hindered by the same core rigidities that affect strategic sensitivity.

The final microfoundation of strategic agility further emphasises the importance of strategic intent (Demir et al., 2021), expressed as a *collective commitment* to strategic goals across the leadership team. Indeed, the role of leaders in facilitating strategic change has been established throughout the literature (Helfat and Martin, 2015; Teece, 2018b). In strategically agile firms, collective commitment represents unity, collaboration, and joint decision making within leadership teams (Doz, 2020). A high level of alignment and commitment from senior leaders is required for the quick implementation of strategic decisions. This is necessary to ensure resources are effectively deployed while avoiding conflict and competition for resources (Doz, 2008). Thus, enabling firms to implement strategic initiatives with high levels of efficiency and momentum. Leadership teams also require cohesive action across the leadership team in orchestrating dynamic capabilities and continual transformation of firm resources in response to new opportunities (Teece, 2014). Senior leaders can also positively impact the performance and agility of NPD processes when senior management teams have executive mindsets and are willing to take risks (Lill and Wald, 2021). In addition, further enhancements are possible when leaders encourage individuals to administer their creativity and ideas during product development.

To summarise, the literature has established strategic sensitivity, resource fluidity and collective commitment as microfoundations of SA (Doz, 2020). Each of these microfoundations has been associated with individual actions centred around senior management. While the literature has identified activities that encourage strategic agility, various factors can also inhibit strategic agility. This can pose problems to firms looking to adopt innovation practises such as OI in pursuit of portfolio expansion, given the literature is unclear about how these microfoundations may impact or be affected by OI. Considering that a sizeable proportion of product innovations occur at the periphery of organisations (Doz, 2013), we turn to the OI literature to explore theoretical linkages between these two concepts.

4.3.2 Open Innovation and Strategic Agility

Firms are increasingly adopting OI to accelerate technological innovations (Randhawa et al., 2016). OI enables firms to supplement internal innovation activities using knowledge resources situated outside the firm boundary (Chesbrough, 2003; Chesbrough, 2006). As such, OI has been defined as *"a distributed innovation process based on purposely managed knowledge flows across organisational boundaries"* (Chesbrough and Bogers, 2014: 1). Firms that engage in OI frequently turn to inbound knowledge flows as a method to convey external knowledge resources (Dahlander and Gann, 2010). Under such circumstances, firms can function as both receivers and providers of knowledge resources (Tranekjer and Knudsen, 2012).

Consistent with the view that firms may combine OI and SA in pursuit of competitive advantage, we expect that the microfoundations that underlie the relationship between SA and OI may reside in individuals' actions, interactions, and context (Barney and Felin, 2013). These factors are influenced by how firms configure and deploy resources, which form the basis of competitive capabilities (Barney, 1991; Teece, 2007; Teece, 2014). Building from a relational view of the firm (Dyer and Singh, 1998), individuals and firms may leverage both internal and external contacts to access knowledge resources during NPD processes in support of technological innovations.

Firms that exhibit strategic sensitivity derive opportunities for new products and innovations by developing an understanding of market knowledge (Doz, 2008; Doz, 2020). In this context, market knowledge refers to customer preferences, needs and wants. Alternatively, technical knowledge concerns the technical attributes that may influence product designs (Cui and Xioa, 2019). Existing research suggests that OI can contribute to strategic sensitivity through inbound mechanisms such as crowdsourcing and ideation by providing individuals with fresh ideas for NPDs (Gatzweiler et al., 2017), or even competing

business models (Demir and Angwin, 2021). Further, by engaging with customers during NPD processes, individuals can enhance market knowledge and understanding (Coviello and Joseph, 2012) by obtaining knowledge concerning the preferences and applications of products (Poetz and Schreier, 2012; Hutton et al., 2021). However, while continual exposure to external sources may increase an individual's creativity up to a certain point, eventually, the cost of searching for knowledge can outweigh the benefits (Salter et al., 2015). The continual pursuit of NPD ideas by individuals will result in the consumption of resources that firms could otherwise deploy to drive efficiencies. This may pose problems to firms looking to leverage OI in pursuit of SA since risk-averse managers may prefer short-term gain over long-term success, increasing their tendency to focus on exploiting existing opportunities as opposed to the exploration of new ones (Ehls et al., 2020).

The literature also emphasises the importance of resource fluidity to efficiently act on new opportunities (Doz, 2020). However, to be agile, firms must be able to accurately deploy resources and quickly integrate knowledge during NPD processes (Teece et al., 2016). Suppliers have been found to enhance the speed of NPD processes by providing firms with valuable sources of technical knowledge (Tavani et al., 2013). Further, sourcing technical knowledge from diverse backgrounds can also quickly lead to novel solutions to long-standing problems and challenges (Lifshitz-Assaf, 2018). However, for firms to effectively use knowledge during OI projects, individuals must combine external knowledge with existing knowledge which has the potential to be costly. For example, customers have been found to reduce NPD performance under certain market conditions due to difficulties with knowledge integration (Chang and Taylor, 2016). Knowledge integration is further impacted by intra-firm and inter-firm communication and the decision-making autonomy of individuals (Foss et al., 2011). Thus, emphasising the impact that conditions internal to the firm can have on the speed and efficiency of resource deployment during NPD.

Finally, senior leaders require collective commitment to effectively assign resources to NPD processes. However, knowledge that is required during NPD processes is frequently tacit in nature and not easily transferrable which can make intra-firm collaboration and project agreement more challenging (Bogers and Horst, 2014). Further, the literature has established that managers may have a tendency to reject external ideas in favour of internal R&D that can negatively impact the adoption of OI initiatives (Burcharth and Fosfuri, 2015). Thus, highlighting potential challenges with the adoption of OI to a firm's SA.

In summary, the literature reveals some overlap between OI and SA microfoundations. However, while the relationship between OI and SA may be complementary in some contexts, intra-firm conditions have the potential to negatively impact the OI-SA dynamic. This presents a challenge to firms looking to leverage OI in business environments that require strategic agility as it remains unclear how the two concepts are related at the intra-organisational level. Our understanding of the OI-SA relationship is limited to a limited number of firm-level studies (West et al., 2014; Bogers et al., 2017). To shed light on this research gap, we turn to our empirical findings after some methodological considerations have been made.

4.4 Research Design and Methodology

Our research required an up-close and in-depth examination of the mechanisms that underlie the OI-SA relationship in a real-world context. Consequently, to meet our research aims, we adopted a case study approach within a manufacturing setting which is a useful method of empirical inquiry to investigate a phenomenon within its real-world context (Yin, 2014). Central to our study was the OI process that is associated with meeting the changing needs and requirements of customers through NPDs (Teece et al., 2016). We consider knowledge flows as the conduit through which OI processes are supplemented by external knowledge resources. We collected and analysed data over a four-year period, focusing on the

organisation's NPD process and more broadly, the organisational environment that facilitated the interplay between OI and SA. Thus, enabling us to establish the interplay between OI and SA as well as the broader organisational mechanisms that support this relationship in giving rise to a firm-level capability.

4.4.1 Research Setting

Our research setting was an established UK small- and medium-sized enterprise (SME) in the chemical industry. The UK chemical industry is continuously under legislative and regulative pressures owing to environmental conditions that require continual changes to products and manufacturing processes. The organisation central to our study demonstrated strategic agility and resilience by steering through four recessions over an 85-year period. Throughout this period, the organisation had consistently developed innovative and market-leading products. Prior to 1999, the organisation had developed a diverse customer and supplier network that were frequently involved in the development of new products. Between the years 2017 and 2020, the organisation had generated sales revenues that were directly attributed to the development of 517 new products. The organisation's continually evolving product portfolio was underpinned by successful NPD processes that frequently leveraged OI. Thus, demonstrating the organisational setting had leveraged OI and exhibited SA concurrently. During this period, the organisation's portfolio size ranged from 1041-1208 products that were sold to 37 different market segments which vary in size across different industry settings. This product portfolio served between 838-1210 customers each year that were managed through a national sales function that targeted new business by gathering information on external development opportunities and market movements. The organisation's broad customer base corresponded with a diverse supply network used collaboratively to support the organisation's development activities. Consequently, most of the organisation's NPD processes had drawn on a wide variety of inputs from external actors,

customers, and suppliers but also industry groups and technology experts. This setting is, therefore, an ideal context for researching OI and SA, both in terms of the activities and the actors involved.

4.4.2 Data Collection and Analysis

Our data collection and analysis were performed in concert to enable the continual refinement of data capture based on emerging themes, the relevant literature, and the data (Corley and Gioia, 2004). Our primary data collection was conducted by the lead author, a researcher-practitioner employed by the organisation in a senior role throughout the duration of the projects. This facilitated ease of access to unusually rich sources of data. This included the senior management team that played a key role in the implementation of strategic initiatives and product developers that played a key role in OI projects. Both co-authors were external researchers and were actively involved in the data collection and analysis to prevent bias. Some of the steps taken included posing basic questions from researchers rather than colleagues and involving external researchers in the participant selection process. Our selection criteria for actors involved in this research was driven by the need for extensive knowledge of the organization and strategic decisions. Hence, we selected 'elite informants' who were considered *"key decision makers who have extensive and exclusive information and the ability to influence important firm outcomes, either alone or jointly with others"* (Aguinis and Solarino, 2019: p1293). Moreover, our research required deep knowledge of resulting OI projects and the technical and market related knowledge that influenced decisions. Hence, similar to Bingham and Eisenhardt, (2011) we selected informants with the greatest insight into OI projects that included project leaders and sales representatives. We conducted our data collection and analysis in three phases (see Table 11) with some collection and analysis occurring concurrently. To provide a rich insight into our area of

study, we combined grounded theory procedures (Corley and Gioia, 2004) with case analysis (Eisenhardt and Graebner, 2007).

During phase one, we established an understanding of the industry context and the firm's strategic agility by initially collecting and analysing company documentation in the form of reports, archival data, press releases and product launches. This was followed by collecting survey data through a questionnaire consisting of 34 questions that were designed to understand how the organisation, through the perspective of management, were able to exhibit strategic agility by rapidly reconfiguring resources during times of crisis. The questionnaire was developed in several stages where initially, questions were designed to understand how the organisation recognised the need to change, followed by the activities that implemented change within the organisation. The open-ended questions were developed by one of the co-authors and piloted by the lead author where they were continually refined to aid comprehension. This cycle was performed five times until all authors agreed on the questions to be posed. The questionnaire was composed using the online survey tool Qualtrics and distributed to members of the organisation's senior management board that consisted of six directors and five senior managers—all of which answered the questionnaire. Company documents and questionnaire responses were initially coded using in-vivo codes, followed by secondary coding where similar codes were grouped into higher-level concepts (Saldana, 2021: p298).

Table 11: Summary of Data Collection Methods and Data Sources

Phase 1: Industry Conditions & Strategic Initiatives		**Phase 2: Product Portfolio & Open Innovation Knowledge Network**		**Phase 3: Open Innovation NPD Projects**	
Data Type/Method	**Data Source (Quantity)**	**Data Type/Method**	**Data Source**	**Data Type/Method**	**Data Source (Quantity)**
Documents	Marketing Reports R&D Reports Product Launches Press Releases	Archival Data (Customers, Suppliers, New Products, Product Portfolio, NPD Projects)	IT Manager	NPD Project Data	Emails Meeting Minutes Project Reports Project Timelines
Archival Data	Product Formulations	Informal Discussions	R&D Manager IT Manager Sales Director	Interviews	Supplier (2) Project Leader (3) Sales Representative (3)
Questionnaire	6 Company Directors 5 Senior Managers			Informal Discussions	Sales Director Sales Representative Production Director Product Developer Purchasing Manager R&D Manager
Interviews	Sales Director (4) R&D Manager (4)				
Informal Discussions	Managing Director Business Development Director Sales Director Marketing Manager R&D Manager Purchasing Manager Production Director				

During phase two, we collected data on the firm's product portfolio and open innovation knowledge network that had developed between the period 1999 to 2020. We collected data on the number of customers and suppliers that had engaged with the organisation throughout this period. In addition, we collected data on the number of products manufactured and new products developed. During this phase, we used nominal codes to ensure customer and supplier data was accurate and batch data to ensure new and existing product data were accurate. This data provided insight into the firm's knowledge network, depth of product offerings and how each had evolved throughout this period.

During phase three, we collected in-depth data on three recent OI projects that had contributed to the firm's SA by enhancing the product portfolio through NPDs. Each project had been initiated in response to a new business opportunity or threat and had resulted in new sales revenues. During this phase, we obtained data including emails, meeting minutes and project reports to construct a chronological story of each development (Langley, 1999). We interviewed available project leaders, sales representatives and suppliers that had been influential to the progression of the projects to aid our understanding of the engagements that occurred during each project and how they influenced the direction and outcome of each project. Next, we coded the stories by reducing each engagement to a type of activity (e.g., request, response), a brief description of the outcome alongside any individuals involved. We were subsequently able to establish the frequency, duration and speed of OI engagements that had occurred during the development process (Eisenhardt and Graebner, 2007). This enabled us to establish intra-organisational engagements across several functions and hierarchical levels, as well as inter-organisational engagements that occurred during a typical OI project.

As our understanding of the context, concepts and projects began to develop, we complemented our hard data with remotely conducted (due to COVID-19 restrictions) semi-structured interviews to offer a rich understanding of the emergent concepts and the underlying activities that contributed to the evolution of the firm's product portfolio (Eisenhardt, 1989). We performed four cycles of structured interviews with the sales director and R&D manager posing questions to determine how the underlying concepts that had previously emerged had contributed to SA. As this interview data was collected, consistent with the questionnaire responses, we initially performed in-vivo coding, followed by secondary coding, then we consolidated and grouped all our second-order codes into aggregate dimensions (Fig. 1). To ensure the coding process was reliable, the second and third authors independently reviewed the coding to ensure agreement.

During our analysis, as any uncertainty surrounding our data arose, we continually sought information from organisational actors including product developers, sales representatives, senior managers, and company directors that were deemed key knowledge agents in the area (Gioia et al., 2013). In total, we performed thirty informal discussions with informants asking them follow-up questions and queries to refine our understanding of the OI-SA interplay. Next, following Demir and Lychnell (2015), we performed thematic analysis by 'articulating' (exposing identifying and generative mechanisms of OI and SA), 'relating' (continuously reconsidering connections within and between characterising OI and SA), and 'conjugating' (pulling together the identifying and generative properties of the interplay of characterising OI and SA as no further plausible options remained). At this stage, we cross-checked the data from our NPD engagements with the emerging themes as a method of triangulating the data. This process enabled us to identify overarching and integrative themes and detect patterns, processes, tensions, explanations, causes, consequences, and conclusions (Rubin and Rubin, 2012).

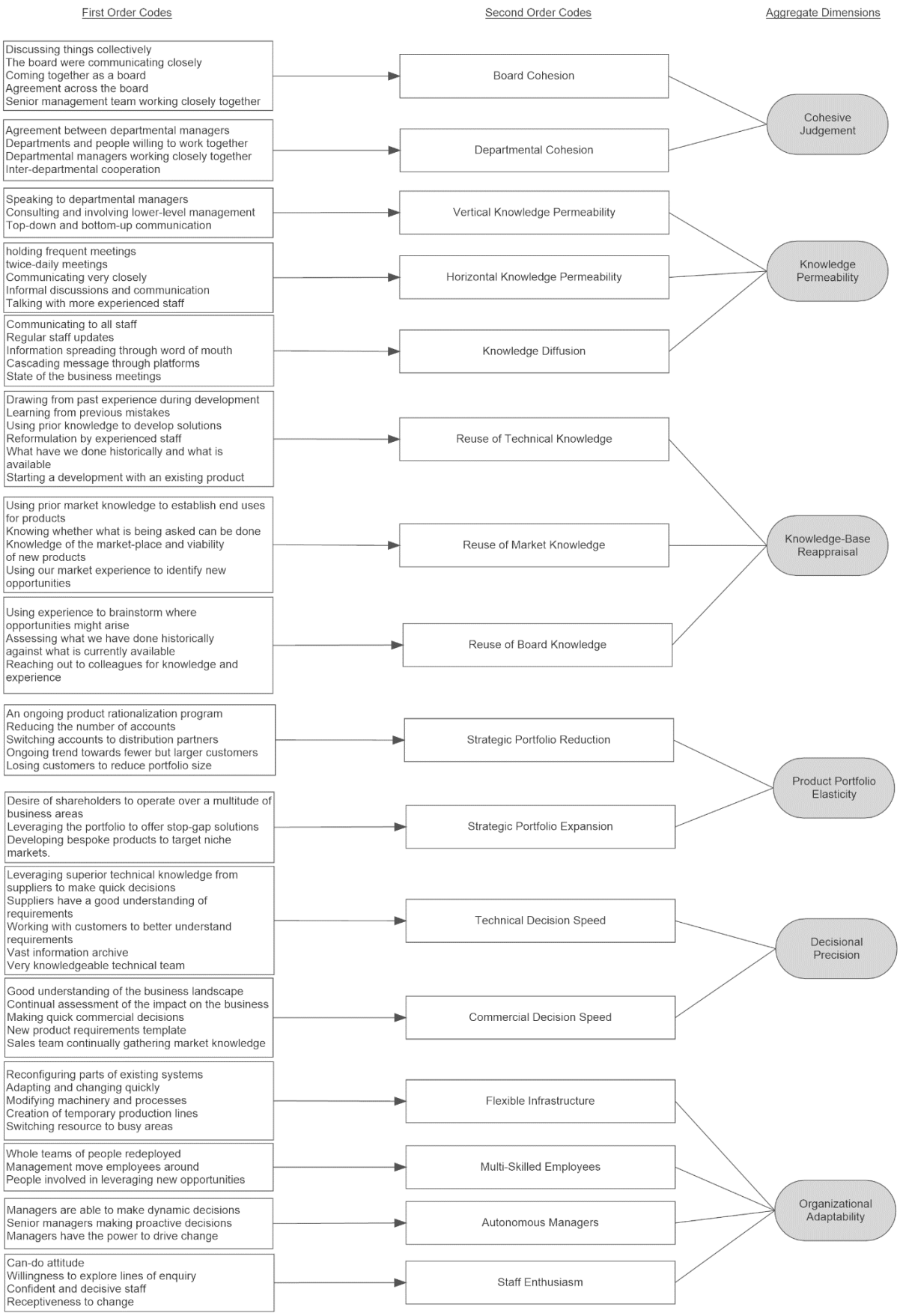

Figure 6: First order codes, second-order codes and aggregate dimensions

Our data analysis revealed an intricate interplay between six mechanisms operating at the microfoundational level: cohesive judgement, knowledge permeability, knowledge-base reappraisal, product portfolio elasticity, decisional precision, and organizational adaptability, across the three domains of NPD, OI and SA.

4.5 Findings

In this section, we introduce each of the six mechanisms that we identified in support of the OI-SA relationship along with a descriptive example (Table. 12). Subsequent to this, we provide a detailed description of the mechanism, functions and interactions gained from our empirical analysis. We use a pseudonym (Alpha) to refer to the organization throughout our study.

Table 12: Activities Identified and Corresponding Descriptions

Activities	**Description and Empirical example**
Cohesive Judgement	The ability of employees to easily take new positions and make consistent judgments with information generated from and across several epistemic boundaries, prior to decisive action. During a time of crisis, the board identified an opportunity to manufacture a new product that was novel to the business. The opportunity was discussed at board-level, where risks were considered and an agreement was reached, followed by each member of the board getting behind the decision and initiating the implementation process.
Knowledge Permeability	In response to a new opportunity, prior to and during the product development process, organizational actors often share market or technical knowledge in response to a particular problem, meaning the solutions to problems are easily accessible if they exist within the organization. *"The main point is knowledge – knowledge of suppliers and products and what is available, we talk to one another and there is usually someone within the team that may know the best suppliers to contact, again the key here is knowledge and ensuring the entire team knows who to contact."* (R&D Manager)
Knowledge-Base Reappraisal	The organization frequently draws on past knowledge and experience through means such as archived formulations prior to and during the process of product development. *"Knowledge again is the key, whether that is a developer's knowledge of the technical attributes of raw materials, or historic formulations and also trusted suppliers that either have test data or a track record within a certain area.".* (R&D Manager)
Product Portfolio Elasticity	The organization demonstrated an ability to expand the product portfolio at a quick rate in response to new opportunities, and also, reduce the size of the portfolio through product rationalization.

	"The vast number of products produced at Alpha brings about a great deal of choice for our sales team and also our customers. However, this reduces the agility and flexibility across the business. An ongoing rationalisation programme is improving our position, however it is very much the desire of both the shareholders and management team to operate across a multitude of business areas." (Sales Director)
Decisional Precision	The organization demonstrated an ability to make precise technical and market related decisions which means the process of product development requires fewer steps and therefore exhibits a high level of efficiency resulting in speedier NPD processes and higher agility. *"the supplier may actually know the market far better than Alpha or the developer as they may have serviced the market for years, if that is the case, then we tend to be guided by our suppliers that can often provide case studies, test results and start point formulations."* (Product Developer)
Organizational Adaptability	The organization has been able to consistently adapt and change during difficult times by reconfiguring people, equipment, systems and processes in order to pursue new opportunities. *"In the aftermath of previous recessions and following previously challenging times, we have been able to turn things around, adapt and change quickly and this results in growth and prosperity for all at Alpha."* (Managing Director)

4.5.1 Cohesive Judgement

Our analysis revealed that cohesive judgement was an organisational mechanism that represented the ability of employees to easily take new positions and make consistent judgments with information generated from and across several "epistemic boundaries" (Håkanson, 2010). Cohesive judgement was an influential factor at the board level in deciding whether to pursue new opportunities, *"The senior management team work closely together in deciding the strategy for the business, decisions on new customers, products and equipment are discussed collectively."* (Questionnaire Respondent). As such, cohesive judgement facilitated alignment across the board and throughout the organization prior to initiating an unanticipated response to a new opportunity, *"When we operate a decision, everyone gets behind it..... dissent is for the boardroom. Unity is crucial outside the boardroom..."* (Managing Director). Cohesive judgement encompassed a good understanding by board members about how a new opportunity would impact the business overall, and the initial actions that were required by each board member to act on the opportunity.

In situations where new opportunities were targeted through OI, cohesive judgement was also about individuals within each department understanding the requirements prior to, during and following the project. However, for such alignment to materialize, cohesive judgement required effective communication that was underpinned by protocols within the business, *"The key is good communication and both formal and informal mechanisms exist within the organization. It's also to do with how closely colleagues work and interact."* (Questionnaire Respondent). Formal mechanisms consisted of monthly meetings, where the board discussed and agreed new strategic opportunities, and technical sales meetings that brought together employees from technical and sales roles that discussed technical offerings and market requirements. Informal mechanisms consisted of impromptu meetings and discussions between smaller groups of individuals from marketing, sales and R&D that occurred prior to and during OI NPD processes. In summary, cohesive judgement facilitated board and employee agreement about new initiatives, enabling the organisation to respond through decisive action.

4.5.2 Knowledge Permeability

Alpha demonstrated the ability to easily diffuse previously unknown technical or market knowledge through their intra-organizational knowledge network. We refer to this ability as knowledge permeability. Knowledge permeability facilitated individuals' access to knowledge through vertical and horizontal channels. In support of cohesive judgement, horizontal knowledge permeability enabled board members and individuals across the business to discuss and agree whether to take on new opportunities *"Alpha were holding daily meetings and sometimes twice daily meetings where information was dissected and plans drawn up."* (Questionnaire Respondent). Once an initiative was agreed upon, vertical knowledge permeability enabled board members to communicate the vision from board-level to organizational functions, *"Speaking on a daily basis and feeding the information to senior*

managers to make proactive decisions." (Marketing Manager). Our analysis revealed both horizontal and vertical knowledge permeability enabled Alpha to quickly agree and act on new OI projects.

Knowledge permeability also helped historical facts and future expectations to permeate across epistemic boundaries within the firm. This increased the likelihood that individuals would succeed in finding and accessing previously unknown technical and market knowledge in support of OI projects. Knowledge permeability required a good understanding by individuals of their colleague's knowledge and experience. This that allowed more knowledgeable staff to anticipate and support less experienced developers when needed. For example, we observed technical knowledge permeating across functions of the business when queries and concerns originating outside the firm were directed at market-facing employees, such as sales representatives: *"[Sales Representative] reported issues to me to do with colour separation at [customer]. I remember historically i.e. years ago…. difficulty with colourant compatibility with the particular [component technology]. It occurred to me that our relatively newly released [colourant] system may have much better compatibility with the [customer] clear base."* (Managing Director). Historically, individuals had uniquely developed technical knowledge within a specific technological domain. However, the shared terminology and memory of past projects helped OI team members, board members and sales representatives to recall and fluently decontextualize the technical knowledge from its original source domain to prospective technical domains.

While shared terminology and memory of past projects, due to high employee retention facilitated the diffusion of historically embedded technical knowledge, market related knowledge was diffused by continuous dialogue across epistemically diverse organizational groups. For example, in reflecting on the firm's ability to develop products for a specific market area, one of our key informants noted, *"The situation with regard to the*

[market area] has been discussed across time and the key issues have been very low prices in the marketplace which led to the exiting of great companies." (Managing Director). In this instance, a long-serving board member shared experiential knowledge with less-experienced R&D staff via simple but easily maintained communication networks.

In some circumstances, vertical knowledge permeability worked in conjunction with horizontal knowledge permeability such as when product developers lacked technical knowledge or knowledge of a current issue, developers knew who to ask internally to locate the required knowledge, *"The main point is knowledge – knowledge of suppliers and products and what is available, we talk to one another and there is usually someone within the team that may know the best suppliers to contact, again the key here is knowledge and ensuring the entire team knows who to contact."* (R&D Manager). This afforded an efficient search and application process during OI projects as product developers spent less time searching for knowledge and adopting trial-and-error approaches that consume resources.

Our analysis also revealed that in support of the OI-SA relationship, knowledge permeability interacted with other microfoundations in several ways. First, there is a link between knowledge permeability and knowledge-base reappraisal. More specifically, knowledge permeability facilitated a greater understanding of current issues that were then appraised against historical facts, *"the knowledge that we have learnt from past development projects is easily accessible and this allows us to make more informed decisions about current issues."* (Sales Director). Our informants repeatedly highlighted how colleagues had unearthed their tacit knowledge by explicating technical knowledge, market knowledge and more delicate understanding of partners and their plans. Such knowledge permeability was vastly supported by the intra-organisational knowledge network, such as high-quality and frequent communication, social relationships, and interpersonal trust.

Second, our data revealed that knowledge permeability facilitated decisional precision. More specifically, knowledge permeability enabled board members and OI project teams to make informed decisions both prior to and during OI projects. By enabling knowledge and ideas to easily diffuse across and within organizational functions, developers could easily obtain knowledge of suppliers and contacts and where to obtain appropriate technical and market related knowledge from customers and suppliers. Individuals were then able to diffuse knowledge of past decisions including what had or had not previously worked. For example, during one development project, an email exchange occurred where a senior manager shared technical knowledge of a past decision with the project leader, *"I also recall in the past, we made [product] using a 1:1 ratio of [component a] and [component b] and this worked really well…. might be an option to reduce [component] usage."* (Colour Manager). This impacted the efficiency of the OI process, by eliminating the requirement for discovery and experimentation and reducing unproductive courses of action.

Third, knowledge permeability played a key role in supporting organisational adaptability, especially during times of crisis. This was also observed when individuals shared knowledge of suppliers and component alternatives prior to and during OI processes. Individuals were then able to quickly diffuse knowledge across the board, R&D and purchasing which impacted the speed and accuracy of management, development and purchasing decisions *"the laboratory and purchasing work in unison to source raw materials. This alliance of both chemical expertise and global supply issues, and good communication means we get the correct product, at a good price and in a timely manner."* (Purchasing Manager). In support of knowledge permeability, individuals across the board and R&D developed and maintained close relationships with current and historical suppliers, trade associations and industry groups that held knowledge about suppliers, component technologies and alternatives.

In summary, knowledge permeability contributed to Alpha's agility by supporting OI projects that led to an expansion of the product portfolio. Knowledge permeability allowed knowledge to span epistemic boundaries in support of organisational adaptability. This enabled quick decision making to occur prior to and during OI processes. Further, knowledge permeability supported both knowledge-base reappraisal and decisional precision. The diffusion of historical knowledge from information archives or employees was used to make more accurate judgements and decisions during OI, and subsequently enhance the efficiency of the OI process.

4.5.3 Knowledge-Base Reappraisal

Alpha also demonstrated an ability to effectively combine historical facts, present individual and higher-level organisational experiences, and future NPD expectations. We refer to this as knowledge-base reappraisal. Our data revealed that developers leveraged knowledge-base reappraisal during OI processes that occurred at a time of crisis. This was achieved by drawing on historical knowledge of past projects to inform present decisions, *"Formulator knowledge and experience is invaluable in terms of reducing development time, as they can draw from past experience and learn from previous mistakes when developing new products."* (Business Development Director). Alpha's existing product portfolio complemented knowledge-base reappraisal, because existing products provided developers with further product knowledge resources to draw from, *"A varied product portfolio can help, sometimes a stop-gap situation can occur whilst we develop a new product, or we have a start point with an existing product and a new product is developed following customer feedback from evaluation of the existing product."* (R&D Manager). Knowledge-base reappraisal required a great depth of historical knowledge and facts to draw from, the ease of access to information and a good understanding of current-day issues. In support of

knowledge-base reappraisal, Alpha demonstrated a well-developed knowledge-base consisting of archive formulations, past-experiences, and long-term staff.

Knowledge-base reappraisal played a key role while engaging in OI projects. For example, Alpha leveraged OI to obtain technical knowledge and experience from suppliers to transform historical facts and present knowledge in pursuit of new knowledge *"new developments may start with an idea from a development chemist, or a historic formulation, in cases like these, our suppliers still play a pivotal role in terms of the time taken to develop products, as we still need to obtain samples and technical information."* (R&D Manager). Further, in each project, developers had leveraged customer knowledge that was subsequently combined with existing knowledge to determine the appropriate adjustments and refine the development process, *"we usually have a good understanding of what the customers want and this might be based on what we have done in the past, but it doesn't always work out. More often than not, we include the customer to find out more about their usage or application methods, and this helps to get the product precisely where the customer needs it to be."* (Product Developer). Consequently, OI was seen to play a pivotal role in NPDs, since the speed and relevance of information impacted the speed of the new development and therefore reduced time to market. This required Alpha to have developed good working relationships with customers and suppliers to gain access to valuable knowledge resources.

Knowledge-base reappraisal and Alpha's product portfolio had a mutually reenforcing relationship because individuals' knowledge of existing products provided ideas and technical knowledge about potential functionality, which contributed to a more efficient development process. Both of which increased the chances of development success. As one informant noted, *"[New Product] was developed directly from a project to create an alternative to [Historical Product] that was cancelled due to lack of customer interest over 3 years ago. Without prior knowledge of the work done, we could have reinvented the wheel*

and spent months developing the new product, instead we had a ready-made solution more or less ready to sample when the new development project was created." (R&D Manager). Moreover, being able to appraise historical facts such as those associated with what has previously worked or not worked aided decisions that directly influence the portfolio size. In one example studied, Alpha had decided to sell a range of products as a system to distributors as opposed to dealing directly with customers to enhance agility and efficiency.

Finally, knowledge-base reappraisal impacted Alpha's decisional precision since the ability for individuals to reappraise historical knowledge served to support the firm in eliminating avenues that have been tried previously during OI projects and not worked or build on successful approaches of the past. As one informant noted, *"Knowledge again is the key, whether that is a developer's knowledge of the technical attributes of raw materials, or historic formulations and also trusted suppliers that either have test data or a track record within a certain area."* (R&D Manager), resulting in more precise decisions (higher efficiency).

4.5.4 Product Portfolio Elasticity

Our analysis of two major crises revealed that Alpha had developed an ability to expand and reduce its product portfolio in response to market conditions. We refer to this ability as product portfolio elasticity, contributing to Alpha's strategic agility by playing a key role in value capture. Expanding the size of the firm's product portfolio through successful new product developments was advantageous to the firm as it represented the ability of the firm to quickly take advantage of new opportunities. For instance, Alpha had increased its portfolio size by 31.77% between the years 1999-2017 and by 17% between the years 2017-2020. However, while 2727 products were successfully developed and integrated with the portfolio

through both periods, the portfolio had only increased in size by 428 products. This was because Alpha had also utilized product rationalization as a value appropriation strategy to protect margins. As one informant revealed Alpha's strategy during crisis had involved, *"Rationalizing of the product portfolio and a production focus on higher margin products and customers"* (Marketing Manager). While our analyses revealed several strategies to reduce the size of the product portfolio, a key outcome of most measures was to improve customer service. Indeed, one of the most prolific strategies was to reduce the product portfolio by directing smaller customers to distribution partners, which also helped maintain, and in some instances improving customer service*, "the [system innovation] allowed us to pass some of our smaller customers across to our distribution partners… reducing the number of accounts by transferring the smaller accounts to distribution partners improves the service levels and turnaround time for those customers."* (Sales Director).

Alpha's use of OI processes in conjunction with their existing portfolio meant that Alpha was reliant on customer and supplier knowledge. Between 1999 and 2017, Alpha had actively reduced the number of customers by 37.79%, directing most to distributors and other suppliers (Table 13). During this period, the number of suppliers to the firm increased by 47.85%. However, more recently, between 2017 and 2020, Alpha increased the number of customers by 29.59% while supplier accounts reduced by 42.08%. One informant suggested the number of suppliers was proportionate to the number of products and customers, "*the main driver for the amount of suppliers we actively used was due to the products we were making. This in turn was due to our customer profile."* (R&D Manager)". Our data revealed the number of suppliers had reduced while customers and products had increased over this period. However, a subsequent enquiry revealed this was a function of supplier consolidation. Another informant suggested the firm's portfolio size impacted the firm's agility and flexibility, *"The vast number of products produced at Alpha brings about a great deal of*

choice for our sales team and also our customers. However, this reduces the agility and flexibility across the business. An ongoing rationalization programme is improving our position, however it is very much the desire of both the shareholders and management team to operate across a multitude of business areas to remain agile." (Sales Director).

Table 13: Customer and Supplier Accounts, Portfolio Size and New Products Developed

	Customers	**Suppliers**	**Customer Supplier Ratio**	**Portfolio Size (Unique Products Sold)**	**New Products Developed (yearly average)**
1999-2017	37.79% reduction	47.58% increase	58.01% reduction	31.77% Increase	2210 (116),
2017-2020	29.59% increase	42.08% decrease	55.40% increase	17% increase	517 (129),

Maintaining many customer and supplier relationships was said to be resource intensive as it required individuals to continually refresh relationships with external actors by building trust and loyalty. In contrast, maintaining relationships with fewer customers and suppliers required fewer resources and the opportunity to build a more intimate relationship. However, there are some drawbacks to fewer relationships. As one of our informants noted, *"the obvious downside to fewer suppliers and customers is fewer sources to turn to during development projects. I think our firm recognized this and has tuned our customer-supplier relationships to the sweet spot that enables us to quickly access a wide range of knowledge without the huge overhead associated with managing a very high number of customer/supplier relationships."* Thus, emphasizing that Alpha strategically controlled the number of customers and suppliers in support of OI-SA relationship which provided quick access to required knowledge during the product development process.

The role of product portfolio elasticity was important to enhancing Alpha's knowledge-base reappraisal and decisional precision. This resulted from the quantity of knowledge reference points that could be drawn from when developing new products. To manage this, the portfolio was expanded by adding new products and reduced by archiving

historical formulations. As one informant noted, *"some developments can be completed quickly if a small alteration to an existing product is required."* (R&D Manager). However, this required a working memory of historical products and archive formulations that Alpha facilitated through the retention of experienced employees and knowledge permeability. As one informant noted, the role of both people and knowledge was essential in contributing to portfolio elasticity, *"People and Knowledge – usually through experience – what have we done historically and what is currently available."*. In sum, product portfolio elasticity was influential to the firm's agility. To enhance agility, Alpha controlled the number of customer and supplier relationships while continually renewing and maintaining their portfolio in support of knowledge-base reappraisal.

4.5.5 Decisional Precision

In two periods of crisis, Alpha demonstrated an ability to make precise technical and market related decisions during NPD. We refer to this ability as decisional precision. In response to market opportunities, decisional precision impacted Alpha's ability to quickly develop new products and take advantage of new opportunities, *"The key here in terms of speed and agility is the relationship developers or Alpha have with their suppliers to quickly source the correct raw materials for a project"* (Product Developer). At Alpha, however, decisional precision was expressed in their deeply rooted understanding of what can be achieved and what cannot be achieved by using their existing resources (in different ways), including market and technical knowledge. As such, knowledge permeability and knowledge-base reappraisal both supported decisional precision.

In one of our example projects, Alpha demonstrated decisional precision when a product developer turned to existing formulations to assess similarities and differences between a newly identified opportunity, *"We looked into some of our existing [products] to see whether we had anything that would fit the bill. We didn't. This was like a more advanced*

requirement that needed better corrosion resistance." ... "meaning we were able to eliminate certain raw materials from the get-go." (Product Developer). Further, Alpha demonstrated that decisional precision was enhanced through OI when individuals leveraged the relevant external technical and market related knowledge from suppliers and customers. One example of OI enhanced decisional precision occurred during the same project *"We were then able to go to our suppliers and explain to them what hasn't worked and this allowed them to provide us with better recommendations."* (Product Developer). The types of external knowledge that supported decisional precision included technical start-point formulations as well as market-related knowledge of component technologies, *"the supplier may actually know the market far better than Alpha or the developer as they may have serviced the market for years, if that is the case, then we tend to be guided by our suppliers that can often provide case studies, test results and start point formulations."* (R&D Manager). However, customers were also important contributor to decisional precision by supplying product feedback and knowledge of product applications, which enhanced Alpha developers' market knowledge and understanding, *"Being in development, feedback from customers is key to producing products that meet their requirements. Without this information we cannot see how our [products] fit their unique circumstances and where we can improve that fit."* (Product Developer). In support of decisional precision, Alpha had developed relationships with customers and suppliers. Both technical and market knowledge gained through OI working in combination with knowledge-base reappraisal quickened Alpha's development process by reducing the time taken to find knowledge and by reducing the need for 'trial-and-error' type development activities.

Our analysis further revealed that in addition to being an important activity during OI, decisional precision enhanced SA via organisational adaptability. Our data shows that being able to make precise market and technical decisions helped Alpha to make quick and accurate

decisions in response to emerging opportunities: *"One of the biggest strengths is the speed of our decision making both commercially and technically which is a tremendous advantage of corporate businesses and is always appreciated with our existing and potential customers"* (Sales Director). Thus, enabling Alpha to focus resources on a fewer number of more precise activities required in the response formulation.

4.5.6 Organisational Adaptability

Alpha also demonstrated an ability to quickly facilitate responsiveness to emerging situations through the malleability of the organisation's infrastructural elements which had implications for the OI-SA relationship. While structural elements remained rigid, enacting changes to the inner workings of the organisation such as people, machines, equipment, processes, and systems enabled Alpha to accommodate responses to new opportunities. For example, to accommodate one OI project, one informant reported, *"the product balance across the business completely changed and we created temporary new production lines to support the areas where demand grew. With the flexibility of the company as a whole and the people we managed to manufacture and supply all of our customers including those unknown to the business only a few weeks previously."* (Questionnaire Respondent).

To facilitate organisational adaptability, Alpha developed multi-skilled employees with can-do attitudes and willingness which enabled labour to be redeployed to new and/or developing areas of the organisation during periods of change, *"We aim to have multi-skilled people across the business which enables the management to move people around very easily to areas where the need is greatest."* (Sales Director). In support of organisational adaptability, Alpha also leveraged cross-functional teams and afforded managers a high degree of autonomy as at the team level, individual and localised decisions engendered coordinated and consistent changes in activities in and across several functions due to the cross-functional nature of the teams, *"Our innovative development team and can-do attitude*

from our production team coupled with flexible infrastructure ensures we can adapt very quickly." (R&D Manager). At the managerial level, autonomous decisions helped increase the speed of change and responsiveness to emergent needs, hence contributing to the firm's agility. *"We have a very close management team that is characterised by a 'can-do' attitude, with a high degree of autonomy to make dynamic decisions. The team is cross-functional and allowed the process (of reconfiguration) to be conducted at speed"* (Questionnaire Respondent).

Organisational adaptability was preceded by Alpha's ability to sense change. This ability was a function of rich market knowledge, frequent communication within the organisation and good relationships with customers and suppliers, all of which were supported through OI. Our data demonstrated organisational adaptability occurred after cohesive judgement, as cohesive judgement facilitated collective and decisive action to occur. Through organisational adaptability, Alpha was able to take advantage of new opportunities through rapid development of targeted new products. During one OI project and while existing business was in a depressed state, *"the firm diverted resources towards the production of the [new product]."* (Sales Director). Taking advantage of this new opportunity increased the total number of products in the portfolio, while the number of products actively being manufactured and sold were reduced for a period. Having a flexible infrastructure therefore supported product portfolio elasticity, since the flexibility and versatility of infrastructural elements enabled the redeployment of vital resources in support of new opportunities and OI projects during a time of crisis. High flexibility in manufacturing and in-house systems enabled Alpha to accommodate new products that differed from the existing products such as new labels, packaging, and volumes.

Finally, organisational adaptability required a good understanding by managers and individuals about the impacts of change. This was facilitated by knowledge permeability and

cohesive judgement that diffused knowledge and underpinned managerial decisions about whether to act on a new opportunity. Further, Alpha also encouraged knowledge permeability by rotating staff giving rise to multi-skilled individuals. Having such a flexible workforce enabled employees to easily and quickly gain an understanding of different roles and perspectives within different organisational functions. Thus, aiding the transfer of knowledge between employees and within intra-organisational knowledge domains.

4.6 Discussion

We began this paper by highlighting a research gap concerning OI-SA intra-firm relationships and how shedding light on this theoretical blind-spot will aid our understanding of how firms can leverage OI and exhibit SA effectively. In answering our research question "What are the underlying microfoundations that support the interplay between OI and SA?" and using our empirical data, we developed a model (Fig. 7) that illustrates six microfoundations that underlie the relationship between OI and SA. Following, we discuss the processes through which these microfoundations interplay resulting in a firm-level OI-SA capability that was facilitated by the development of new technological innovations. We also discuss the implications for OI and SA research.

Implications for OI-SA Research

Firms require strategic agility to remain flexible and adaptive to exogenous changes in pursuit of competitive advantage. In developing our understanding of firm-level SA, existing research has conceptualised the dynamics of SA (Doz and Konosen, 2008), key capabilities (Weber and Tarba, 2014) and microfoundations that reside within managerial abilities (Doz, 2020). However, while each of these perspectives offers insight into firm-level SA, our study builds on existing research by establishing empirically how OI complements a firm's SA through intra-organisational processes and conditions that underlie the OI-SA relationship.

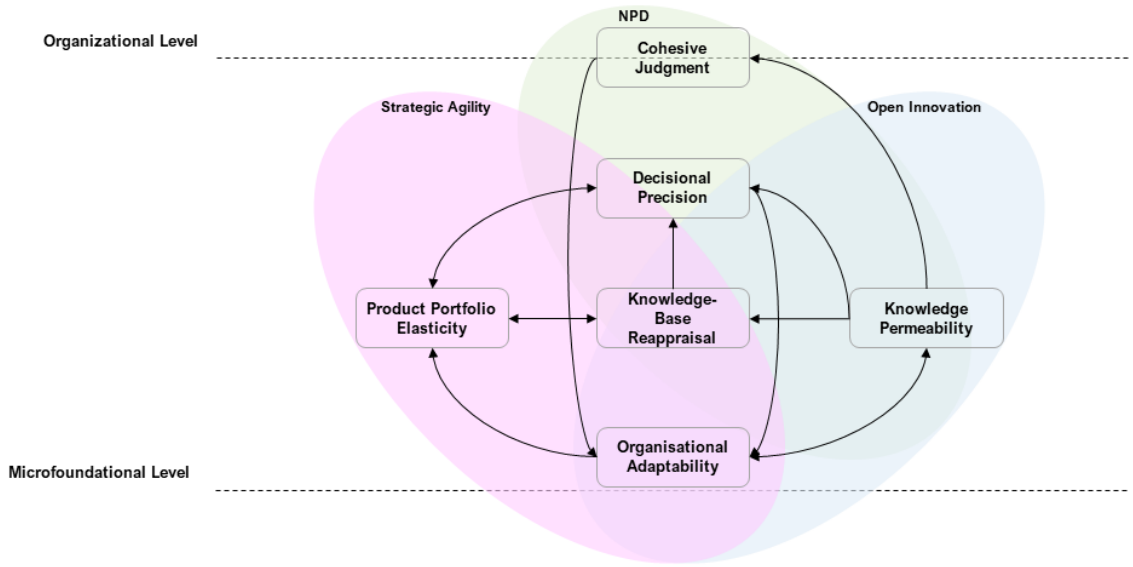

Figure 7: Microfoundational Model Linking OI and the Firm's SA

Our findings reveal that in support of SA, firms can leverage OI to complement innovation activities by drawing on knowledge resources outside the firm's boundary. Effective OI can lead to technological innovations that enhance the firm's portfolio in response to exogenous market changes. However, as our findings demonstrate, maintaining a larger product portfolio is more resource intensive and can negatively impact agility and flexibility. In contrast, while a smaller portfolio may be less resource intensive to manage, it may inhibit the effectiveness of combined OI-SA. This is a consequence of the balance between a less diverse knowledge base to combine external knowledge resources with and the availability of external knowledge resources to draw from. Hence, we argue that portfolio elasticity complements the OI-SA relationship, and the portfolio size has implications for this relationship. Our findings build on existing research associated with the cost of individual knowledge search (Laursen and Salter, 2006; Salter et al., 2015) that can affect firms OI adoption and the role of intra-organisational knowledge networks (Foss et al., 2011) in reducing search costs. More

specifically, in support of the OI-SA relationship, strong horizontal and vertical intra-organisational knowledge networks facilitate individuals' access to dispersed knowledge situated outside the firm boundary, resulting in a more efficient search process. However, we suggest firm size is a key factor that impacts this relationship, as knowledge may be more widely dispersed in larger organisations.

Existing research has also emphasised the role of strategic sensitivity in anticipating strategic situations so that firms can deploy resources in response (Doz, and Kosonen, 2008; Doz and Kosonen, 2010; Doz 2020). Firms that leverage OI in pursuit of product innovations can benefit from continual exposure to external actors to derive market and technical knowledge (Hutton et al., 2021) that can increase the firm's sensitivity to environmental opportunities (Nayak et al, 2020). However, to maximise the impact of OI derived strategic sensitivity, we illustrate knowledge permeability as a microfoundation responsible for the diffusion of externally sourced market and technical knowledge through the firm's intra-organisational knowledge networks. Our findings build on existing research (Foss et al., 2011) by establishing the role that formal and informal communication mechanisms play in enabling the senior leadership team and lower-level functions to understand both the implications and requirements of new opportunities. Thus, reducing the potential risk associated with OI adoption and increasing the agility and performance of NPD projects (Lill and Wald, 2021). Further, in support of strategic sensitivity, we reveal the role of the firm's existing knowledge in supporting knowledge integration by facilitating the cross-fertilisation of historical, present, and new to the firm knowledge. However, this requires firms to make a conscious effort to retain knowledge and experience through long-term employment and information archives.

Collective commitment and resource fluidity are concerned with the implementation of appropriate resource redeployment in persuit of new strategic opportunities (Doz, 2020).

This requires managerial agreement and subsequent actions that are influenced by a combination of aggregated managerial forces. In support of the OI-SA relationship, our findings advance our understanding of collective commitment by establishing the role of *cohesive judgement*. Creating a shared understanding of new opportunities, requirements, and roles at the organsiation-level using formal and informal communication mechanisms created alignment and unification across the senior leadership team and lower-level functions. However, we also reveal the vital role that knowledge permeability plays in enabling the diffusion of knowledge across epistemic boundaries in support of understading the implications and requirements of a new OI project.

The literature has also emphasised the importance of speed for firms looking to keep up with environmental change (Prange, 2021) and for the implemention of NPDs (Teece et al., 2016). In support of the OI-SA relationship, we highlight the critical roles of *decisional precision* and *organisational adaptability* to the implemention speed of strategic initiatives through NPDs. While decisional precision allows individuals throughout the organsiation to reduce trial and error approaches and discovery processes, the malleability of organisational infrastructural elements accomodates the implementation of new initiatives through NPD. While existing research associated speed with the SA concept, there is a paucity of research that addresses the speed dimension of SA. Firms that are able to make accurate market, technical and commercial related decisions are better positioned to exhibit agility. The decision making process can be enhanced through OI related knowledge flows when intra-organsiational conditions support knowledge retention, diffusiion and integration. We argue firms with such conditions combined with the autonomy and malleability to act on new opportunities will experience more efficient innovation processes.

Finally, our research develops our understanding of the OI concept by offering an alternative but complementary perspective to firm-level OI studies (West et al., 2014; Bogers et al.,

2017). Increasingly, consideration is being given to the microfoundations of OI (Salter et al., 2015; Dahlander et al., 2016; Bogers et al., 2018). Our study contributes to OI microfoundational research by considering the impact of OI activities on organisational SA. Our study offers an activity-level perspective (Johnson et al., 2003) that spans multiple levels within the firm providing insight into aggregating mechanisms that give rise to a firm-level capability. In doing so, we reveal the underlying architecture that enables OI and SA to co-exist and give rise to a firm-level OI-SA capability.

4.7 Conclusions and limitations

At the start of our research, we set out to explore the interplay between OI and a firm's SA with the view that the concepts were complementary. Through careful examination of a firm's activities, we have identified six microfoundations that underlie the relationship between OI and a firm's SA allowing both to co-exist and give rise to a firm-level capability. Our study contributes to the growing body of OI research (Dahlander and Gann, 2010; West et al., 2014) by empirically linking these two important firm-level concepts through their microfoundations. In doing so, we advance our understanding of OI (Bogers et al., 2017) and SA microfoundations (Doz, 2020) by revealing the organisational conditions and activities that contribute to their actuality. Further, we have positioned the microfoundations in relation to existing OI and SA literature and discussed the implications for these theories.

While our case-study offers a rich insight into organisational activities, our study does have several limitations that may open some avenues for future research. The organisation central to this study is a single entity within an industry setting. Although our study was rigorous and theoretically underpinned, the organization may have some unique characteristics that require additional explanatory factors. For example, while we have not explicitly theorised the ownership structure of our case company—a family-owned firm— recent research

demonstrates vast opportunities to explore the implications of “openness” and the boundary work of family businesses (Lambrechts et al. 2022). However, our more general approach allows future studies to build on our work by examining multi-level activities that relate OI and SA within a variety of organizations. This offers an opportunity to develop models and insights into the relationships between OI and SA in firms that range in size and operate within different industry settings. Indeed, our focus on SA in the context of OI could be refined further by exploring the microfoundations of other forms of agility, such as workforce agility (Franco and Landini, 2022) and flexibility (Brunswicker and Schecter, 2019) in relation to OI.

Chapter 5: Discussion and Implications

This chapter discusses the theoretical and managerial implications of this study. I begin with a summary of contributions that each research paper makes to each research field by using a microfoundations lens (Table 14). The first paper established a relationship between open innovation and a firm's dynamic capabilities by uncovering three mechanisms through which open innovation processes result in resource and capability creation. In doing so, paper one develops our understanding of how open innovation contributes to a firm's dynamic capabilities by supporting a firm's sensing and seizing abilities. Paper two extends existing links between open innovation and a firm's dynamic capabilities by considering open innovation processes in conjunction with resource bundling activities, dynamic managerial capabilities and organizational supporting conditions and mechanisms. In doing so, paper two resulted in a framework for understanding the context and individuals' activities through which open innovation contributes to a firm's dynamic capabilities. Paper three further builds on our understanding of how open innovation contributes to resources and capabilities by revealing the interplay between open innovation and a firm's strategic agility. Paper three resulted in a framework for understanding organizational supporting conditions and mechanisms that underlie the open innovation – strategic agility relationship. In doing so, paper three helps to shed light on how open innovation impacts the speed of resource and capability creation. Subsequently, I discuss, the implications of each paper for open innovation, dynamic capabilities, and strategic agility literatures in more detail. This is followed by an overview of the managerial implications of this study. The chapter concludes with limitations and avenues for future research.

Table 14: Summary of most Salient Contributions from each Research Paper

	Paper 1	Paper 2	Paper 3	Corresponding Literature
Overall Contribution	Used a microfoundations lens to develop a model for understanding how open innovation processes contribute to a firm's dynamic capabilities.	Used a microfoundations lens to develop a framework for understanding organisational conditions and individuals' activities that support open innovation processes in contributing to a firm's dynamic capabilities.	Used a microfoundations lens to develop a framework for understanding the organisational conditions and activities that support the interplay between open innovation and a firm's strategic agility.	
Open Innovation	Contributes to our understanding of how open innovation relates to other firm-level concepts			Vanhaverbeke and Cloodt, 2014; Bogers et al., 2019.
	Contributes to our understanding of the intra-firm factors and the multi-level nature of open innovation.			Chesbrough et al., 2006; West et al., 2014; Bogers et al., 2017; Dahlander et al., 2021.
	Contributes to the growing body of open innovation literature that examine microfoundations.			Du et al., 2014; Salter et al., 2015; Dahlander et al., 2016; Lopez-Vega et al., 2016; Ahn et al., 2017;

			Bogers et al., 2018b; Rangus and Černe 2019.
Dynamic Capabilities	Contributes to dynamic capabilities research by linking open innovation to a firm's sensing and seizing mechanisms through empirical research. In addition, uncovers organisational supporting mechanisms and activities that contribute to the development of resources and capabilities.		Teece et al., 1997; Helfat et al., 2007; Teece 2007; Teece, 2014; Teece, 2016; Teece, 2018b; Teece, 2023.
	Contributes to research concerning the antecedents and outcomes of dynamic capabilities and links open innovation to dynamic managerial capabilities and the development of the non-cognitive substrate of individuals.		For a comprehensive literature review of antecedents and outcomes, see Schilke et al., 2018; Adner and Helfat, 2003; Helfat and Martin, 2015; Helfat and Peteraf, 2015); Nayak et al., 2020
Strategic Agility		Contributes to existing strategic agility literature by establishing microfoundations to explain the conditions and activities that support the interplay between open innovation and a firm's strategic agility.	Doz, and Kosonen, 2008; Doz and Kosonen, 2010; Doz, 2013; Weber and Tarba, 2014; Doz 2020;

5.1 Implications for Open Innovation Research

This thesis began by highlighting two tenets of existing open innovation research that have led to an important research gap. First, the greatest proportion of open innovation research has considered the firm as the object of study (West et al., 2014; Bogers et al., 2017), while less consideration has been given to the intra-organisational factors concerning open innovation. Second, owing to the manner in which the open innovation concept emerged, the relationship between open innovation and other firm-level concepts such as dynamic capabilities and strategic agility are yet to be empirically established (Vanhaverbeke and Cloodt, 2014). Research in this thesis addressed these research gaps through three research papers with each paper offering new insights. Following, I discuss contributions to open innovation literature from each paper.

While these studies provide useful insights, this thesis complements this growing body of microfoundational research through examination of the open innovation process from a resource-based perspective to understand how open innovation leads to resource and capability creation (Barney, 1991). In doing so, paper one reveals three microfoundations that imbue activities embedded within the open innovation process: i) realization of capability gaps, ii) engaging in external search and iii) knowledge appropriation. These microfoundations relate open innovation to the dynamic capabilities framework through sensing and seizing capacities by revealing how the aggregation of process-level activities leads to the creation of new resources and capabilities.

While the existing literature has conceptually linked open innovation and dynamic capabilities by relating the benefits of sensing and seizing capacities to open innovation effectiveness (Bogers et al., 2019), paper one affords new insights into the role of open innovation in support of sensing and seizing capacities through empirical analysis. First, firms that adopt open innovation benefit from being in close proximity to external actors that

can lead to the realization of critical resource or capability gaps during the search for and appropriation of external knowledge. Thus, engaging in open innovation processes is effectively a sensing mechanism that can lead to the identification of new opportunities when customers become aware of the focal firm's capabilities and/or the focal firm becomes aware of unmet needs and requirements of the customer. As such, paper one reveals the impact of open innovation processes on the individual's cognition by focusing attention that can have positive strategic implications (Eklund and Mannor, 2021) and by revealing behaviour modifications as a mechanism that contribute to individual-level ideation (Salter et al., 2015). Second, prior studies have positioned inbound and outbound knowledge flows as firm-level mechanisms that grant access to knowledge resources situated outside the firm boundary (Dahlander and Gann, 2010; West and Bogers, 2014; Stanko et al., 2017). Paper one illustrates how individual-level knowledge flows occur as part of a cumulative learning process that builds on reciprocal knowledge and extended knowledge networks. While existing research has associated a firm's ability to recombine knowledge with increased innovation performance (Carnabuci and Operti, 2013) and considered individual-level outcomes of knowledge search in isolation (Salter er al., 2015; Dahlander et al., 2016), this study offers a longitudinal perspective of the dynamic process through which activities embedded within open innovation processes result in technical knowledge recombination and thus, contribute to a firm's seizing capacity.

In paper two, I explored the relationship between open innovation and dynamic capabilities by considering resource bundling (Sirmon et al., 2007) and dynamic managerial capabilities (Helfat and Martin, 2015). Also, by considering broader organisational conditions and activities, I reveal how open innovation processes contribute to dynamic capabilities through the aggregation of individual-level resource bundling activities that result in the accumulation of new resources and capabilities. These resource bundling activities are

underpinned by seven microfoundations: i) environmental alertness, ii) cultivating relationships, iii) exposure to knowledge variety, iv) knowledge fluidity, v) knowledge accumulation, vi) resource bundling and vii) outwards projection. Building on the microfoundations of open innovation (Du et al., 2014; Salter et al., 2015; Dahlander et al., 2016; Ahn et al., 2017; Bogers et al., 2018b), paper two reveals how open innovation processes impact resource and capability creation in two ways. First, the study reveals that engaging in open innovation processes results in new resources and capabilities by supporting new product development activities. This process results in exposure to knowledge variety and increased environmental alertness that impact an individuals' human capital and cognition and can help focus attention. Second, and more broadly, paper two reveals the mechanisms through which individual-level human capital, social capital, cognition, and the non-cognitive substrate develop during open innovation processes, including the broader organisational conditions and activities required for this to occur. While existing research has explored the impact of individual-level human capital on open innovation outcomes (Du et al., 2014; Bogers et al., 2018b), this study offers an alternative perspective that explains how resource accumulation occurs during open innovation processes. When individuals are exposed to knowledge variety during open innovation processes, individuals accumulate resources which place them in a better position to assess the utility of knowledge, and therefore enhancing their sensing and seizing capacities. Finally, this study extends Alam et al.'s (2022) study by revealing how cultivating relationships facilitates access to external knowledge during open innovation processes and encourages the development of social capital through loyalty and trust.

The transition from paper two to paper three of this thesis resulted from an important finding that concerns the impact of open innovation on the speed at which new resources and capabilities are developed. Existing research has suggested that by aligning open innovation

and the firm's business model, NPD speed can be enhanced (Zhu et al., 2020) and that NPD speed can also enhance NPD success (Cankurtaran et al., 2013). However, this can be problematic to firms that leverage open innovation in pursuit of dynamic capabilities given the complexities associated with social relationships and remote knowledge domains. While the microfoundations cultivating relationships and resource accumulation have the potential to impact the speed at which new resources and capabilities are developed, paper three addresses the problem of speed by considering the interplay between open innovation and a firm's strategic agility.

In paper three, I reveal that in support of strategic agility, firms can leverage open innovation to complement innovation activities by drawing on knowledge resources outside the firm's boundary. The resulting outputs from open innovation include technological innovations that enhance the firm's portfolio in response to exogenous market changes. The findings from this study reveal six microfoundations that explain the interplay between open innovation and a firm's strategic agility: i) cohesive judgement, ii) knowledge permeability, iii) knowledge-base reappraisal, iv) product portfolio elasticity, v) decisional precision, and vi) organizational adaptability. Paper three contributes to open innovation research by empirically linking open innovation to the firm-level concept of strategic agility through these six microfoundations. In doing so, this thesis addresses calls to link open innovation research to other firm-level concepts (Vanhaverbeke and Cloodt, 2014).

These microfoundations also have the potential to resolve some of the tensions associated with the cost of knowledge search (Laursen and Salter, 2006; Salter et al., 2015; Bahemia et al., 2018) and risks associated with agility (Lill and Wald, 2021) by revealing the role of intra-organisational knowledge networks (Foss et al., 2011) in the relationship between open innovation and strategic agility. Existing research has suggested that when firms are exposed to external knowledge, organisational design is an important consideration

to successfully capture, process and share external knowledge (Foss et al., 2013). This study reveals the microfoundation knowledge permeability is underpinned by strong horizontal and vertical intra-organisational knowledge networks and facilitates individuals' access to dispersed knowledge situated within and outside the firm boundary. Thus, resulting in a more efficient search process. In addition, while speed of product development is an important consideration for agility in environments with high turbulence (Prange, 2021), this study reveals how open innovation can impact the speed of product development. Through knowledge-base reappraisal, individuals can combine historical facts with present knowledge and future expectations to allow decisional precision and enhance the speed of product development.

5.2 Implications for Dynamic Capabilities Research

The dynamic capabilities literature emphasises that firms develop organisational processes that correspond with sensing, seizing and transformation capacities (Teece, 2007; Teece, 2014). These capacities are influenced by managerial ability to recognise new opportunities through scanning and monitoring activities (Teece, 2007). This requires firms develop a good understanding of suppliers' technologies and customer needs to align product offerings with market requirements (Teece, 2007; Teece, 2014). In support of this, organisations should aim to place individuals into close contact with their environment (Felin and Powell, 2016).

Recently, the literature has suggested open innovation processes benefit a firm's dynamic capabilities by enhancing new product developments (Teece, 2016). Open innovation places an emphasis on the use of external knowledge to enhance innovation processes (Chesbrough and Bogers, 2014). Through the use of external knowledge, firms can enhance internal innovations to meet new market opportunities (Teece, 2016). While open innovation is considered a complement to dynamic capabilities, the relationship between open innovation and a firm's dynamic capabilities is conceptual in nature and lacking in

empirical grounding. Paper one and two address this research gap by linking open innovation processes to the dynamic capability's framework through empirical investigation. In doing so, this thesis addresses opportunities to develop the dynamic capabilities framework (Schilke et al., 2018). Paper one provides insight into microfoundations through which open innovation contributes to sensing and seizing capacities resulting in resource renewal, while paper two reveals the supporting conditions and mechanisms through which resource bundling occurs during open innovation processes. Further, the framework developed in paper two reveals how open innovation leads to the accumulation of new knowledge and experience that contributes to the non-cognitive substrate of individuals within the organisation (Nayak et al., 2020). Thus, revealing the activities through which previous open innovation processes are influential in anticipating future opportunities. The knowledge and experience accumulated through open innovation better equips individuals with the resources to efficiently bundle during open innovation processes, in isolation and collectively. Thus, supporting the firm's dynamic capabilities. As suggested by Leiponen and Helfat (2011: 225) "By accessing a greater number of knowledge sources, the firm improves the probability of obtaining knowledge that will lead to a valuable outcome". This thesis empirically distinguishes the mechanisms underpinning this claim.

By integrating open innovation with the dynamic capabilities' perspective through empirical research, paper two resulted in a framework to illustrate the microfoundations through which resources are accumulated during open innovation processes, and how open innovation sharpens environmental alertness. In doing so, this study sheds light on the feedback effects that occur during open innovation engagements that relate to the dynamic capabilities sensing and seizing capacities. Hence, this thesis reveals the benefit of open innovation processes are not limited to the resource and capability renewal associated with product innovations but encompass the feedback effects associated with the proximity

between a focal firm and external actors. Finally, this framework extends research by Salvato (2009) by revealing the mechanisms through which resource and capability heterogeneity originate. As such, this study broadens the scope of resource and capability renewal to encompass how open innovation processes enact changes to the firm's resource base. Thus, complementing the existing studies that focus on what dynamic capabilities are and why they are important (Teece, 2007; Teece, 2014).

5.3 Implications for Strategic Agility Research

This thesis also has implications for strategic agility literature. Existing research has conceptualised the dynamics of strategic agility (Doz and Konosen, 2008), key capabilities (Weber and Tarba, 2014) and identified microfoundations of strategic agility that reside within managerial abilities (Doz, 2020). These microfoundations correspond with strategic sensitivity, resource fluidity and collective commitment. While existing research highlights activities through which open innovation may contribute to strategic agility such as crowdsourcing and ideation (Gatzweiler et al., 2017) competing business models (Demir and Angwin, 2021), enhanced market knowledge and understanding (Coviello and Joseph, 2012) and knowledge of product preferences (Poetz and Schreier, 2012), the literature is yet to directly consider the role of open innovation processes in contributing to strategic agility. Paper three addresses this gap empirically, and in doing so, provides a complementary alternative to managerial abilities that have been linked to strategic agility. A framework was developed to illustrate the interplay between intra-organisational conditions and activities that enable open innovation and strategic agility. This framework illustrates how strategic sensitivity is supported by knowledge permeability by diffusing externally sourced market and technical knowledge through the firm's intra-organisational knowledge networks. In addition, paper three reveals the role of the firm's existing knowledge in support of

knowledge integration by facilitating the cross-fertilisation of historical, present, and new to the firm knowledge.

Paper three also establishes the role of cohesive judgement in support of collective commitment. While collective commitment and resource fluidity are concerned with the implementation of appropriate resource redeployment in persuit of new strategic opportunities (Doz, 2020), both require managerial agreement and subsequent actions that are influenced by a combination of aggregated managerial forces. In support of the open innovation – strategic agility relationship, cohesive judgement is a microfoundation through which a shared understanding of new opportunities, requirements, and roles are developed at the organsiation-level. This requires formal and informal communication mechanisms in order to create alignment and unification across the senior leadership team and lower-level functions. In addition, knowledge permeability plays a vital role in enabling the diffusion of knowledge across epistemic boundaries in support of understading the implications and requirements of a new open innovation project.

5.4 Managerial Implications

While the primary objective of this research was to extend existing theory, this thesis also has several managerial implications. First, in support of a firm's dynamic capability, paper one suggests that managers can leverage open innovation as an instrument to effectuate the development of new resources and capabilities through new product developments. However, the advantages of open innovation are not limited to the outputs arising from new product developments, but the strategic benefits associated with sensing new opportunities and the potential solutions that arise due to working closely with customers and suppliers. Second, paper two provides managers with a framework for understanding the organisational conditions and activities that support the relationship between open innovation and a firm's dynamic capabilities. The framework highlights the importance of developing environmental

alertness through exposure to knowledge variety and illustrates the importance of building relationships with internal and external actors to facilitate access to useful knowledge resources. Finally, paper three provides managers with a framework that can be used to understand how open innovation can be leveraged in support of strategic agility. This framework provides managers with insight into the relationship between existing knowledge and historical knowledge and how this can impact the accuracy of strategic decisions. Paper three reveals that this relationship can be supported by encouraging staff rotation and long-term employees. Once new knowledge and competences have been developed, managers can use tools to enhance value capture by projecting competences outwards. Finally, by combining open innovation with strategic agility, the framework reveals benefits to the speed at which firms can develop new product innovations.

5.5 Limitations and Future Research

Although the author made every effort to conduct a rigorous study that was theoretically underpinned, as with all research, this thesis is not without limitations. The data from this study were obtained from a single manufacturing organisation operating within a specific industry sector. While it is the author's belief that context is an important factor when considering firm concepts such as open innovation, dynamic capabilities, and strategic agility, it is entirely possible that the firm central to this study has some unique characteristics that are not transferrable to other firms or industry settings. However, this research has also identified a number of mechanisms and relationships that can be explored in different contexts to further shed light on the relationship between open innovation and a firm's dynamic capabilities. For example, paper one revealed the existence of a relationship between inbound knowledge flows and a cognitive process that resulted in a new idea, a subsequent behaviour modification and a reciprocal outbound knowledge flow. Examining this relationship in different settings has the potential to shed light on the effect of external

knowledge on individual-level cognition and the circumstances which may result in a more or less favourable outcomes.

Another example revealed during paper two concerns cultivating relationships and knowledge fluidity as supporting mechanisms through which open innovation contributes to dynamic capabilities. These mechanisms may be affected by firm size that has implications for the use of this framework to understand the relationship between open innovation and dynamic capabilities in larger firms. Indeed, as suggested by Brunswicker and Van de Vrande (2014), innovation processes in smaller firms may differ from those in larger firms which can have implications for innovation speed and decision making. However, examining these relationships in larger firms can potentially explain some of the differences in open innovation related performance outcomes such as those arising through dynamic capabilities. Finally, paper four highlights the relationship between portfolio size and the firms existing knowledge base in support of strategic agility, both of which may be impacted by firm-size and industry setting (Xiao et al., 2021). However, this also provides some direction for future research that can explore the frameworks in different industry settings and firm contexts. Future studies could elaborate on the relationships between the mechanisms identified, or groups of elements of our model in other settings. For example, these could include non-SMEs; non-manufacturing firms; firms that operate in different industry sectors; and firms that have other governance and ownership structures.

Finally, this research has focused on an essential organisational process, namely that of new product development. However, other distinct mechanisms of inbound, outbound and coupled open innovation processes exist, and all of these can potentially contribute to the firm's dynamic capabilities in diverse ways. The more general approach to framework development adopted by this thesis allows future studies to build on this work by examining

multi-level activities that relate open innovation with other firm-level concepts within a variety of organizations, using a variety of open innovation mechanisms.

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