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You Have to Play to Win: Value Capture in Open Innovation

John T. Pritchard
University of Denver

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Next, an empirical analysis is conducted using an unbalanced panel of 3002 firm-year observations in the U.S. stock market for the years 2017–2021. The analysis examines the mediating impact of knowledge, derived from externally acquired and internally developed intangible assets, on firm performance. Results of the mediation analysis show that external and internal knowledge partially mediates the effects of open innovation but require time to diffuse within an organization. This dissertation challenges previous arguments that knowledge from open innovation is free to all. Rather, it demonstrates that firms must participate for value capture from knowledge spillovers to occur.

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Paul Olk

Second Advisor

Michael Nalick

Third Advisor

Stephen Hutt

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John T. Pritchard

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Advisor: Paul Olk

Author: John T. Pritchard
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Chapter One: Value Capture in Open Innovation

Today's firms are operating within the "fourth industrial revolution," a period that is described as a blurring between the physical and digital worlds. These advances are driven from technological innovations like cloud computing, blockchain and artificial intelligence (Radziwill, 2018). With these innovations come high levels of change and uncertainty in the market (Bonaccorsi et al., 2020; Magruk, 2016). During these periods, firms seek out external knowledge and exercise dynamic capabilities to sense, seize and reconfigure (Pavlou & El Sawy, 2011; Teece et al., 1997). This has led to greater adoption of open innovation, a concept developed by Chesbrough (2003) to describe a set of practices firms use to acquire external knowledge and leverage external stakeholders to create and capture value. Open innovation is an evolution of the classic model of internal linear innovation through supply-chains (Chapman & Corso, 2005), to a distributed innovation processes where firms share a free-flow of knowledge (West & Bogers, 2014) to accelerate internal innovation (Chesbrough et al., 2006). This sharing of knowledge allows firms to leverage the technological research efforts of all participants to achieve their own innovation (Jaffe, 1986; Smith, 1995; Yan et al., 2019).

The current research in open innovation considers external knowledge resources as being freely available to all (Hoving et al., 2013) and ready to be exploited by firms (Zobel, 2017). Though we have a limited understanding of how knowledge is discovered and accessed from external sources (Dahlander & Gann, 2010) and how it flows into organizations (Spithoven et al., 2011), we lack a deeper understanding about how external knowledge leads to value capture in open innovation (Dell'Era et al., 2020). From the technology transfer literature, we know that the successful transfer requires "purposeful, goal-oriented interactions" between two or more organizations (Amesse & Cohendet, 2001). The externalizing of the innovation process therefore focuses on the relationships between firms. A key tenet in open innovation is the establishment of collaborative innovation relationships with other organizations (van de Vrande et al., 2009) through open innovation ecosystems (Öberg & Alexander, 2019) which allow for knowledge exchange with external partners (Bogers et al., 2018). Studying these ecosystems is essential to better understand how firms jointly create and capture value through external stakeholders. Research on value capture in open innovation ecosystems, however, remains largely understudied (da Silva Meireles et al., 2022; Radziwon & Bogers, 2019; Randhawa et al., 2021). The dominant focus of most prior studies has been understanding how to create value rather than how to capture it (Chesbrough et al., 2018; Sjödin et al., 2020). This is of particular importance to open innovation research given that ignoring firm performance relative to competitors neglects the impact on the downstream portions of the innovation process (West & Bogers, 2014).

This dissertation helps close this gap by first developing a research agenda and a theoretical model that explains how firms exercise dynamic capabilities to acquire and transform knowledge from open innovation ecosystems into intangible assets. In this capacity it presents a theoretical linkage between the value creation and value capture phases of the value chain. It then tests a subset of these relationships on an unbalanced panel of 3002 firm-year observations in the U.S. stock market for the years 2017–2021. It concludes with a discussion of the findings, limitations, and areas for future research.

This dissertation contributes to the open innovation research stream by synthesizing literature on dynamic capabilities, open innovation, and intangible assets to theoretically explicate the role of external and internal knowledge on the value creation - value capture process. Though there is a strong stream of research within the academic literature on open innovation, theoretical weaknesses still exist in understanding the foundation of the relationships from which a practical understanding can be pursued (Vanhaverbeke & Cloodt, 2014). Specifically, examinations of theory-based mediators and moderators on value outcomes have been understudied (Rubera et al., 2016; Wang & Jiang, 2019). This dissertation seeks to close these gaps and answer calls for more recent research on open innovation (Gerosa et al., 2021), examination of value capture from external sources of innovation (West & Bogers, 2014), and the overall value perspective in open innovation (Chesbrough et al., 2018).

Chapter Two: Value Capture in Open Innovation – Integrating Innovation and Management Literature on the Role of Knowledge

Open innovation has attracted considerable attention from researchers and practitioners since the theoretical concept was first introduced by Chesbrough (2003). It has been the subject of a rich and active literature stream across various disciplines with substantial evidence supporting positive effects on innovation (C. C. J. Cheng & Huizingh, 2014; Cruz-González et al., 2015). In practice, open innovation can be found in various industries, composed of small, medium, and large organizations. For example, in 2007, 84 firms joined together to form the Open Handset Alliance with a goal of developing open mobile device standards. Composed of hardware, software and telecommunication firms, this ecosystem would later launch the ‘Android’ operating system that now powers mobile devices worldwide[1]. Another example is the Open Source Electronic Health Record Alliance. It formed in 2009 with participants from the software industry, government agencies and government managed hospitals. This effort sought to define common approaches to digital patient data information and advance electronic health record technology (Mun et al., 2016). At the height of this effort there were “850 registered members representing 160+ industry, academic, and government organizations”. One of the longest running and most active open innovation efforts

[1] Source - www.openhandsetalliance.com/press_102108.html

is the Linux Foundation. Founded in 2000 to standardize the Linux operating system, this ecosystem would later produce the technologies that enable the cloud computing market. The Linux foundation today has over 1300 corporate firm participants collaborating on hundreds of projects[2]. These examples demonstrate how open innovation may manifest different organizational forms and lead to different linkages and systems of relationships (Öberg & Alexander, 2019).

Research on value outcomes from open innovation has been broad but a central question remains on how this business model helps create and capture value (Chesbrough, 2006; Chesbrough et al., 2018; Chesbrough & Rosenbloom, 2002; Olk & West, 2020). Previous studies have demonstrated that firms can create value through collaboration with external actors (Boudreau & Lakhani, 2011; Von Hippel, 2005; West & Bogers, 2014) where more ideas result in more opportunity to generate value through innovation (Laursen & Salter, 2006; Salter et al., 2015) and ultimately have a positive effect on product innovation (Bae & Chang, 2012). From this stream of literature, the positive effects of open innovation on *value creation* are generally accepted (Bogers et al., 2017; Chesbrough, 2003; Lopes & de Carvalho, 2018; Randhawa et al., 2016; West et al., 2014). In comparison, the positive effects of open innovation on *value capture* have been inconclusive. No consensus exists on the measures of performance or if the relationship is positive, negative, or non-linear (de Leeuw et al., 2014; Laursen & Salter, 2006; Sabidussi et al., 2014). The dominant focus of most prior studies has been understanding how to create value rather than how to capture it (Chesbrough et al., 2018;

[2] Source - www.linuxfoundation.org/about/members

Sjödin et al., 2020) and the aspects of value capture specifically are largely understudied (Dell'Era et al., 2020). An often-cited business concern is 'value slippage', when the firm that creates value does not capture it (Lepak et al., 2007). Though open innovation affords the opportunity for shared value creation, value capture is required for continued firm participation (Simcoe, 2006). Further study of value capture is of particular importance to open innovation research given that ignoring firm performance relative to competitors neglects the impact on the downstream portions of the innovation process (West & Bogers, 2014). Overall, the value perspective in open innovation is insufficiently addressed (Chesbrough et al., 2018) and the linkages between value creation and value capture are not well understood.

Capturing value in open innovation involves the acquisition of external knowledge and the creation of value through internal innovation (Boudreau & Lakhani, 2011; Von Hippel, 2005; West & Bogers, 2014). Both the dynamic capabilities view, (Teece et al., 1997) and the resource-based view (Barney, 1991) emphasize the importance of organizational knowledge processes between heterogenous firms for value creation. The knowledge-based view, an extension to the resource-based view, states that knowledge is the essential unit of value to an organization and value creation within firms is fundamentally a process to acquire and leverage knowledge (Asiaei et al., 2021). External knowledge is of specific importance to firms during periods of environmental turbulence where market uncertainty exists (Pavlou & El Sawy, 2011; Teece et al., 1997). Recent research has shown that firms who participate in open innovation gain knowledge through spillovers (Terán-Bustamante et al., 2021). From this knowledge flow, value is generated as intangible assets, from which firms extract value leading to value capture (Dell'Era et al., 2020; Moretti & Biancardi, 2020; Terán-Bustamante et al., 2021).

Knowledge exchange occurs between external partners in open innovation (Bogers et al., 2018). One of the defining concepts in this business model is the establishment of collaborative relationships with other organizations (van de Vrande et al., 2009). Described as open innovation ecosystems (Randhawa et al., 2021), these collaborative arrangements involve sets of actors with different competencies (Öberg & Alexander, 2019). By leveraging the developed research and competencies of others in an ecosystem, firms grow their knowledge stocks and ultimately their innovation performance (Ahuja, 2000). Open innovation ecosystems improve knowledge discovery and knowledge sharing of participating firms which, in turn, advances firms' innovation capability (Clauss & Kesting, 2017; Luzzini et al., 2015; Zhou & Li, 2012).

This dissertation seeks to understand these knowledge exchanges in open innovation ecosystems and attempts to theoretically explicate the linkage between value creation and value capture as phases through which firms exercise dynamic capabilities to transform external knowledge into intangible assets. The following research questions are addressed:

- What is the role of knowledge in the management literature on dynamic capabilities and open innovation ecosystems?
- What is the relationship between externally acquired knowledge from open innovation ecosystems and internally developed knowledge?
- How is value created and captured in open innovation?

Conceptual Model

This chapter adopts a strategy of concept mapping to determine and relate multiple concepts in the literature review. A concept map is a visual representation used to organize and represent knowledge to answer research questions (Novak & Cañas, 2008). The use of concept mapping enables a better understanding of the relationships between concepts across different domains. Concept mapping is done in four phases: 1) defining the research questions; 2) identifying the most important concepts associated with the research questions along with supporting authors; 3) ordering the concepts from left to right in a logical sequence; and 4) labeling the linking phrases. Per the research questions above, this chapter examines how firms exercise dynamic capabilities during market uncertainty to sense knowledge by participating in open innovation ecosystems. Firms seize knowledge gained from spillovers and reconfigure this knowledge into intangible assets. This is examined from the lens of a value process composed of two phases: a value creation phase, where value is created from open innovation ecosystem knowledge, and a value capture phase, where value is captured as intangible assets that are exploited for greater firm performance. These relationships are depicted in Figure 1.

Organization of the Study

The rest of this chapter is structured into three sections. The literature review discusses six core theoretical concepts: market uncertainty, dynamic capabilities, open innovation ecosystems, industry diversity, external and internal knowledge, and intangible assets. It then defines the value creation and value capture phases in open innovation. Next, a conceptual framework interrelates these theoretical elements to establish a set of propositions with supporting literature. Finally, the conclusion presents a discussion with managerial and research implications.

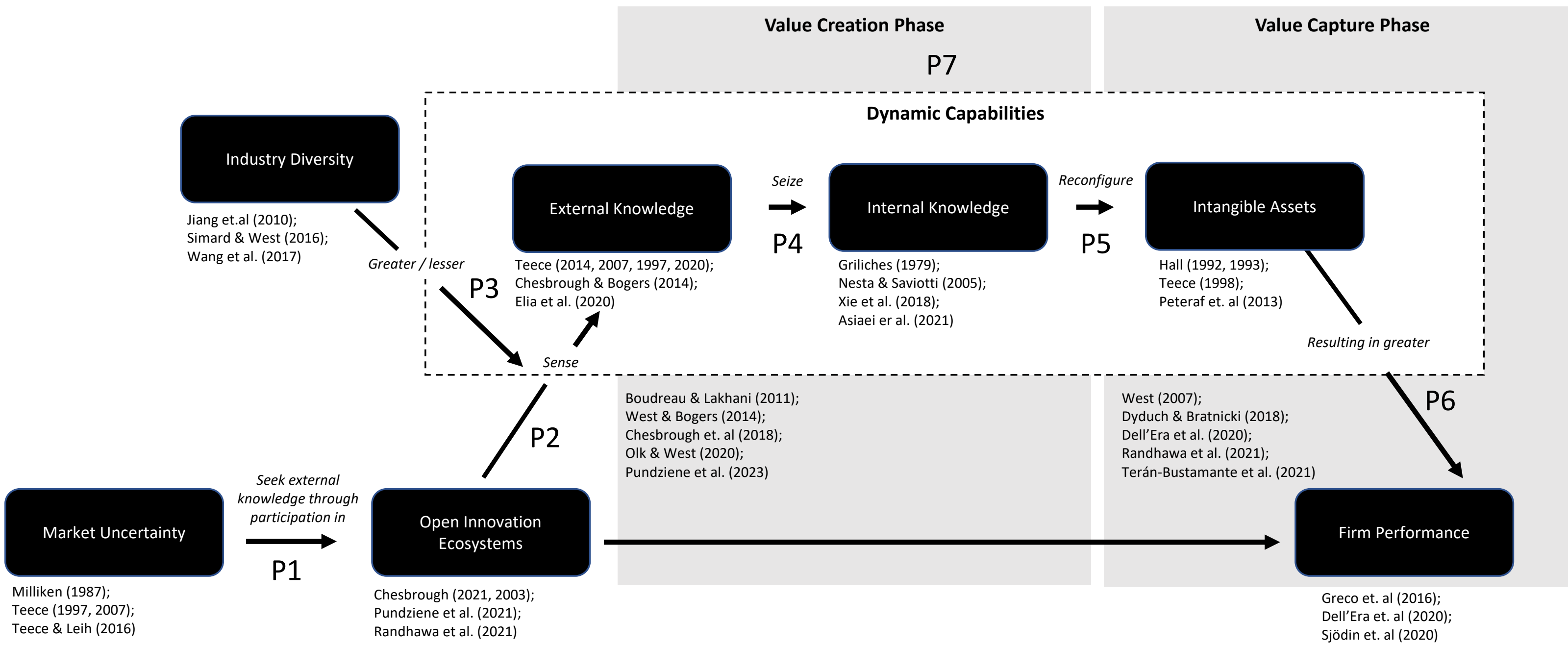

Figure 1: Concept Map

Literature Review

Market Uncertainty

Market uncertainty is defined as a general state of not knowing or a lack of knowledge about the future direction. It can be interpreted as the uncertainty that firms face, either from the rate of change in innovation or unpredictability of actions by competitors and/or customers. This limits their ability to determine viable alternatives to current and future business activities (Milliken, 1987). As managers weigh future strategic options, they face many complexities, making it very difficult to know in advance what the appropriate response should be regarding entering a given market (Leifer & Mills, 1996). Market uncertainty is caused by an unpredictable business environment and often characterized by rapid technological change and its effects on organizations (Teece et al., 1997; Teece, 2007). It has become more prevalent in recent years due to the growing interconnectedness of economies (Teece et al., 2016). In today's business environment, highly disruptive business models and rapid technological change have substantially increased the instability and complexity of the competitive landscape (Grant, 2003; Vecchiato, 2015).

Changing industry environments are often characterized by shifts in supply and demand due to disruptive technologies (Karna et al., 2016). For example, an unexpected technological innovation within the market can create new opportunities but also invite new threats, change competitive positioning, or disrupt dominant designs. These technological innovations create large-scale discontinuous changes that significantly alter production methods and outputs in an industry (Schilling, 2015). New advances from innovations may displace dominant designs (P. Anderson & Tushman, 2018) or bring technology into a new domain (Levinthal, 1998).

Market uncertainty results from several interoperating factors such a change in the size and number of organizations within an industry, and an increase in the rate of technological change and its diffusion throughout that industry (Simerly & Li, 2000). During periods with high rates of technological change, firms attempt to reconfigure their resource base (Collis, 1994; Tripsas, 1997; Wang & Ang, 2004). This can lead to the creative destruction of incumbent firms, thus allowing production factors to be reallocated to the most efficient technology delivered in new firms (Caballero & Hammour, 1996). Although market uncertainty cannot be quantified, it is assumed that firms are able to infer potential changes that may occur (Mero & Haapio, 2022).

Dynamic Capabilities

Maintaining business performance and achieving competitive advantage in dynamic environments places great importance on firm dynamic capabilities. These are a firm's ability to sense, learn, and integrate internal and external competencies to navigate environmental turbulence (Pavlou & El Sawy, 2011; Teece et al., 1997). Dynamic capabilities allow firms to adjust current strategies and develop new ones and are therefore essential elements for enhancing competitive advantage amid highly uncertain situations (Teece, 2007).

Dynamic capabilities comprise three general types of firm behavior: 1) scanning for threats and sensing new opportunities, 2) seizing these opportunities, and 3) transforming or reconfiguring existing business models and strategies (Teece, 2007). For instance, previous literature has suggested that strong sensing capabilities allow firms to detect environmental changes early, thus providing more time to react (Teece et al., 2016). Reacting can be defined as a firm's capacity to seize opportunities that were obtained during sensing activities, and reconfiguring in response (de Aro & Perez, 2021). Thus, by detecting an emerging technology or market opportunity, firms can capitalize through new products, processes, or services. Firms with these capabilities are therefore better able to successfully navigate environmental turbulence (Teece & Leih, 2016).

Researchers have argued that dynamic capabilities are critical in managing uncertainty (Teece & Leih, 2016). Dynamic capabilities are valuable during environmental turbulence (Teece et al., 1997; Teece, 2014) especially when changes in technology are frequent (Karna et al., 2016; Pavlou & El Sawy, 2011; Pezeshkan et al., 2016; Teece et al., 1997). This occurs because the continued reconfiguration of resources allows the firm to adapt to rapid technological change (Drnevich & Kriauciunas, 2011; Teece, 2014; Zahra & George, 2002). Dynamic capabilities theory states that in environments of great change and uncertainty, firms must align their strategy and capabilities to be agile (Teece et al., 2016). This view has evolved into an extensive research stream broadly espousing two main tenets: (1) dynamic capabilities contribute to firm performance (Helfat et al., 2007; Helfat & Peteraf, 2009; M. Peteraf et al., 2013), and (2) the effect is magnified in environments experiencing rapid technological change (Mero & Haapio, 2022; Salvato & Rerup, 2011; Teece et al., 1997; Teece, 2014).

External and Internal Knowledge

The knowledge-based view (Grant, 1996) is an extension of the resource-based view (Barney, 1991) and states that knowledge is the essential unit of value to an organization. The central tenant of this view is that any analysis of firms or their relationships should be done from the lens of their knowledge, resources and capabilities (Grant, 1996). Firms gain competitive advantage by harnessing the knowledge potential of their human resources to achieve organizational outcomes. Through this process, firms continuously evolve through the production and use of knowledge (Spender, 1996). From this perspective, the creation of value within firms is fundamentally a process to acquire and leverage knowledge (Asiaei et al., 2021).

Internal knowledge, especially technical knowledge, is created through a collection of search activities, R&D, and interactions with the technical community (Antonelli, 2002). Previous scholars describe this process as a knowledge-generation function (Phelps, 1966) where knowledge is the output of dedicated knowledge generating activities (Nelson, 1982) and past and current R&D efforts (Griliches, 1979). This literature stream considers internal knowledge as a stock that accumulates to form a firm's knowledge base (Nesta & Saviotti, 2005). It is this knowledge base that largely determines a firm's ability to generate innovations (Xie et al., 2018).

External knowledge, knowledge that exists outside of the firm, is a necessary input to the knowledge-generation function. External knowledge and internal knowledge that is gained from R&D are considered 'Kremer' complementaries. That is, to increase output, it may be necessary to reduce one and increase the other. Both are required, however, and neither can be reduced to zero (Kremer, 1993). Firms acquire external knowledge when they exploit knowledge that originates in other firms (Griliches, 1991). A ‘knowledge spillover’ refers to the transfer of knowledge between firms (Smith, 1995; Yan et al., 2019) where the technological research efforts of other firms are used to achieve research results (Jaffe, 1986). Knowledge spillovers can occur between partners, competitors, or firms in other industries as well as publications and technical associations (Audretsch et al., 2019).

External knowledge is an essential but complementary input into the generation of internal knowledge. Scholars describe the interplay of external and internal knowledge as a recombinant approach where the existing knowledge base of a firm is recombined with both new R&D, and complementary external knowledge, to generate new knowledge (Antonelli & Colombelli, 2015). In this view, external knowledge is a required input to the knowledge generation function and internal knowledge is a necessary antecedent to a firm’s ability to seize external knowledge. No single firm possesses all the knowledge inputs necessary to fuel the recombinant processes, thus a firm requires external knowledge from other firms.

Open Innovation Ecosystems

Historically, new ideas come from ‘closed innovation’ Research & Development (R&D) investments, where all activities involved in the innovation life cycle are performed internally. Open innovation, in contrast, is a radically different business model where firms use “inflows and outflows of knowledge” with other organizations to accelerate internal innovation (Chesbrough, 2003). In the open innovation approach, firms openly collaborate and co-develop with other firms on a common effort. No intellectual property exists. All outcomes are jointly shared and available in the public domain (Hoving et al., 2013). Firms are often willing to participate in such arrangements because there is strong appropriability of the innovation outcomes to their products (Olk & West, 2020). Firms may employ open innovation to reduce the cost of technology development, reduce the development time of products or reduce the risk of new market entry (Tidd & Bessant, 2020). Open innovation can be viewed as a somewhat linear process where firms take the products or services that are developed from the inter-firm collaboration and combine them with internal initiatives inside the organization (Randhawa et al., 2021). Thus, open innovation can be considered as a type of R&D strategy alternative along with traditional, buy, build, and partner options.

Scholars describe three types of open innovation strategies: outside-in, inside-out and coupled (Gassmann & Enkel, 2004). An *outside-in* strategy involves the acquisition of external knowledge to enhance a firm's own knowledge stocks. An *inside-out* strategy involves firms opening their internal innovation process to external participants and sharing their ideas and intellectual property. This strategy can be employed to seed new concepts into the market or establish co-development relationships with customers and suppliers. A *coupled strategy* is the combination of both inside-out and outside-in strategies where firms cooperate with other firms in strategic innovation networks by which external and internal knowledge flow freely (Gassmann & Enkel, 2004).

A key tenet in open innovation is the establishment of collaborative innovation relationships with other organizations (van de Vrande et al., 2009). These collaborative arrangements involve sets of actors with different competencies (Öberg & Alexander, 2019) which allow for knowledge exchange between participants (Bogers et al., 2018) allowing firms to combine their contributions into a “coherent, customer facing solution” (Adner, 2006). The open innovation literature characterizes these types of arrangements as open innovation ecosystems (Randhawa et al., 2021). An ecosystem is defined as a “set of actors with varying degrees of multilateral, non-generic complementarities that are not fully hierarchically controlled” (Jacobides et al., 2018). Open innovation ecosystems improve knowledge discovery and knowledge sharing of participating firms which in turn advances firms’ innovation capability (Clauss & Kesting, 2017; Luzzini et al., 2015; Zhou & Li, 2012). This type of knowledge exchange is essential for innovation (Xie et al., 2016).

In a recent systematic literature review of open innovation and collaboration, da Silva Meireles et al. (2022) found that “the decisive point for classifying an innovation as open innovation is the network of relationships between the company and other actors”. This network perspective has been predominantly examined as bilateral collaborations between firms (Chesbrough, 2003) or various typology configurations of open innovation networks (West et al., 2006). In this literature stream, the most cited papers examine network processes or measure process effectiveness. Rampersad et al. (2010) examined the management process of open innovation networks to contribute to perceptual network effectiveness. Scuotto et al. (2016) conducted a case study to understand the strategy and process for external knowledge acquisition, internal absorption and integration from open innovation networks. Wang et al. (2017) studied the efficiency of knowledge spillovers in open innovation networks and Xie et al. (2016) studied knowledge transfer performance in open innovation networks.

In comparison, the ecosystem perspective in open innovation attempts to examine the communities of actors within open innovation projects. This literature stream has focused on collaboration within the ecosystem. Farias et al. (2018) examined the role of influencers in open innovation ecosystems and which characteristics influence decision making. Lyulina & Jahanshahi (2021) studied communication and collaboration patterns among participants in open innovation ecosystems. Similarly, Hou et al. (2021) investigated how to detect the formation of communities within open innovation ecosystems based on participation intensity.

Path-breaking innovations, especially those that challenge or disrupt a dominant design, are increasingly developed in innovation ecosystems of co-creating actors (Walrave et al., 2018). Innovation ecosystems to support new product design can take the form of science-driven efforts to develop algorithms, platform constructing efforts to build foundational capabilities, or standards driven efforts whereby a consortium develops a new method. While the firm-centric approach in open innovation (Chesbrough, 2003) has dominated much of the research (Bogers et al., 2017), the ecosystem perspective highlights the innovation process through the interactions across a diverse set of actors (Bogers et al., 2017). This area of open innovation research continues to attract attention, but overall, it is still under-studied (Radziwon & Bogers, 2019; Randhawa et al., 2021; Remneland Wikhamn & Styhre, 2023).

Industry Diversity

From the literature on alliance portfolio diversity, industry diversity occurs when firms collaborate with other firms that span many different industries (Jiang et al., 2010). Industry diversity refers to the industry mix of the participants. A diverse mix can be beneficial in that it provides access to complementary resources (Dussauge et al., 2000) and new knowledge and learning opportunities (Lavie, 2007; Wassmer et al., 2017). When industry diversity is low, firms are more similar, and knowledge is more likely to be redundant and less useful. Similarly, repeated interactions with the same firms can lead to over embeddedness where knowledge between firms becomes redundant (Simard & West, 2006). As such, collaborating with firms from diverse industries, each with distinctive knowledge bases, allows firms to exploit heterogeneous technical knowledge for their own innovative purposes (Xu & Zeng, 2021).

Previous research has demonstrated that industry diversity triggers different knowledge sharing mechanisms and allows firms to exploit complementarities from other firms' knowledge bases (Grant & Baden-Fuller, 2004; Lavie, 2007). From the literature stream, industry diversity has been shown to have a positive impact on firm performance (Lavie, 2007) through the acquisition of valuable external knowledge (Hagedoorn et al., 2018).

Intangible Assets

An organization's resources can be categorized into tangible and intangible assets. Intangible assets are firm assets that do not have a physical form, such as patents, trademarks, intellectual property, and technological know-how. Hall (1992) describes intangible assets as the 'feedstock' of the four competitive capability differentials defined by Coyne (1986): regulatory differential, positional differential, functional differential and cultural differential. Broadly, these intangible resources can be classified as either assets, such as brand reputation, or competencies, such as organizational skills (Hall, 1993). Examples of assets include intangible resources within a legal context, such as contracts and trade secrets, where firms leverage legal protections to create an advantage, and thus contribute to regulatory differentials. Similarly, intangible resources outside a legal context, such as reputation and customer lists, contribute to positional differentials, differentiation that comes from previous endeavors. Intangible assets that are competencies, such as organizational culture, contribute to cultural differentials (e.g., aptitudes of the firm). Lastly, intangible assets, such as know-how, contribute to functional differentials (e.g., firm skills and expertise).

According to the resource-based view (RBV), differences in firm performance are a result of differences between firm resource endowments, namely intangible assets (Rumelt, 1984). Extensive prior literature has explored how both internally and externally generated intangible assets lead to competitive advantage (Hall, 1992; M. A. Peteraf, 1993; Teece, 1998). Intangible assets play an important role in competitive markets where firms use intangible assets such as market and technical knowledge to complement changing technologies and create competitive advantage (Hall, 1992; M. Peteraf et al., 2013). Sustainable competitive advantage is therefore a process of managing tangible and intangible resources (Aaker, 1989).

Value Creation and Value Capture in Open Innovation

Since its early definition by Chesbrough (2003), open innovation has enjoyed an active stream of literature considering antecedents, taxonomies and outcomes (Lopes & de Carvalho, 2018; Randhawa et al., 2016; West & Bogers, 2014). From a review of literature given in Table 1, the value process in open innovation has two distinct phases: value creation and value capture. Value creation is generally analyzed within the resource-based view, where the importance of dynamic capabilities is stressed (Helfat & Peteraf, 2003). Value is created through the acquisition of valuable, rare, hard to imitate and non-substitutable resources (Dyduch & Bratnicki, 2018). Value capture is defined as the transfer and exploitation of created knowledge (Chesbrough & Rosenbloom, 2002) to secure financial or nonfinancial return from value creation (Chesbrough et al., 2018). Value is captured when firms secure profits from value creation (Sjödin et al., 2020). Previous literature has examined value capture from the perspective of firm performance. This dissertation adopts this perspective and uses the terms value capture and firm performance interchangeably.

The concept of value process is a fundamental concern in the study of firms (Lepak et al., 2007) and the concepts of value creation and value capture in open innovation require particular attention (Chesbrough & Appleyard, 2007; Dell'Era et al., 2020). More recent research on the value process has examined this relationship from different perspectives. Sjödin et al. (2020) considered a business model innovation perspective and proposed a process framework for aligning value creation and value capture activities between firms and customers in the delivery of services. From this literature, the authors find that value creation and value capture are distinct, but interdependent, phases of the value process and should be considered together. Similarly, Randhawa et al. (2021) described this relationship as phases in an open innovation value chain where value creation and value capture flows occur via shared cognitive artifacts. From this literature stream, researchers highlight the need for deeper study given the number of theoretical questions that remain on process steps (Sjödin et al., 2020), the flow between value creation and value capture (Randhawa et al., 2021), and an overall comprehensive understanding of the specific mechanisms that lead to value capture in open innovation (Dell'Era et al., 2020).

Table 1: Key Categories for Research on an Open Innovation Value Framework

Stage	Open Innovation Topic	Representative Articles
Value Creation	• Knowledge flow from external actors in open innovation ecosystems leads to value creation. • External actors generate more ideas which result in more opportunity to generate value through innovation. • Collaboration with external actors leads to value creation through new products and improved products, novel innovation, innovation performance and digital services.	Boudreau & Lakhani (2011); West & Bogers (2014); Chesbrough et. al (2018); Olk & West (2020); Pundziene et al. (2023)
Value Capture	• Value capture occurs from exploiting the knowledge from external collaboration. • Increase in value capture depends on strategic interactions. • A firm's relationship to the innovation network of complementary providers determines its value capture. • Governance mechanisms through an ecosystem are necessary to facilitate value capture. • Heterogenous open innovation ecosystems promote value capture through joint R&D. • Value capture requires tangible and intangible resources.	West (2007); Chesbrough et. al (2018); Dyduch & Bratnicki (2018); Dell'Era et al. (2020); Randhawa et al. (2021); Terán-Bustamante et al. (2021)

Theoretical Interpretation of the Literature

Following previous research in open innovation, this chapter conceptualizes value creation and value capture as two distinct but interrelated phases (Dell'Era et al., 2020; Randhawa et al., 2021; Sjödin et al., 2020). It builds on Chesbrough et al. (2018) and Teece (2020) to theoretically explicate how firms exercise dynamic capabilities during market uncertainty to create and capture value through open innovation. Following the concept map in Figure 1, a value process is then presented as a set of propositions that describes the transformation of knowledge into intangible assets, and ultimately greater firm performance.

Value Creation Phase

The knowledge-based view (Grant, 1996) states that knowledge is the essential unit of value to an organization. During periods of uncertainty or technological turbulence firms seek external knowledge (Chesbrough & Bogers, 2014) and increasingly explore external sources and interactions with external actors for new ways to identify innovative ideas and solutions (Chesbrough et al., 2021). Through these strategies, firms discover new ideas from external organizations and exploit their technical and market knowledge (Elia et al., 2020). The ability to efficiently sense and make necessary adjustments during market uncertainty is the only way for firms to achieve short-term competitive advantage (D'Aveni et al., 2010). The nature of the environment plays a significant role in firm behavior. In highly dynamic markets with great uncertainty, firms rely more on other firms for new expertise (H. Yang & Steensma, 2014). Previous literature has established that market uncertainty influences the relationship between firm strategy and firm performance (Akgün et al., 2008). Firms with significant differences in adaptive capabilities will therefore incur performance implications in the face of increasing environmental change (Simerly & Li, 2000). From these interactions, firms benefit from value creation through collaboration with external actors (Boudreau & Lakhani, 2011; Von Hippel, 2005; West & Bogers, 2014) where more ideas result in more opportunity to generate value through innovation (Laursen & Salter, 2006; Salter et al., 2015) and ultimately have a positive effect on product innovation (Bae & Chang, 2012).

External Knowledge from Open Innovation Ecosystems

Both the dynamic capabilities and open innovation literature describe environmental and technological change as the impetus for the pursuit of external knowledge. The dynamic capabilities view states that the consistent renewal of knowledge stocks is necessary to maintain competitive advantage during market uncertainty (Helfat et al., 2007; Katkalo et al., 2010; Kraaijenbrink et al., 2010). The literature on open innovation provides a template for the dynamic capabilities of scanning and sensing beyond firm boundaries, allowing firms to enrich their knowledge stocks (Teece, 2020). Both literature streams, dynamic capabilities (Eisenhardt & Martin, 2000; Protogerou et al., 2012; Wilden et al., 2016) and open innovation (Chelliah et al., 2022; Mostafiz et al., 2022; Oltra et al., 2018; Pundziene et al., 2023) agree that the effects of both on firm performance are positive, but indirect, suggesting a need to further understand the relationship.

This chapter builds on previous literature that conceptualizes dynamic capabilities and open innovation as being tightly intertwined (Bogers et al., 2019; Grimaldi et al., 2013; Teece, 2020) and highly related (Grimaldi et al., 2013; Pundziene et al., 2021). Open innovation has been described as a dynamic capability that changes the resource base of the firm (Chesbrough et al., 2018). Teece (2020) observed that open innovation and dynamic capabilities are mutually reinforcing: open innovation enriches the firm's knowledge stocks and provides a template for the dynamic capability of scanning or sensing new technologies beyond firm boundaries. This consistent renewal of these knowledge stocks maintains competitive advantage in turbulent environments (Helfat et al., 2007; Katkalo et al., 2010; Kraaijenbrink et al., 2010). Similarly, Bogers et al., (2019) argued that sensing, seizing and transforming dynamic capabilities allow firms to achieve the full benefits of open innovation.

The choice to employ open innovation as an R&D strategy may be best understood in the context of dynamic capabilities. These capabilities are "the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments" (Teece et al., 1997). Rapid external changes reduce the effectiveness of existing capabilities and resources. Detecting an emerging technology or market opportunity requires firms to seek out threats and technological changes through sensing the external environment (Teece, 2007). Even the most innovation-centric organizations cannot invest in internal R&D alone. They require knowledge from beyond their boundaries (Rigby & Zook, 2002).

Firms increasingly augment their internal R&D with external ideas and internal resources. This perspective is shared by previous research which defines dynamic capabilities as the steps firms take to manipulate existing resource configurations

(Eisenhardt & Martin, 2000; Lado et al., 2006). Firms implement these steps to recognize and respond to opportunities and threats (Hoopes & Madsen, 2008; Winter, 2003).

A long stream of literature on the dynamic capabilities - open innovation relationship has empirically studied a spectrum of firms from small and medium enterprises to large global firms. Grimaldi et al. (2013) demonstrated that firms with strong dynamic capabilities in sensing, seizing and reconfiguring develop more open innovation processes. Pundziene et al. (2021) empirically demonstrated that dynamic capabilities and open innovation are deeply interlinked showing that dynamic capabilities create value through integrating and recombining open innovation processes. The sensing capability affords firms the ability to identify and evaluate valuable external knowledge, while the seizing capability allows firms to establish cross-boundary collaboration. Firms then reconfigure their organization to integrate the externally acquired knowledge, leading to new product development.

Operating during market uncertainty requires firms to repeatedly reconfigure resources. In these environments, firms pursuing open innovation and by participating in open innovation ecosystems, use their dynamic capabilities to adapt to technological change and achieve a “novel fit” with the environment (Helfat et al., 2007). By leveraging the developed research and competencies of others in an open innovation ecosystem, firms build their knowledge stocks and thereby their innovation performance (Ahuja, 2000).

Firms who participate in open innovation ecosystems are afforded greater access to external knowledge and awareness of environmental changes through the other ecosystem participants. Previous research in the innovation and inter-organizational learning literature streams have argued that collaboration within networks are essential methods by which firms discover and access external knowledge (Powell et al., 1996). More recent literature has shown that firms are willing to participate in joint value creation through innovation networks because there is strong appropriability to their products (Olk & West, 2020). By leveraging the developed research and competencies of others in an ecosystem, firms grow their knowledge stocks and their innovation performance (Ahuja, 2000).

Previous scholars have long considered open innovation as external knowledge resources freely available to all (Hoving et al., 2013) and ready to be exploited by firms (Zobel, 2017). Open innovation ecosystems are composed of diverse set of firms which collectively represent a large pool of external knowledge. These ecosystems afford firms greater access to external knowledge and awareness of environmental changes. By this logic, open innovation ecosystems represent external knowledge stocks that are highly valuable during market uncertainty.

P1: During market uncertainty, firms seek out external knowledge through open innovation ecosystems.

Sensing Knowledge through Open Innovation Ecosystem Participation

The pursuit of external knowledge acquisition in response to market uncertainty is the dynamic capability of sensing. Teece (2020) observed that open innovation provides a template for enriching firm knowledge stocks through sensing new technologies beyond firm boundaries. During time of market uncertainty, open collaboration with other firms improves knowledge gathering (Arnold et al., 2010). This knowledge sharing between firms fosters mutual learning and stimulates new ideas (Boudreau & Lakhani, 2011; van de Vrande et al., 2009). For open innovation to be effective however, firms require knowledge acquisition capabilities (Cheng et al., 2016a). Firms use these capabilities to uncover threats and sense technological opportunities from the external environment (Teece, 2007). The ability to efficiently sense and make necessary adjustments during market uncertainty is the only way for firms to achieve short-term competitive advantage (D'Aveni et al., 2010).

Within open innovation ecosystems external knowledge is acquired through knowledge spillovers (Han et al., 2012). Early research into knowledge spillovers framed the spilling of knowledge outside firm boundaries as a loss to the originating firm (Kogut & Zander, 1992). Most recent studies, however, demonstrate that firms can benefit from this sharing. A firm may share knowledge to influence standards (Spencer, 2003) or promote an innovation ecosystem (Alexy et al., 2013) or combine the external knowledge with other internal knowledge to create new innovations (Sorenson et al., 2004). Firms are therefore motivated to participate in open innovation to improve their ability to generate these knowledge spillovers (Audretsch & Feldman, 1996; Griffith et al., 2006; Griliches, 1991; Jaffe et al., 1993).

Firms who participate more frequently or participate in more projects, have more interactions, and thus more opportunities for spillovers to occur. Firms then use this newly acquired knowledge to create new products from collaboration with external partners (Bogers et al., 2018; Bogers, Sims, et al., 2019; Cappelli et al., 2014; Granstrand & Holgersson, 2020).

The open innovation literature treats knowledge as free flowing and open. The very concept of open innovation allows for the free use of all aspects of the effort. Open innovation practices involve firms interacting via a shared knowledge repository that is open to anyone. Firms are willing to participate in such arrangements for joint value creation because there is strong appropriability to their products (Olk & West, 2020). Shared knowledge, specifically tacit knowledge, has been shown to transfer more effectively in free and unformalized organizational models (Schmoch et al., 2000). These informal links positively correlate with knowledge outcomes (Claus, 2012).

Previous authors have argued that the result of collaboration in open innovation is freely available for everyone (Hoving et al., 2013) and that the knowledge within the public domain does not require any direct interaction between producer and receiver (Audretsch et al., 2006; West & Bogers, 2014). From the technology transfer literature however, we find that successful technology transfer requires “purposeful, goal-oriented interactions” between two or more organizations (Amesse & Cohendet, 2001) and these interactions must be social in nature. Empirical research on inter-organizational technology transfer has demonstrated that interaction quality was a key predictor on technology transfer success (Leischnig et al., 2014). While network linkages between participants may remain informal, social interactions must be strong (Nonaka & Takeuchi, 2007). By this logic, external knowledge from open innovation requires participation within an ecosystem. Firms exercise their dynamic capability of sensing through the purposeful participation in open innovation ecosystems. Through this participation firms form social ties and interact with other firms affording them the ability to sense and evaluate valuable external knowledge (Pundziene et al., 2021). These strong sensing capabilities allow firms to detect environmental changes early, thus providing more time to react (Teece & Leih, 2016). Even though external knowledge from open innovation ecosystems is freely available to all (Hoving et al., 2013), participation is required for knowledge spillovers to occur.

Proposition 2: Firms exercise the dynamic capability of sensing by participating in open innovation ecosystems to acquire external knowledge.

The effects of Industry Diversity on Knowledge Sensing

From the literature on alliance portfolio diversity, it is argued that the more dissimilar firms are, the greater the diversity of knowledge. New ideas arise from interaction with firms in different business areas who have different knowledge (Granovetter, 1973). Firms bring knowledge and experience from their interactions with their other partners in other industries who in term bring knowledge of their partners (Gulati & Gargiulo, 1999). A diverse mix can be beneficial in that it provides access to complementary resources (Dussauge et al., 2000) and new knowledge and learning opportunities (Lavie, 2007; Wassmer et al., 2017).

Within open innovation ecosystems, the value of collaboration is also affected by the differences in membership. Wang et al. (2017) found that knowledge spillovers within open innovation networks are more efficient the more diverse the membership. During market uncertainty, firms seek out or explore external knowledge through external networks thereby benefiting from the diversity of resources (Burt, 1995). The more diverse the ecosystem, the greater the chance of new knowledge discovery from other industries (Gubbins & Dooley, 2014).

Industry diversity does not come without drawbacks, however. According to learning theory, exploring knowledge from diverse sources entails administrative costs (Jiang et al., 2010). Firms have limited resources and attention-span to allocate to knowledge gathering activities (Ocasio, 1997). More industry diversity requires firms to apply more resources to the search for knowledge (Powell et al., 1996). Coping with industry diversity however has been shown to raise transaction costs (Hagedoorn et al., 2018; Jiang et al., 2010; Lee et al., 2017). According to transaction cost theory, firms will increasingly choose internal R&D versus external collaboration as transaction cost rise (Penney & Combs, 2020). Diminishing returns manifest themselves as the transaction costs that firms must pay begin to exceed the benefits from the heterogeneous resources.

Previous empirical studies have shown the presence of an inverted U-shaped relationship between inter-partner heterogeneity and performance (Nooteboom et al., 2007; Petruzzelli, 2011; Wuyts et al., 2005) suggesting that at a certain point the transaction costs outweigh the diversity benefits. Similarly, an inverted U-shaped relationship has been shown to exist between the industrial heterogeneity of firms and performance from new product development (Von Raesfeld et al., 2012). Hagedoorn et al. (2017) demonstrated that an inverted U-shaped relationship exists between partner diversity and firm innovation performance.

From this logic, the greater the industry diversity in an open innovation ecosystem, the weaker the similarity, and the greater knowledge that can be collectively shared. Transaction costs, however, reach a point where they outweigh the benefits of the diverse knowledge, resulting in diminishing returns. This results in an inverted U-shaped relationship between external knowledge sensing and industry diversity.

Proposition 3: Greater industry diversity in open innovation ecosystems is associated with external knowledge sensing such that it first increases and then decreases, forming an inverted U-shape.

Seizing External Knowledge from Knowledge Flows

The knowledge-based view suggests that the value of knowledge is associated with the desired organizational outcomes (Grant, 1996). Previous scholars have argued that knowledge is the key strategic intangible resource that enables firms to compete in dynamic environments (Spender, 1996). Knowledge flow describes how new knowledge and know-how is acquired through interactions between firms (Kim et al., 2016). To successfully manage the flow of knowledge, firms must establish and maintain internal and external knowledge sharing practices (Ferreira et al., 2023). Firms must continuously develop these practices to internalize both sourced and spilled-over knowledge with internal knowledge (Kloosterman, 2008).

Within open innovation, knowledge flows are purposely managed to achieve innovation outcomes (Chesbrough & Bogers, 2014). Early literature stressed that managing knowledge flows is a key aspect of the open innovation process where purposive inflows and outflows of knowledge become an accelerant of internal innovation (Chesbrough & Bogers, 2014). Technological accumulations from knowledge flows can act as a bridge between external sources of knowledge and internal innovation (Brunswicker & Vanhaverbeke, 2015), allowing firms to build knowledge stocks (Shin et al., 2018). Coordinating these knowledge flows is a key aspect of the open innovation process. As firms explore multiple external channels, they identify innovative ideas and solutions (Chesbrough et al., 2021), and uncover innovation opportunities (West & Gallagher, 2006). A firm's ability to make use of external knowledge therefore requires the ability to create and retain internal knowledge. Even if the participating actors have high levels of knowledge, the capability to translate and assimilate the knowledge is still required (Öberg & Alexander, 2019).

The process of external to internal knowledge flow is a "dynamic cycle of knowledge absorption, knowledge transfer, and knowledge application" (Feng et al., 2022). Scholars describe this interplay of external and internal knowledge as a recombinant approach where the existing knowledge base of a firm is recombined with both, new R&D, and complementary external knowledge, to generate new knowledge (Antonelli & Colombelli, 2015). In this view, internal knowledge is a necessary antecedent to a firm's ability to absorb external knowledge, and external knowledge is a required input to the knowledge generation function. When firms exploit external knowledge, they combine the external knowledge with other internal knowledge to create new innovations (Sorenson et al., 2004). Extensive prior research has demonstrated that the recombination of internal knowledge and external knowledge leads to breakthrough innovations (Cassiman & Valentini, 2016; Criscuolo et al., 2018). These efforts enable the integration of external resources and value capture of distinct technological competencies (Najafi-Tavani et al., 2018). By this logic, firms that are able to seize external knowledge will recombine it with existing internal knowledge, leading to the development of new internal knowledge. Greater external knowledge stocks will lead to greater internal knowledge stocks, thus value creation.

Proposition 4: The dynamic capability of seizing transforms external knowledge from open innovation ecosystems into internal knowledge, leading to value creation.

Value Capture Phase

The linkage between value creation and value capture in open innovation is not well understood and findings have been inconclusive. On the one hand, several studies have demonstrated a positive relationship between open innovation and innovation performance (Aloini & Martini, 2013; Katila et al., 2012; Tsai et al., 2011). For example, Sabidussi et al. (2014) evaluated innovation performance and found that the diverse external actors from outside-in open innovation increases the ability of firms to acquire new solutions. Laursen & Salter (2006) however, measured the level of interaction with external actors in open innovation and demonstrated a curvilinear relationship where, after a certain degree of external interaction, innovation performance diminishes. Similarly, de Leeuw et al. (2014) examined external actor diversity and demonstrated an inverted U-shaped relation on innovation performance. Overall, the effects of open innovation, on value capture, that is firm performance, has been understudied and suffer from two main limitations: a lack of consensus on firm performance measures, and disagreement on the relationship being positive, negative, or non-linear. Performance measures vary greatly across studies and much of the open innovation literature focuses on innovation outcomes. While these provide insight into innovation outcomes, they do not measure the effect on overall firm performance (Moretti & Biancardi, 2020).

Much of the existing research on performance is dominated by case studies of open innovation implementation in firms, survey studies on open innovation adoption, and self-reported performance implications (Michelino et al., 2015). Recent open innovation scholars have argued that bias predominates these studies due to a reliance on self-assessments using measures derived from secondary data (Moretti & Biancardi, 2020). One of the main limitations of previous research has been a focus measuring firm openness versus considering firm performance through the value that is created (Moretti & Biancardi, 2020). The success of open innovation depends on a firm’s ability to both create value and capture it (Chesbrough et al., 2018; Chesbrough & Bogers, 2014). Value creation occurs when firms generate new assets through the open innovation process

(Chesbrough et al., 2018). Value capture occurs when firms are able to realize the value of the assets that were created (Chesbrough et al., 2018).

Reconfiguring Knowledge into Intangible Assets

Previous literature on open innovation and dynamic capabilities has shown that firms exercise their dynamic capabilities to seize opportunities that were obtained during sensing activities and reconfigure their resources in response (de Aro & Perez, 2021). Teece (2007) describes the reconfiguration of resources as a "continuous alignment and realignment of specific tangible and intangible assets". Several authors have underlined the importance of intangible assets as a measure of success from open innovation strategies and the effectiveness of open innovation processes (Bader & Enkel, 2014; Lu et al., 2013; Michelino et al., 2014; Teece, 2007). Traditionally, intangible assets represent the outcome of business internal R&D initiatives (Chesbrough, 2003). The relationship between open innovation and intangible assets has been active research stream (Grimaldi et al., 2017; Moretti & Biancardi, 2020). This literature considers intangible assets as the types of resources produced or exchanged from open innovation (Grimaldi et al., 2017). Creating value through innovation requires using of intangible resources (Dyduch & Bratnicki, 2018), and within open innovation specifically, the use of complementary resources (West, 2007). Since open innovation fosters collaboration and knowledge sharing, it can be an important factor in acquiring intangible assets. By being open to new ideas and perspectives, firms can work together to develop new technologies and new product innovations.

Knowledge spillovers are considered by researchers as intangible knowledge channels that allow participants to capture valuable knowledge, resulting in new technological innovation (Andrea & Cinzia, 2007; Jaffe, 1986; Yan et al., 2019). These scholars describe the interplay of external and internal knowledge as a recombinant approach where the existing knowledge base of a firm is recombined with both new R&D, and complementary external knowledge, to generate new knowledge (Antonelli & Colombelli, 2015). From the dynamic capabilities literature, this recombinant knowledge management process is described as reconfiguration (Easterby-Smith & Prieto, 2008). During periods with high rates of technological change, firms attempt to reconfigure their resource base (Collis, 1994; Tripsas, 1997; Wang & Ang, 2004). Firm exercise knowledge management steps to reconfigure operational resources and routines in response to new learning (Cepeda & Vera, 2007). Firms that invest in building internal knowledge are able to integrate external knowledge resulting in the creation of intangible assets (Grimaldi et al., 2013). Thus, firms exercise dynamic capabilities to reconfigure their resources to extract internal knowledge, resulting in new intangible assets.

Proposition 5: The dynamic capability of reconfiguration transforms internal knowledge into a unique, internally developed intangible asset.

Capturing Value from Intangible Assets

An essential premise of the dynamic capabilities view is that firms must use and renew their intangible resources to sustain competitive advantage in dynamic environments (Easterby-Smith & Prieto, 2008b). From this literature stream scholars assert that intangible assets are “the main basis of competitive differentiation” given the current goods and factor markets (Teece, 1998). The argument being that resources used by firms to produce goods and services are so readily available, the only way to generate competitive advantage is through the creation and exploitation of intangible assets. This argument is supported by more recent empirical research which shows that higher growth firms, those in the top quartile for gross value added, invest more than twice as much in intangible assets as compared to lower growth firms (Hazan et al., 2021).

Knowledge is shared between firms through spillovers which act intangible asset channels to capture valuable knowledge and produce technological innovation (Andrea & Cinzia, 2007; Jaffe, 1986; Yan et al., 2019). From the literature stream on open innovation, several authors have emphasized the importance of intangible assets on open innovation success (Bader & Enkel, 2014; Lu et al., 2013; Michelino et al., 2014; Teece, 2007). These authors argue that a combination of both tangible and intangible resources is required for value capture (Dollinger, 2008). These arguments are held in more recent empirical research which shows that firms must acquire and exploit intangible resources from inter-firm collaboration (Dell’Era et al., 2020) to capture value (Moretti & Biancardi, 2020). Intangible assets are therefore a necessary outcome of knowledge exploitation from open innovation.

Effective ecosystem governance mechanisms, such as clear agreements, trust-building measures, and conflict resolution mechanisms, are needed to facilitate value capture from open innovation (Belderbos et al., 2014). Previous literature has shown that from relationships and interactions with ecosystem members, firms generate intangible assets of value (Grimaldi et al., 2013). Knowledge is considered one of the most valuable and significant intangible assets a firm can possess. Companies that effectively manage and leverage their intangible assets, particularly knowledge, have a competitive advantage in today's knowledge-driven economy (Nonaka & Takeuchi, 2007). According to the theory of the firm, a company is a repository of knowledge with the essential goal of creating and exploiting knowledge assets (Holmstrom & Tirole, 1989). From this knowledge, firms create valuable intellectual property that can be protected and monetized (Belderbos et al., 2014). Knowledge therefore becomes the key strategic intangible resource that enables firms to compete in dynamic environments (Spender, 1996). By this logic, firms capture value from open innovation by exploiting the unique intangible assets created from knowledge flows.

Proposition 6: Firms capture value from open innovation by exploiting the unique intangible asset.

Value Capture from Open Innovation Ecosystems

Though previous studies have examined firm performance from open innovation, they have not accounted for the indirect effects of knowledge spillovers from ecosystem interactions. The literature stream on knowledge spillovers and open innovation has demonstrated the positive relationship between open innovation and innovation performance (Aloini & Martini, 2013; Fu et al., 2019a; Katila et al., 2012; Tsai et al.,

2011) with more recent research demonstrating an indirect and mediating role of knowledge spillovers on the open innovation - innovation performance relationship (Wang & Jiang, 2019). Jiang & Wang (2018) demonstrated that knowledge spillovers have a mediating effect between open innovation and innovation performance. Similarly, Sun et al. (2020) showed that knowledge plays a partial mediating role in the open innovation and innovation outcome relationship. Given the central role of external knowledge in dynamic capabilities and open innovation, examining this topic is theoretically significant. Although open innovation has been shown to be an important trigger of knowledge spillovers (Gay, 2014; Spithoven et al., 2013), the linkage of knowledge spillovers to performance outcomes is debated (Berchicci, 2013; Jaffe & Lerner, 2001) and more study of open innovation from the knowledge perspective is required (Shi et al., 2020).

Within the open innovation literature, most research examines the direct effects of open innovation on value outcomes. Examinations of theory-based mediators and moderators have been understudied (Rubera et al., 2016; Wang & Jiang, 2019). Some studies have explored moderating factors such as environment competitiveness (Zhang et al., 2016) and competitive intensity (Foroughi et al., 2015), as well as mediating factors such as firm characteristics (Stanislawski & Lisowska, 2015). A noticeable gap in the literature exists, however, in the study of indirect effects on value outcomes. Previous studies have theoretically defined the relationship between dynamic capabilities and firm performance (Augier & Teece, 2009; Helfat & Peteraf, 2009; Teece, 2007). From this literature stream, researchers have proposed conceptual reasoning that dynamic capabilities positively impact firm performance, but the relationship is indirect (Augier & Teece, 2009; Helfat & Peteraf, 2009; Teece, 2007; Wang & Ahmed, 2007) and mediated through firm operating capabilities (Eisenhardt & Martin, 2000). Similarly, the relationship between open innovation and firm performance has been shown to be indirect and mediated (Chelliah et al., 2022; Mostafiz et al., 2022; Pundziene et al., 2023).

Synthesizing these literature streams allows for a better understanding of the effects of knowledge spillover on firm performance. From the knowledge management literature, it is understood that firms must establish and maintain both internal and external knowledge sharing practices for knowledge flow to occur (Ferreira et al., 2023). By this logic, external knowledge and internal knowledge interact in a serial fashion. Firms acquire external knowledge through open innovation ecosystem participation. Firms are then able to integrate external knowledge with internal knowledge resulting in the creation of intangible assets (Grimaldi et al., 2013). From these assets, firms create valuable intellectual property that can be protected and monetized (Belderbos et al., 2014). Firms exploit these assets leading to competitive advantage. It is therefore argued that open innovation ecosystem participation has a positive effect on firm performance, but the relationship is mediated through the transformation of external and internal knowledge into intangible assets.

Proposition 7: The effect of open innovation ecosystem participation on value capture is mediated by the transformation of knowledge through a firm's dynamic capabilities.

Summary

This chapter contributes to the value perspective by addressing conceptual ambiguities in the value chain and developing a set of research questions for future study. It synthesizes the literature on dynamic capabilities and open innovation and attempts to theoretically explicate how the progression between value creation and value capture is through the transformation of knowledge into intangible assets which generate competitive advantage. A summary of these propositions is given in Table 2. The dynamic capabilities view states that market uncertainty motivates firms to seek out external knowledge from external actors. Firms exercise dynamic capabilities to integrate, build and reconfigure their resources. Dynamic capabilities and open innovation have been shown to be closely interlinked as firms exercise sensing, seizing and reconfiguration capabilities through integrating and recombining open innovation processes (P1). The sensing capability affords firms the ability to discover valuable external knowledge and to establish cross-boundary collaboration (P2). Open innovation brings together multiple firms for collaboration and value co-creation. The diversity of these firms affords sensing of greater knowledge, but transactions outweigh knowledge benefits at a point (P3). Through these open innovation interactions, knowledge spillovers occur allowing firms to create value by seizing external knowledge and integrating it with internal knowledge (P4). Firms then reconfigure their organizations to extract the value of the integrated knowledge as unique intangible assets (P5). Finally, firms capture value by exploiting these intangible assets (P6), resulting in greater firm performance (P7).

Table 2: Summary of Propositions

	Proposition & Authors
Proposition 1	In dynamic environments, firms seek out external knowledge through open innovation ecosystems. (Pundziene et al., 2021)
Proposition 2	Firms exercise the dynamic capability of sensing by participating in open innovation ecosystems to acquire external knowledge. (Teece, 2020)
Proposition 3	Greater industry diversity in open innovation ecosystems is associated with external knowledge sensing such that it first increases and then decreases, forming an inverted U-shape. (Laursen & Salter, 2006)
Proposition 4	The dynamic capability of seizing transforms external knowledge from open innovation ecosystems into internal knowledge, leading to value creation. (Bogers, et. al, 2019)
Proposition 5	The dynamic capability of reconfiguration transforms internal knowledge into a unique, internally developed intangible asset. (Grimaldi et al., 2017)
Proposition 6	Firms capture value from open innovation by exploiting the unique intangible asset. (Dell'Era et al., 2020)
Proposition 7	The effect of open innovation ecosystem participation on value capture is mediated by the transformation of knowledge through a firm's dynamic capabilities. (Pundziene et al., 2023)

Conclusions

Even though there is a large cross-domain intersection of literature streams, a theoretical gap still exists in understanding the path linkage between value creation and value capture within open innovation. A theoretical proposition on the mediating path of knowledge in open innovation is essential to understanding the knowledge-based economy (Alexander & Martin, 2013). This chapter describes and discusses a value process in open innovation interlinking value creation and value capture. It theoretically explicates the role of external and internal knowledge that results from open innovation ecosystem participation and the transformation of this knowledge (value creation), via dynamic capabilities, into intangible assets, which ultimately lead to greater firm performance (value capture). As previous authors have argued, value creation and value capture are interdependent and must be considered in parallel (Sjödin et al., 2020).

Previous scholars in both the strategic management literature (Dyduch & Bratnicki, 2018) and open innovation literature (Chesbrough & Appleyard, 2007; Randhawa et al., 2021; Sjödin et al., 2020) have called for deeper study and a comprehensive understanding of the value creation to value capture process. Within open innovation, the mechanism that enables value capture in financial, economic and human resource terms remain unexplored (Dell’Era et al., 2020). This is of particular importance to open innovation research given that ignoring firm performance relative to competitors neglects the impact on the downstream portions of the innovation process (West & Bogers, 2014). Overall, the relationships between value creation and value capture have been largely neglected and the value perspective is insufficiently researched (Chesbrough et al., 2018).

This chapter contributes to this field of inquiry. The introduction raised three research questions which are elaborated below.

What is the role of knowledge in the management literature on dynamic capabilities and open innovation?

Literature from dynamic capabilities and open innovation both describe environmental and technological change as the impetus for the pursuit of external knowledge. The knowledge-based view states that knowledge is the essential unit of value to an organization and value creation within firms is fundamentally a process to acquire and leverage knowledge. A central tenet of open innovation is the establishment of collaborative relationships with other organizations which serve as a mechanism for knowledge exchange with external partners. Pundziene et al. (2021) empirically demonstrated that dynamic capabilities and open innovation are deeply interlinked showing that dynamic capabilities create value through integrating and recombining open innovation processes. The intersection of the dynamic capabilities and open innovation literature lies in the role of external knowledge.

Prior research in open innovation research has treated knowledge as free flowing and available to all. Previous authors have argued that the outcomes of open innovation collaboration are freely available to everyone (Hoving et al., 2013), knowledge within this public domain does not require any direct interaction between producer and receiver (Audretsch et al., 2006; West & Bogers, 2014), and knowledge is ready to be exploited by firms (Zobel, 2017). From the technology transfer literature however, we find that successful knowledge transfer requires "purposeful, goal-oriented interactions" between two or more organizations (Amesse & Cohendet, 2001). In addition, previous empirical research on inter-organizational technology transfer demonstrated that interaction quality was also a key predictor on technology transfer success (Leischnig et al., 2014). From this literature stream it is argued that while network linkages between participants may remain informal, social ties must be strong (Nonaka & Takeuchi, 2007). This chapter applies these findings to the open innovation literature and challenges the concept of knowledge being a pool available to anyone. Rather, external knowledge acquisition from open innovation, even if it is freely available, requires participation between firms. Firms that participate in open innovation gain external knowledge through spillovers (Han et al., 2012). For spillovers to occur, firms must interact with other firms to develop social ties and share their own knowledge. The more diverse the open innovation ecosystem, the greater the chance of new knowledge discovery from other industries. Diminishing returns, however, manifest themselves as the transaction costs exceed the benefits from diverse knowledge.

What is the relationship between externally acquired knowledge from open innovation and internally developed knowledge?

For open innovation to be effective firms require knowledge acquisition capabilities (Cheng et al., 2016). Knowledge flows act as a bridge, connecting external sources of knowledge with internal innovation (Brunswicker & Vanhaverbeke, 2015), allowing firms to build knowledge stocks (Shin et al., 2018). A firm's ability to make use of external knowledge requires the ability to create and retain internal knowledge. Even if the participating actors have high levels of knowledge, the capability to translate and assimilate the knowledge is still required (Öberg & Alexander, 2019). Scholars describe this process of external to internal knowledge flow as a "dynamic cycle of knowledge absorption, knowledge transfer, and knowledge application" (Feng et al., 2022). When firms exploit external knowledge, they combine it with other internal knowledge to create new innovations (Sorenson et al., 2004). Thus, greater external knowledge stocks lead to greater internal knowledge stocks. Firms that search for external knowledge establish practices that lead to the development of internal knowledge.

How is value created and captured in open innovation?

During market uncertainty, firms seek out sources of external knowledge. Firms express their dynamic capabilities of sense and seize through their open innovation ecosystem participation through which inter-firm collaboration occurs. A central tenet of open innovation is the establishment of these types of collaborative relationships with other organizations (van de Vrande et al., 2009). The appropriation of external knowledge from the open innovation ecosystem is facilitated through this collaboration with other firms. The diversity of these firms afford access to greater knowledge, but transactions outweigh knowledge benefits at a point. The exchange of knowledge between firms occurs via knowledge flows resulting in knowledge spillovers (Han et al., 2012). Greater external knowledge stocks lead to greater internal knowledge stocks. The relationships and interactions with ecosystem members allow firms to generate intangible assets of value (Grimaldi et al., 2013). This in turn leads to the creation of valuable intellectual property that can be protected and monetized (Belderbos et al., 2014). Firms capture value by exploiting these new intangible assets. Value capture therefore comes from the creation of value, the exchange and flow of knowledge through participation in open innovation efforts, not simply the harvesting of the knowledge from the public domain. Firms must create value to capture it. They have to play to win.

Managerial Implications

For firms engaging in open innovation for performance outcomes it is important to consider the link between external and internal knowledge and the resulting effect on value capture. This chapter asserts that the dynamic capabilities of sense, seize and reconfigure can be realized using open innovation strategies but that the knowledge gains require knowledge sharing, e.g., open innovation ecosystem participation and investment in internal knowledge creation. Assuming that freely available knowledge can be easily appropriated fails to account for the technology transfer costs and equally misses the tacit knowledge gains that occur through knowledge spillovers. Additionally, investment in internal knowledge development, that is internal R&D, is still required for knowledge to flow from open innovation to occur. A firm’s ability to make use of external knowledge requires the ability to create and retain internal knowledge. Even if the participating actors have high levels of knowledge, the capability to translate and assimilate the knowledge is still required.

Managers need to also consider the composition of open innovation ecosystems that position them best for competitive advantage. All open innovation ecosystems differ in their membership. Very homogenous ecosystems potentially offer less in the form of new knowledge while overly diverse ecosystems incur growing transaction costs in the knowledge flow. The choice of ecosystem is as important as the open innovation area of exploration.

Research Implications

In this chapter, a theoretical model and set of propositions were developed to better understand the value creation and value capture linkage and the role of knowledge in the open innovation – firm performance relationship. It is an important area of research because a theoretical proposition on the mediating path of knowledge in open innovation is essential to understanding the knowledge-based economy (Alexander & Martin, 2013). In the next chapter, a subset of these relationships will be empirically tested, specifically examining the flow of knowledge from open innovation ecosystems, and the transformation of that knowledge into valuable and unique intangible assets.

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Chapter Three: Value Capture in Open Innovation – The Economic Value of Intangible Knowledge

In the previous chapter a theoretical model for value creation and value capture was introduced that explained how firms exercise dynamic capabilities to sense, seize and reconfigure knowledge from open innovation ecosystems. In this model, external and internal knowledge play a mediating role as they are transformed into intangible assets to capture value. Mediators in open innovation have been understudied (Rubera et al., 2016; Wang & Jiang, 2019) and the relationship between open innovation, knowledge and firm performance is not well understood. This chapter seeks to address this gap by exploring the appropriate measures and controls to answer the research question: Does knowledge from open innovation lead to greater firm performance?

During market uncertainty, firms seek out external knowledge from external actors (Teece, 2007). Using their dynamic capabilities, firms leverage this external knowledge to reconfigure their resources (D. Teece et al., 1997). Open innovation is a source of external knowledge and has been shown to be closely interlinked with dynamic capabilities (Pundziene et al., 2021). From this research, firms have been shown to exercise their sensing, seizing and reconfiguration capabilities through integrating and recombining open innovation processes. The sensing capability affords firms the ability to discover valuable external knowledge and to establish cross-boundary collaboration.

Firms seize the external knowledge through knowledge spillovers which is then combined with internal knowledge (Kloosterman, 2008). The recombination of external and internal knowledge results in valuable intangible assets (Grimaldi et al., 2017). Firms then exploit these intangible assets to extract value (Dell'Era et al., 2020). These assets are a necessary resource for open innovation success (Bader & Enkel, 2014; Lu et al., 2013; Michelino et al., 2014; Teece, 2007) and value capture (Dell'Era et al., 2020; Dollinger, 2008; Moretti & Biancardi, 2020).

Open innovation brings together multiple firms for collaboration and value co-creation. As firms explore these external channels, they identify innovative ideas and solutions (Chesbrough et al., 2021), and uncover innovation opportunities (West & Gallagher, 2006). Although practice and theory seem to indicate that open innovation is beneficial to firms, scholars are still looking for appropriate metrics to evaluate the effects of these investments. To date, the open innovation literature has yet to find a consensus. Prior studies have used differing frameworks and classifications resulting in heterogenous views. Some demonstrate positive effects, others, negative or non-linear (de Leeuw et al., 2014; Laursen & Salter, 2006; Sabidussi et al., 2014). The question therefore remains, beyond value creation, how is value captured from open innovation. Previous research has extensively demonstrated that firms can create value through collaboration with external actors where more ideas result in more opportunity to generate value through innovation. This literature uses both established and newly developed measures of value creation, such as rate of new product releases, product performance and revenue growth. Value capture, by comparison, is understudied

(Dell'Era et al., 2020). This is of particular importance to open innovation research given that ignoring firm performance relative to competitors neglects the impact on the downstream portions of the innovation process (West & Bogers, 2014).

Much of the existing research on performance is dominated by case studies of open innovation implementation in firms, survey studies on open innovation adoption, and self-reported performance implications (Michelino et al., 2015). Recent open innovation scholars have argued that bias predominates these studies due to a reliance on self-assessments using measures derived from secondary data (Moretti & Biancardi, 2020). Within the knowledge management literature, it has also been argued that field quantitative surveys often suffer from response bias due to subjective measurement scales (Bontis, 2001; Chareonsuk & Chansa-ngavej, 2010). This chapter addresses some of these shortcomings by identifying objective measures and controls for understanding the relationships between open innovation, knowledge, and firm performance. It contributes to extant literature by focusing on the mediating role of open innovation knowledge on value capture.

The rest of this chapter is organized into four sections: (1) Literature review and theoretical model, (2) Data and methods, (3) Findings, and (4) Discussion.

Literature Review and Theoretical Model

Knowledge as an Intangible Asset

According to the resource-based view, differences in firm performance are a result of differences between firm resource endowments, namely intangible assets (Rumelt, 1984). Prior research has explored how both externally acquired and internally generated intangibles lead to competitive advantage (Hall, 1992; M. Peteraf et al., 2013). Other authors have argued that a combination of both tangible and intangible resources is required for value capture (Dollinger, 2008). An essential premise of the dynamic capabilities view is that firms must use and renew their intangible resources to sustain competitive advantage in dynamic environments (Easterby-Smith & Prieto, 2008). From this literature stream scholars assert that intangible assets are "the main basis of competitive differentiation" given the current goods and factor markets (Teece, 1998).

Knowledge is considered one of the most valuable and significant intangible assets a firm can possess (Bogdanowicz & Bailey, 2002). Intangible assets are how knowledge is accounted for in the business enterprise (Green, 2006). They are assets that are non-physical, but identifiable and include things such as technology (e.g., computer software), copyrights, patents, licensing agreements, and know-how. According to the theory of the firm, a firm is a repository of knowledge whose essential goal is to create and exploit knowledge assets (Holmstrom & Tirole, 1989). Companies that effectively manage and leverage their intangible assets, particularly knowledge, have a competitive advantage in a knowledge-driven economy (Nonaka & Takeuchi, 2007). Knowledge therefore becomes the key strategic intangible resource that enables firms to compete in dynamic environments (Spender, 1996).

Both the global economy and increasingly turbulent technological evolution have resulted in the decentralization of knowledge and diversification of the brand portfolio. As such, firms cannot pursue a strategic path with internal investment alone due to the complexity of the market. Previous literature emphasizes that firms must source both external and internal knowledge to compete (Stolwijk et al., 2012). In response to market uncertainty, firms open their business model and consider intangibles developed by external organizations (Chesbrough, 2006; Huang, 2011). This offers several advantages. The acquiring firm usually gains an external intangible asset in its full value while the sharing firm has already gained its potential, thus reducing the risk of the investment (Granstrand et al., 1992). For the same reason, by leveraging externally generated intangibles, the company reduces the time lag between investment (expenditure) and returns. Previous research has demonstrated that such investments in externally generated intangibles positively boost firm performance (Denicolai et al., 2015).

Knowledge can be shared between firms through spillovers. Previous scholars have described knowledge spillovers as intangible asset channels that allow participants to capture valuable knowledge, resulting in technological innovation (Andrea & Cinzia, 2007; Jaffe, 1986; Yan et al., 2019). Within the open innovation literature, several authors have underlined the importance of intangible assets for the success of open innovation strategies and the effectiveness of open innovation processes (Bader & Enkel, 2014; Lu et al., 2013; Michelino et al., 2014; Teece, 2007). This literature stream considers intangible assets as the types of resources produced or exchanged from open innovation (Grimaldi et al., 2017). As firms explore external knowledge within an ecosystem, they build new or reinforce existing relationships with a diverse range of partners. Input from these ecosystems enable firms to access knowledge held by people other than internal employees (Dahlander & Piezunka, 2014). Knowledge spillovers from these external partners contribute positively to organizational strategy, internal processes, allowing firms to appropriate external knowledge as intangible assets (Grimaldi et al., 2017). The general assumption is that open innovation is beneficial because the more a firm interacts with other firms, the higher its access to external ideas and knowledge, and thus the higher its chances for innovation (Greco et al., 2016). Intangible assets are therefore a necessary outcome of knowledge exploitation from open innovation.

Firm Performance

Since the early work by Laursen & Salter (2006), a considerable body of research has tried to address the open innovation - firm performance relationship. This literature stream has, however, varied considerably in the choice of performance measures. Previous scholars have chosen perceived firm performance benefits (Hung & Chiang, 2010), novel innovation (Parida et al., 2012), innovation performance (Cruz-González et al., 2015; Ebersberger et al., 2012; Greco et al., 2016; Pullen et al., 2012), improved products (Hwang et al., 2009; Mention, 2011), return on sales (Moretti & Biancardi, 2020), firm profitability (Hitt et al., 1997; Kafouros & Forsans, 2012; Kotabe et al., 2002), Tobin’s Q (Belderbos et al., 2010; Hung & Chou, 2013; Sisodiya et al., 2013). From this literature stream we find a strong prevalence of studies using innovation outcomes as the performance measure. While these studies provide insight into the output of innovation efforts, they fail to address the impact on overall firm performance (Moretti & Biancardi, 2020). The use of innovation outcome variables fails to fully account for the downstream impacts of the investment and ignores firm performance relative to competitors (West & Bogers, 2014). Despite a highly active stream of literature, it remains debated if the open innovation – firm performance relationship is positive, negative, or non-linear (de Leeuw et al., 2014; Laursen & Salter, 2006; Sabidussi et al., 2014).

Overall, the broad literature stream on open innovation and firm performance suffers from two main limitations: a lack of consensus on firm performance measures, and disagreement on the relationship being positive, negative, or non-linear. Performance measures vary across studies and value capture in open innovation overall is understudied (Dell'Era et al., 2020).

Hypothesis Development

There is extensive previous literature hypothesizing and demonstrating that open innovation has a positive effect on firm performance measured in different capacities. Researchers have studied R&D cost effectiveness (Caloghirou et al., 2004; Chesbrough, 2003), innovation performance (Aloini & Martini, 2013; Katila et al., 2012; Tsai et al., 2011), introduction of new products (Köhler et al., 2009; Salter et al., 2015) and financial measures (Moretti & Biancardi, 2020). These authors argue that the more a firm engages with other firms, the greater its access to external ideas, knowledge, technologies, and other intangible assets. From this they improve their chances to innovate successfully

(Greco et al., 2016; Teece, 1998). This extensive line of research suggests that open innovation is a source of firm competitiveness. Recent open innovation scholars have however argued that bias predominates these studies due to a reliance on self-assessments using measures derived from secondary data (Moretti & Biancardi, 2020). Secondly, measures for open innovation have differed across the literature with some authors using self-reported measures of openness (Bigliardi et al., 2020), while other authors use implied or synthetic measures (Michelino et al., 2014, 2015). Few studies have considered open innovation from the perspective of participation within an open innovation ecosystem which allows for objective observation. It is argued that this participation will create greater access to external ideas and other intangible assets which can then be exploited, leading to greater firm performance.

H1: Open innovation participation is associated with greater firm performance.

Firms that leverage more external search channels have a greater ability to sustain exchanges and collaborations with external partners. This facilitates the discovery and exploitation of innovative opportunities, which positively relates to the firm's innovation performance (Laursen & Salter, 2006). From these external relationships come new ideas and know-how for product innovation (Schroll & Mild, 2011). Cheng et al. (2016) demonstrated that for open innovation to be effective, firms require knowledge acquisition and knowledge sharing capabilities. Knowledge sharing between firms has also been shown to foster mutual learning and stimulate new ideas (Boudreau & Lakhani, 2011; van de Vrande et al., 2009).

As firms explore external knowledge, they build new or reinforce existing relationships with a diverse range of partners. When firms are open and transparent in their dealings with others, they are more likely to establish positive relationships and build trust with partners, customers, and stakeholders. Input from these interactions enable firms to access knowledge from other firms (Dahlander & Piezunka, 2014). These knowledge spillovers from external partners have a positive impact on organizational strategy and the appropriation of intangible assets (Grimaldi et al., 2017). This leads to increased collaboration, shared learning, and the creation of intangible assets that are jointly owned and protected. By this logic, participation in open innovation ecosystems affords collaboration with external partners from which external knowledge is gained and exploited.

H2: The relationship between open innovation participation and firm performance is mediated by external knowledge.

For open innovation to have payoffs in firm performance, it is crucial for companies to manage relations with other firms to define a strategic plan that combines external and internal knowledge (Bigliardi et al., 2020). When firms seek out external knowledge, they must possess in-house knowledge related to what is being acquired (Cohen & Levinthal, 1990; Laursen & Salter, 2006). This internal knowledge creation is necessary to create the absorptive capacity to evaluate external knowledge (Dahlander & Gann, 2010). While external knowledge acquisition through collaboration is a desired outcome, the knowledge must flow internally for it to be appropriated.

Prior scholars have argued that, within open innovation, external knowledge acquisition will have a negative effect if not supported by internal R&D (Denicolai et al., 2016; Teece, 1998). Similarly, Chesbrough & Crowther (2006) asserted that open innovation is not an outsourcing of the entire R&D function but rather a compliment. From this literature stream it has been shown that open innovation affects both the utilization of existing resources and creation of new ones (Cassiman & Valentini, 2016; Chesbrough, 2003; Laursen & Salter, 2006). Firms must balance the exploration of external knowledge with the exploitation of internal knowledge (Gupta et al., 2006) to affect performance outcomes thus internal knowledge is required to achieve performance outcomes.

H3: The relationship between open innovation participation and firm performance is mediated by internal knowledge.

Prior studies on the open innovation – firm performance relationship have used differing frameworks and classifications resulting in heterogenous views. Some demonstrate positive effects, while others argue the relationship is negative or non-linear (de Leeuw et al., 2014; Laursen & Salter, 2006; Sabidussi et al., 2014). Still others have shown the relationship to be indirect and mediated (Chelliah et al., 2022; Mostafiz et al., 2022; Pundziene et al., 2023). These findings suggest that there is still more to be learned.

We know that knowledge flows are necessary to achieve innovation outcomes in open innovation (Chesbrough & Bogers, 2014). We also know that external knowledge is acquired through knowledge spillovers (Han et al., 2012) and that internal knowledge creation is necessary to create the absorptive capacity to evaluate external knowledge (Dahlander & Gann, 2010). From the knowledge management literature, it is understood that firms must establish and maintain both internal and external knowledge sharing practices for knowledge flow to occur (Ferreira et al., 2023). The knowledge management and open innovation literature proposes that knowledge flow demonstrates an indirect and mediating effect on the open innovation - innovation performance relationship (Wang & Jiang, 2019). When firms exploit external knowledge, they often combine the external knowledge with other internal knowledge to create new innovations (Sorenson et al., 2004). They must also continuously develop these practices to internalize both externally spilled-over knowledge with internal knowledge (Kloosterman, 2008). By this logic, external knowledge and internal knowledge interact in a serial fashion. This interaction positively but indirectly affects the open innovation firm performance relationship.

H4: The relationship between open innovation participation and firm performance is serially mediated by external knowledge and internal knowledge.

These relationships are depicted in the research model given in Figure 2.

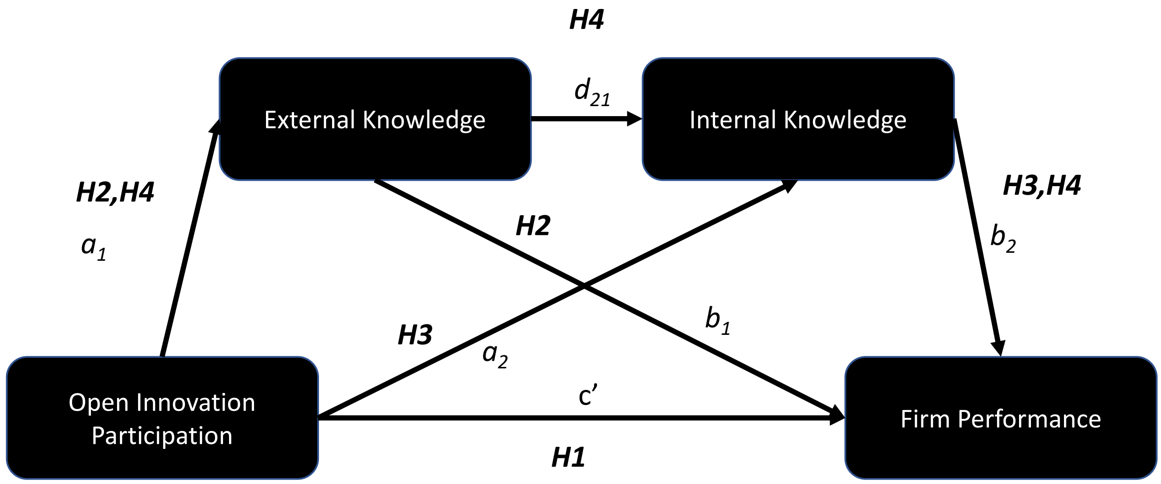


Figure 2: Empirical Research Model

Data and Methods

Sample Selection

This chapter explores open innovation within the context of an ecosystem. Ecosystems improve knowledge discovery and knowledge sharing of participating firms which in turn advances firms' innovation capability (Clauss & Kesting, 2017; Luzzini et al., 2015; Zhou & Li, 2012). In general, the considerable research in open innovation has largely been based on surveys and case studies where the firm is the level of analysis (Bogers et al., 2017; Chesbrough, 2003). Beyond recent conceptual work by Öberg & Alexander (2019), the limited research stream considering the ecosystem perspective has focused primarily on participant collaboration, either as the bilateral cooperation between two organizations (Randhawa et al., 2016), collaboration between individual participants (Constantino et al., 2020; Wang & Redmiles, 2021; Yang et al., 2020; Zhou et al., 2019) or collaboration within the network (Farias et al., 2018; Lyulina & Jahanshahi, 2021).

Given the prevalence of open innovation ecosystems in industry, the ecosystem perspective has significant value for both conceptual and empirical research. Nevertheless, it is still understudied in the open innovation literature (Radziwon & Bogers, 2019; Randhawa et al., 2021; Wikhamn, Remneland & Styhre, 2023).

For innovation ecosystems to be successful, they require the network effects of multiple participants. The greater the number of collaboration points, the greater the innovation outcome (Schilling, 2015). One of the largest and most active worldwide open innovation ecosystems is the Linux Foundation. Founded in 2000 to standardize the Linux operating system, this ecosystem has since fostered technologies that have led to the rise of cloud computing, fintech and blockchain. The Linux foundation today has over 1300 corporate firm participants collaborating on hundreds of projects[3]. Large scale multi-firm participation is most apparent in the recent area of Artificial Intelligence (AI). The Linux Foundation's AI & Data consortium has over 300 open innovation projects with over 100 firms participating worldwide [4]. Notable examples include PyTorch, a critical machine learning module originally developed by Meta that has been used in drug development, self-driving cars, and space exploration and Acumos, a platform originally developed by AT&T and TechMahindra that enables firms to build AI applications.

The Linux Foundation has a deep understanding of how to build open innovation communities and provides community organizing assistance, legal help, and marketing (Dhillon et al., 2017). It provides data on firm participation through its LF Insights

[3] Source - www.linuxfoundation.org/about/members
[4] Source - www.linuxfoundation.org/research/artificial-intelligence-and-data-in-open-source

service[5]. This service provides archival and time series data including firm name, year of participation and the specific open innovation projects that each firm participates in.

Data Collection

The data collection process consisted of four main steps. First, an a priori power analysis was conducted using G*Power3.1 to determine the minimum sample size (Faul et al., 2009). The results indicated that for a linear multiple regression, a sample of N = 245 was required to achieve 95% power for detecting a small effect at a significance criterion of $\alpha = 0.05$. Next, a preliminary analysis was conducted of all firms participating in open innovation through the Linux Foundation. From this set, only firms listed on stock market exchanges in the United States were chosen. Next, the industrial sector for each of these companies was derived from Compustat using the six-digit NAICS code of each firm. For each of these codes, all other firms in the same national industry were then collected from Compustat. The issue of zero-revenue firms was then considered. Zero-revenue public companies have seen enormous growth in the most recent years fueled by the emergence of Special Purpose Acquisition Companies (SPAC) formed strictly to raise capital (Blankespoor et al., 2022). Zero-revenue IPOs, however, are often performed by firms seeking to raise funding for R&D (Signori, 2018). These types of firms are deemed uncharacteristic of the larger market and were removed. Next, firm data for each of these remaining firms was collected from Compustat for the years 2017-2021, a period of great technological disruption described as the fourth industrial revolution (Radziwill, 2018).

[5] Source - lfx.linuxfoundation.org/tools/insights/

Measures

To address gaps in the previous literature on open innovation and firm performance, this study relies purely on objective and comparable measures. Rather than depend on self-reported activities of open innovation or internal measures of performance, it relies on archival data for both. Additionally, this chapter follows the open innovation literature that considers pecuniary measures as a preferred option to be able to objectively compare firms in the context of their competitive markets (Caputo et al., 2016; Lamberti et al., 2015; Michelino et al., 2014; Moretti & Biancardi, 2020).

Independent Variable – OI Participation

The independent variable, open innovation ecosystem participation (OI Participant), is operationalized as participation by a firm in one of the Linux Foundation open-source projects. Linux Foundation Projects use GitHub, a publicly available knowledge repository, to manage contributions by participants[6]. These GitHub repositories let researchers quantitatively measure firm participation over time and show firm tenure in the project. Linux Foundation projects follow an ascending lifecycle from initial sandbox, to incubated, to graduation. To account for firms that may depart once a project has matured, all lifecycle phases are chosen for the sample. Following prior studies, only projects with active community participation (at least 10 contributors and over 100 contributions) are considered (Crowston et al., 2006). In this model, open innovation ecosystem participation is dichotomous and represented by a dummy variable of "1" for participating firms and "0" for non-participating firms.

[6] Source - github.com/cncf

Mediating Variables – Intangible Assets

Dramatic changes in North American accounting procedures occurred in 2008, where the identification and quantification of intangible assets as a separate item in national accounts was introduced. This balance sheet asset allows firms to quantify knowledge capital used in the production process. As such this opens new opportunities for empirical exploration of knowledge driven technological change (Corrado et al., 2005, 2013). More recent literature has examined firm behavior to acquire external knowledge from open innovation using accounting measures, namely the amount invested in the acquisition of externally developed intangible assets (Moretti & Biancardi, 2020). It is argued that the unit of analysis for open innovation should be accounting measures that record the transaction in the innovation market (Michelino et al., 2015). An intangible asset may only be included on the balance sheet if the cost can be measured reliably, and it is expected that future economic benefits from the asset will flow to the firm (Denicolai et al., 2015). While customer loyalty, brand reputation, and other non-quantifiable assets are similarly non-physical, their non-quantifiable nature requires that they be recorded on the balance sheet separately as goodwill. Thus, from an accounting perspective, intangible assets are inherently quantifiable and valued resources.

To operationalize the transformation of knowledge into intangible assets, this chapter uses two accounting measures, externally acquired intangible assets (EXT IA), and internally developed intangible assets (INT IA). These variables are sourced from Compustat. From an accounting perspective, the unit of analysis for open innovation "should be the transaction in the innovation market which will be registered either in the income statement or in the balance sheet" (Michelino et al., 2015). Moretti & Biancardi (2020) argued that such variables provide more reliable indicators than other synthetic measures adopted so far by the open innovation literature.

Following previous studies on open innovation, knowledge and performance outcomes, a two-year lag is used when considering the effects of knowledge on firm performance (Martinez-Conesa et al., 2017; Shin et al., 2018). These authors observe that a time gap exists as innovation processes require time to be performed. From the author's practice perspective, this also a generally accepted time lag for external knowledge to influence internal efforts. New product development is done by internal R&D teams. These efforts often follow the firm's fiscal year planning cycle. New knowledge can influence existing product development, but it is expected that there would be a natural delay for the knowledge to diffuse within the organization.

Dependent Variable – Firm Performance

This chapter follows prior literature examining OI and firm performance (Fu et al., 2019; Hung & Chou, 2013; Torres de Oliveira et al., 2022) and adopts Tobin's Q as the firm performance measure. For this analysis, Tobin's Q offers several advantages. Firstly, it is considered a forward-looking measure of firm value that reflects long-term profitability (Chung & Pruitt, 1994; Lee & Kim, 2010) and contains an assessment of firms' future financial results from current technological activities (Faems et al., 2010). The forward-looking aspect is particularly important since returns from technological activities often manifest years after the activities occur (Czarnitzki et al., 2006). Secondly, Tobin's Q measures the performance of intangible assets - a dimension important to the concept of intangible knowledge gained from external searching. Lastly, Tobin's Q is not affected by differing accounting conventions, so it is ideal to compare firms across different industries (Anderson et al., 2004; Chakravarthy, 1986).

This chapter leverages the measure developed by Chung & Pruitt (1994) who proposed a simplified formula that captures at least 96.6% of the variability of a firm's Tobin's Q ratio. This approximate Q is a proxy for a firm's long-term performance. The formula is as follows,

$$Approximate\ Q = (MVE + PS + DEBT)/TA \qquad (1)$$

were,

MVE: (closing price of shares at the end of the fiscal year) X (number of common shares outstanding),

PS: liquidation value of the firm's outstanding preferred stock,

DEBT: (current liabilities − current assets) + (book value of inventories) + (long-term debt),

TA: book value of total assets.

Control Variables

The literature stream on open innovation and firm performance has considered various controls for empirical studies. Given in Table 3, these variables are chosen to account for other factors that may affect firm performance outcomes. This chapter leverages several. Firm size is included because prior research shows a potential positive impact of size on the relationship between open innovation and innovation (Cheng & Huizingh, 2014; Josefy et al., 2015). Though some previous studies have operationalized firm size as number of employees, other researchers have argued that this measure may not be the best choice for industries that include part-time and contract-based workers (Dang et al., 2018). This situation is more prevalent in the period under consideration given the worldwide shortage of technology workers where innovative firms often face more skill shortages (Horbach & Rammer, 2020). Dang et al. (2018) suggests that the choice of firm size measure should be driven by the purpose of the study. Given that the focus of this chapter is on value capture, where firms with more assets possess more complementary functions such sales channels and marketing (Teece, 1986), firm size is operationalized as the market value of equity (market capitalization). This variable is calculated as the value of firm shares at the end of each reference year and sourced from Compustat. This choice follows more recent studies in open innovation and firm performance which have chosen financial measures for firm size (Schäper et al., 2023).

Firm age is included because younger firms have been shown to be more open to new knowledge than older firms (Harison & Koski, 2010). This may also manifest itself as younger firms being more familiar with open innovation as a business model. This variable is calculated as the number of years since the firm’s IPO date using the Field-Ritter dataset of company founding dates (Loughran & Ritter, 2004).

R&D intensity is frequently adopted as a control variable in open innovation studies given that it may influence innovation and firm performance (Caputo et al., 2016; Hung & Chou, 2013; Michelino et al., 2015). It is calculated as the ratio of R&D expense to sales (Michelino et al., 2015). Both variables are sourced from Compustat.

Lastly, this chapter adopts two remaining controls: industry sector, given that the degree of openness in firms has been shown to differ between industries (West & Bogers, 2014), and panel year, to account for observation years in the fixed effects analysis (Moretti & Biancardi, 2020). A summary of the variables used is presented in Table 4 and the resulting research model operationalization is given in Figure 3.

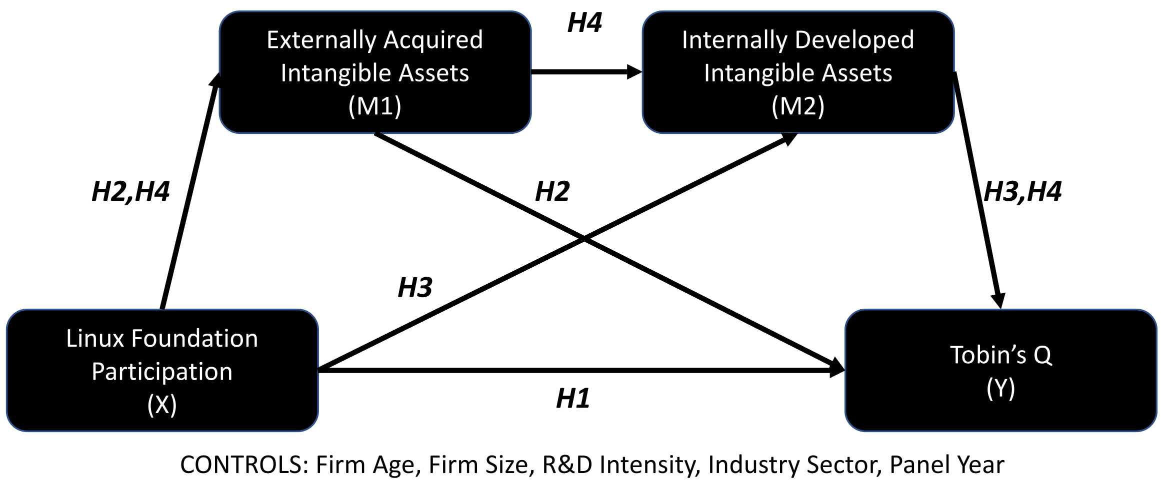


Figure 3: Research Model Operationalization

Table 3: Extant literature on Open Innovation and Firm Performance

Authors	Year	Dependent Variable	Independent Variables	Control Variables
de Oliveira, Verreynne, Steen & Indulska	2021	1. Tobin's Q	1. New Products from Open Innovation	1. Firm Age 2. Firm Size 3. Industry
Moretti & Biancardi	2020	1. Sales Turnover 2. Valuation 3. Number of Employees	1. Externally Acquired Intangible Assets 2. Internally Developed Intangible Assets	1. Industry 2. Country 3. Time 4. R&D Expense
Liao, Fu & Lu	2020	1. Market Performance 2. Profitability	1. Openness Ratio	1. Environmental Turbulence 2. Firm Size 3. Firm Age 4. Lifecycle Stage 5. Industry
Fu, Liu & Zhou	2019	1. Tobin's Q	1. Openness Ratio	1. Firm Age 2. Firm Size
Zhang, Yang, Qiu, Bao, Li	2018	1. Return on Equity	1. Royalty	1. Total Assets 2. Firm Age 3. Assets / Liabilities
Michelino, Lamberti, Cammarano, Caputo	2015	1. Revenue / Employee 2. EBIT / Employee 3. Growth 4. Valuation	1. Openness Ratio	1. Firm Size 2. Firm Age 3. R&D / Sales 4. R&D / Employee
Hung & Chou	2013	1. Tobin's Q	2. Openness Ratio	1. R&D / Sales 2. Technology Turbulence 3. Market Turbulence 4. Firm Size 5. Industry

Table 4: Operationalization of Variables

Group	Variable	Description	Type	Operationalization
Control	Firm Age	Age of the firm since IPO date	Continuous	Log(AGE)
	Firm Size	Market capitalization	Continuous	Log(MRKTCAP)
	R&D Intensity	Ratio of R&D expense to sales	Continuous	Log(RDINT)
	Industry	Industry of the firm	Dummy	NAICS Sector Dummies
	Year	Reference year	Dummy	Y17 = 2017 Y18 = 2018 Y19 = 2019 Y20 = 2020 Y21 = 2021
Independent	OI Participant	Firm participation in open innovation ecosystems	Dichotomous Dummy	"1" = Yes, "0" = NO
Dependent	Tobin's Q	Ratio of firm value	Continuous	Log(TOBINSQ)
Mediators	INT IA	Value of internally developed intangible assets at the end of each reference year	Continuous	Log(INT IA)
	EXT IA	Value of externally acquired intangible assets at the end of each reference year	Continuous	Log(EXT IA)

Empirical Strategy

The identification strategy is based on a panel data regression. The empirical model is described in (2) and depicted in Figure 4.

$$Y = (b_0 + a_1b_1 + a_2b_2 + a_1d_{21}b_2) + (a_1b_1 + a_2b_2 + a_1d_{21}b_2 + c')X \quad (2)$$

For H1, the *c* path is tested which is the direct effect of X on Y. For H2, the a_1 to b_1 path is tested which the indirect effect of M1 on X and Y. For H3, the a_2 to b_2 path is tested which is the indirect effect of M2 on X and Y. For H4, the a_1 to d_{21} to b_2 path is tested which is the indirect effect of X through M1 to M2 to Y. Finally, the total effect of the serial mediation is tested using the *c'* path. The Hayes PROCESS macro Version 4.2 beta (Hayes, 2017) in SPSS version 29 is used for the empirical analysis. The Hayes PROCESS macro model 4 is used for H2 and H3. The Hayes PROCESS macro model 6 is used for H4. Tests are conducted using a percentile bootstrap estimation approach (MacKinnon et al., 2004) with 5000 samples at a 95% confidence interval.

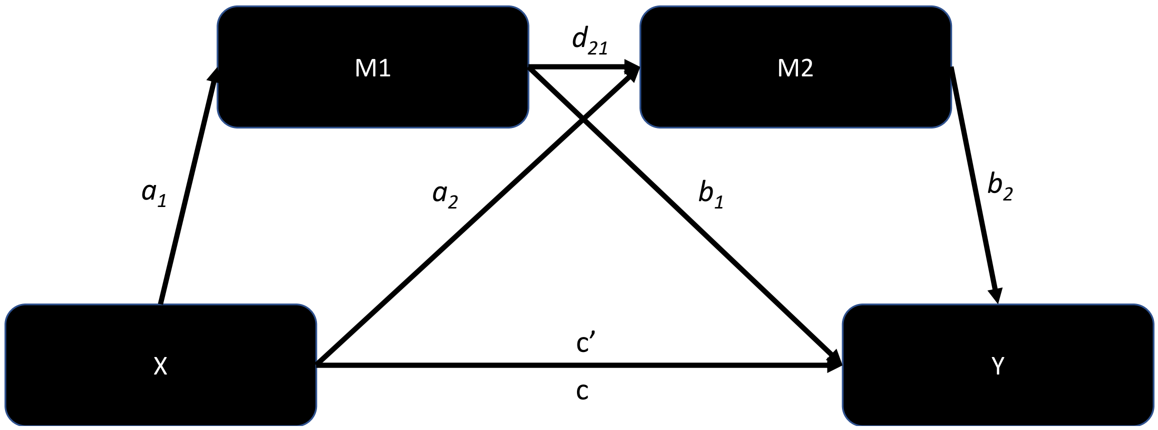


Figure 4: Statistical Form

Findings

Data Screening

The sample data demonstrated some skewness, but no linear relationships were found. A Z-score analysis was then performed on the data sample to identify and remove firm observations that were more than 3.29 standard deviations from any of the outcome variables. To test for discriminant validity, variance-inflation factor (VIF) tests were conducted to see if the data met the assumption of collinearity. All the variables used were below the cut-off value of 5 (Chatterjee & Simonoff, 2013), thus multicollinearity was not a concern. The resulting sample yielded N = 779 distinct firms, well within the power analysis objective of N = 245. From these steps, the final sample is an unbalanced panel consisting of 3002 firm-year observations for the period 2017 - 2021.

Descriptive Results

Table 5 shows the summary statistics and Table 6 shows the correlation matrix of all variables used in the econometric analysis. All continuous variables are in logarithmic form. Open innovation ecosystem participation is a dichotomous variable. Industry sector and panel year are dummy variables and therefore not included.

Table 5: Summary Statistics

Variable	N	Min	Max	Mean	Std. Deviation
OI Participant	3002	0	1	0.09	0.289
Log(EXT IA)	883	-3.24	9.71	3.477	2.163
Log(INT IA)	2557	-6.91	11.99	3.776	2.699
Log(TOBINSQ)	2986	1.67	14.78	7.786	2.417
Log(AGE)	1983	-3.13	3.83	2.419	1.142
Log(MARKETCAP)	2993	-5.78	8.11	3.013	1.650
Log(RDINT)	2400	-137.34	18.70	0.576	2.892

Industry representation by year is depicted in Table 7. In total, 14 NAICS industries are included. The top three representative sectors are Information (Sector 51) at 53%, Manufacturing (Sector 33) at 37% and Scientific and Professional Services (Sector 54) at 7%. The sample includes 275 firm-year observations of firms participating in open innovation ecosystems. While some technology heavy firms such as Apple, IBM and Microsoft are expected, the sample also includes companies such as Toyota, General Motors, DoorDash, EverQuote and RobinHood. It is also noted that open innovation participation by industry was consistent or growing in each observation year. This suggests a broad cross-sector and growing trend.

Table 6: Correlation Matrix

	OI Participant	LOG (EXT IA)	LOG (INT IA)	LOG (TOBINSQ)	LOG (AGE)	LOG (RDINT)	LOG (MRKTCP)	2017	2018	2019	2020	2021	NAICS 3333	NAICS 3341	NAICS 3342	NAICS 3344	NAICS 3345	NAICS 3361	NAICS 4541	NAICS 5112	NAICS 5132	NAICS 5182	NAICS 5191	NAICS 5192	NAICS 5231	NAICS 5415
OI Participant	1																									
LOG(EXT IA)	.155**	1																								
LOG(INT IA)	.108**	.811**	1																							
LOG (TOBINSQ)	.213**	.556**	.600**	1																						
LOG (AGE)	.090**	.145**	.119**	.044*	1																					
LOG (RDINT)	0.025	.136**	.104**	.054**	0.010	1																				
LOG (MRKTCP)	.214**	.277**	.277**	.430**	.077**	.068**	1																			
2017	0.014	-0.041	0.019	.074**	.158**	0.001	-0.005	1																		
2018	0.011	0.014	0.027	.047*	.115**	0.007	-.050**	-.201**	1																	
2019	0.005	0.012	-0.008	-0.031	.054*	-0.036	-.046*	-.213**	-.227**	1																
2020	-0.003	0.028	-0.015	-.044*	-0.023	0.011	.071**	-.227**	-.242**	-.257**	1															
2021	-0.022	-0.014	-0.018	-0.033	-.254**	0.015	0.024	-.255**	-.271**	-.288**	-.307**	1														
NAICS 3333	0.008	-0.052	-0.024	-0.033	.048*	-0.006	-.067**	0.014	0.008	0.002	-0.005	-0.016	1													
NAICS 3341	.115**	-0.024	-0.029	-.037*	.128**	-0.003	-0.018	0.020	0.013	0.006	-0.006	-0.027	-0.028	1												
NAICS 3342	0.019	0.033	-0.012	-.052**	.179**	0.003	-.150**	0.025	0.011	0.004	-0.007	-0.028	-0.035	-.065**	1											
NAICS 3344	-0.034	.068*	0.035	0.013	.146**	0.012	.038*	0.032	0.019	0.006	-0.012	-.038*	-.047*	-.086**	-.108**	1										
NAICS 3345	-0.008	.079*	.102**	0.033	.066**	0.004	.068**	0.015	0.005	0.000	-0.007	-0.011	-0.026	-.047**	-.059**	-.079**	1									
S 3361	.053**	0.041	.103**	.078**	0.015	-.133**	.049**	-0.003	-0.002	-0.008	0.006	0.006	-0.016	-0.029	-.036*	-.048**	-0.026	1								
S 4541	-0.034	-0.046	-0.019	0.017	-.161**	-0.003	-.048**	-0.017	-0.023	-0.004	0.003	0.035	-0.028	-.051**	-.064**	-.086**	-.047*	-0.028	1							
S 5112	0.004	-.086*	-0.026	-0.032	.073**	0.009	-0.015	0.001	0.004	-0.006	0.000	0.001	-.043*	-.079**	-.099**	-.133**	-.072**	-.044*	-.079**	1						
S 5132	-0.013	0.061	0.012	0.013	.094**	0.004	0.035	0.014	0.006	-0.001	-0.009	-0.008	-0.019	-.036*	-.045*	-.060**	-0.033	-0.020	-0.036	-.055**	1					
S 5182	-0.004	0.014	0.020	-0.007	-.185**	0.012	.071**	-.040*	-0.020	-0.023	0.012	.060**	-.057**	-.105**	-.131**	-.176**	-.096**	-.058**	-.104**	-.161**	-.073**	1				
S 5191	-.047**	-.075*	-.088**	-0.019	-.226**	0.013	-0.015	-.045*	-0.015	0.012	0.017	0.024	-.064**	-.117**	-.147**	-.196**	-.107**	-.065**	-.116**	-.180**	-.081**	-.238**	1			
S 5192	.065**	0.019	0.037	0.024	0.038	0.010	.074**	0.005	0.001	0.005	0.000	-0.009	-0.012	-0.022	-0.028	-.037*	-0.020	-0.012	-0.022	-0.034	-0.015	-.045*	-.050**	1		
S 5231	-.055**	0.029	0.028	.091**	0.003	0.001	0.007	0.013	-0.001	0.008	-0.002	-0.016	-0.024	-.044*	-.055**	-.074**	-.040*	-0.024	-.044*	-.068**	-0.031	-.090**	-.100**	-0.019	1	
NAICS 5415	0.033	0.027	-0.006	0.003	.088**	-0.002	0.000	0.022	0.012	0.003	-0.007	-0.025	-0.033	-.060**	-.075**	-.101**	-.055**	-0.033	-.060**	-.092**	-.042*	-.122**	-.136**	-0.026	-.051**	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 7: Sample Distribution by NAICS Code, Industry and Year

NAICS	INDUSTRY	2017	2018	2019	2020	2021
3333	Service Industry Machinery	9	9	9	9	9
3341	Computer Equipment Manuf.	28	29	30	30	30
3342	Communication Equip Manuf.	43	43	45	46	48
3344	Semiconductor Manuf.	72	74	76	77	81
3345	Control Instruments Manuf.	23	23	24	25	29
3361	Motor Vehicle Manufac.	7	8	8	11	13
4541	Electronic Shopping	19	20	27	32	47
5112	Software Publishers	52	59	61	70	84
5132	Cable Networks	14	14	14	14	17
5182	Data Processing and Hosting	67	84	92	119	165
5191	Information Services	80	104	128	144	174
5192	Periodicals & Newspapers	5	5	6	6	6
5231	Securities Brokerage	20	19	23	23	24
5415	Information Technology Srvcs	37	38	39	40	42

Entry counts represent the number of firms by industry, for each year.

Regression Results

Table 8 depicts the regression results for the base model consisting of the control variables and firms' Tobin's Q, using a two-year lag. The year 2021 is the last observation year and chosen as the reference year and left out. NAICS 5191 is the largest industry by representation and chosen as the reference industry and left out. The base model fit is R^2 = .229.

Table 8: Base Model with Control Variables

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	5.638	.177		31.768	<.001
	LOG(AGE)	.007	.049	.003	.136	.892
	LOG(RDINT)	.016	.014	.024	1.100	.271
	LOG(MRKTCP)	.675	.033	.469	20.589	<.001
	2017	.400	.157	.066	2.547	.011
	2018	.329	.151	.057	2.181	.029
	2019	-.070	.146	-.012	-.481	.630
	2020	-.328	.140	-.061	-2.349	.019
	NAICS 3333	-.046	.453	-.002	-.101	.920
	NAICS 3341	-.534	.237	-.054	-2.252	.024
	NAICS 3342	.204	.203	.026	1.006	.315
	NAICS 3344	-.032	.159	-.005	-.200	.841
	NAICS 3345	.022	.275	.002	.080	.936
	NAICS 3361	.433	.355	.028	1.220	.223
	NAICS 4541	.128	.371	.008	.344	.731
	NAICS 5112	-.250	.173	-.037	-1.439	.150
	NAICS 5132	-.047	.309	-.003	-.151	.880
	NAICS 5182	-.275	.149	-.048	-1.848	.065
	NAICS 5192	-.828	.421	-.044	-1.969	.049
	NAICS 5231	-2.148	.982	-.047	-2.186	.029
	NAICS 5415	-.539	.283	-.044	-1.902	.057

a. Dependent Variable: LOG (TOBINSQ)

Model Summary

Figure 5 depicts the results of the direct effect. Open innovation participation is associated with greater Tobin's Q, b=1.096, $p < .001$. Model fit is improved at $R^2 = .253$. H1 is supported. These findings support previous literature on the positive effects of open innovation and suggest that participation in open innovation ecosystems has a significant and positive effect on firm performance.

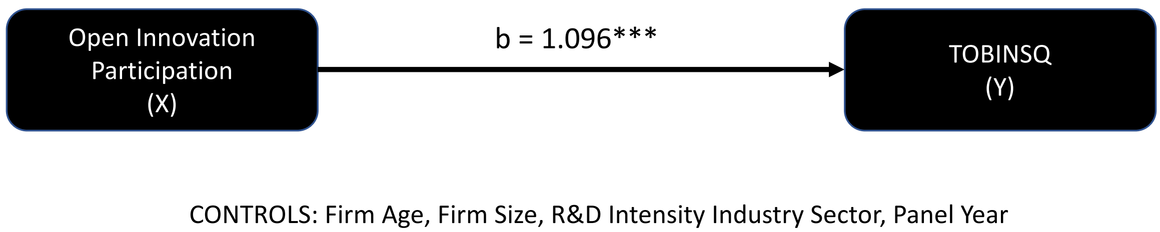


Figure 5: H1 Direct Effect

Figure 6 depicts the results of the mediating role of externally acquired intangible assets on the OI participation – Tobin's Q relationship. The results are significant, t(480) = 6.922, $p < .001$, 95% CI[1.109,1.989]. The model fit is improved at R^2 =.289. H2 is supported. Though externally acquired intangible assets have been used in previous open innovation research to demonstrate the positive effects on firm performance (Chen et al., 2011; Moretti & Biancardi, 2020; Rass et al., 2013), it is argued that the variable is misaligned as a proxy for open innovation activities. By itself, externally acquired intangible assets can represent the results of active Mergers and Acquisitions (M&A) growth (Arikan, 2002). By using an objective measure for open innovation, such as open innovation ecosystem participation, the relationship of externally acquired intangible assets is better understood. In this case, the findings suggest that open innovation ecosystem participation is associated with greater externally acquired intangible assets and those assets partially mediate the relationship between open innovation and firm performance.

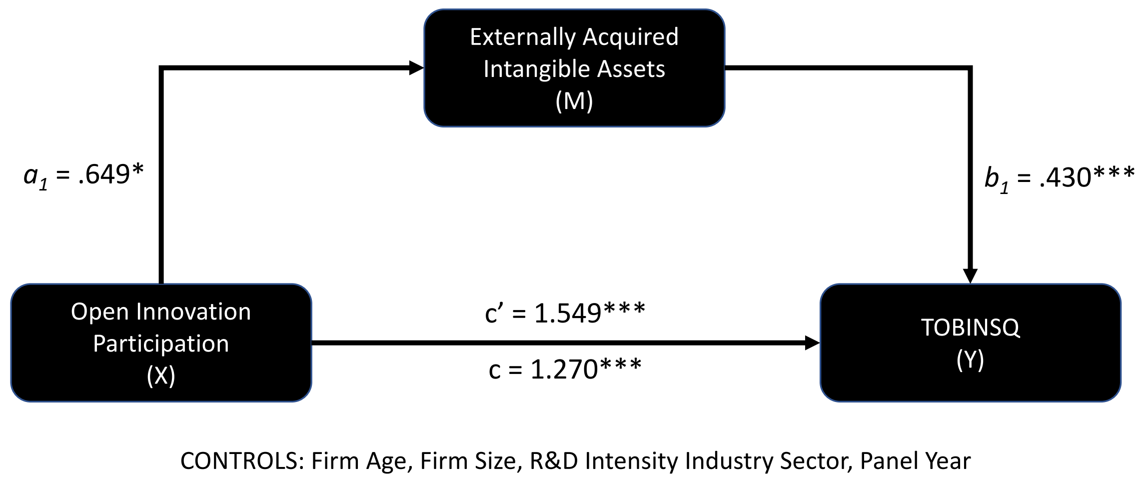


Figure 6: H2 Indirect Effect – Externally Acquired Intangible Assets

Figure 7 depicts the results of the mediating role of internally developed intangible assets on the OI participation – Tobin's Q relationship. The results are significant, t(1412) = 7.324, $p < .001$, 95% CI[.835,1.447]. The model fit is improved at R^2 =.247. H3 is supported. Previous open innovation research has used internally developed intangible assets as a measure of openness and demonstrated the positive effects on firm performance (Moretti & Biancardi, 2020). This literature, however, did account for any observable or self-reported measures for open innovation practices and failed to make a strong argument on the open innovation – internally developed intangible asset relationship. The findings in this chapter strengthen this argument but show that internally developed intangible assets play a partially mediating role.

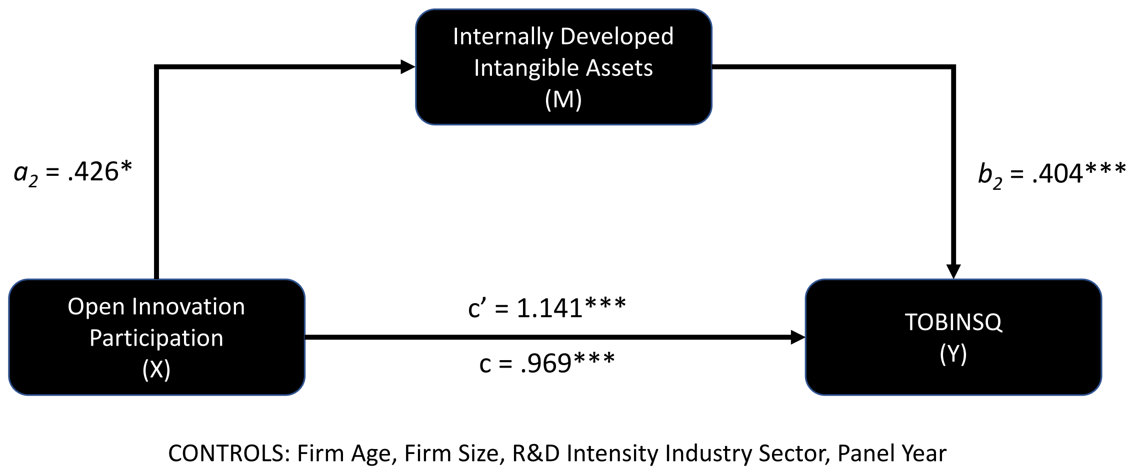


Figure 7: H3 Indirect Effect - Internally Developed Intangible Assets

Taken together, H2 and H3 suggest that both externally acquired and internally developed intangible assets play an important role in the open innovation – firm performance relationship. Open innovation participation is positively and significantly related to greater intangible assets in both cases, and both play a partially mediating role. This leads to the final analysis of these two variables acting in a serial fashion. Figure 8 depicts the results of the serial mediating role of externally acquired intangible assets to internally developed intangible assets on the OI participation – Tobin’s Q relationship. The results are significant, $t(478) = 6.788$, $p < .001$, 95% CI[1.085,1.969]. The model fit at R^2 =.287 is however reduced when compared to H2.

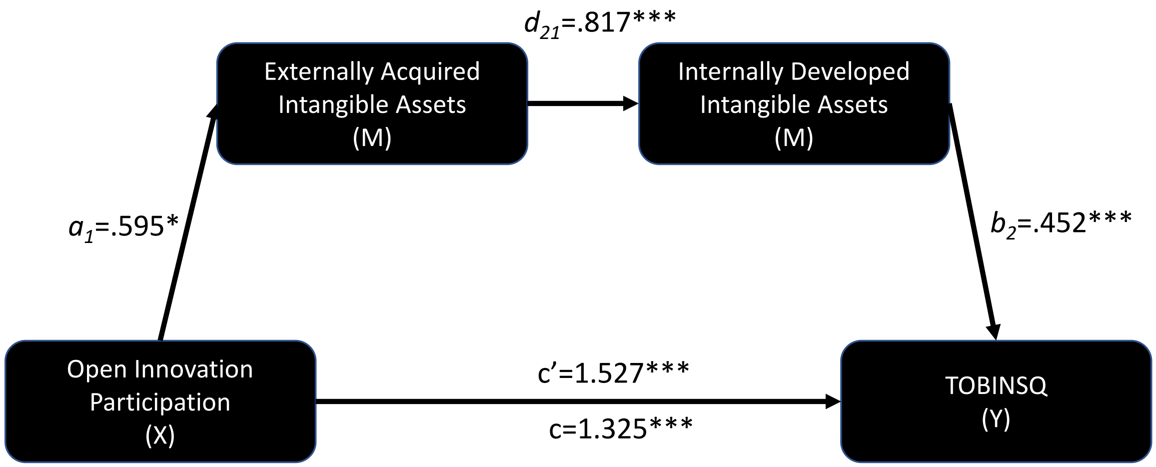


Figure 8: H4 Indirect Effect – Serial Mediation

A comparison of the mediation results is given in Table 9. Partial mediation is observed in all hypotheses. Though all models are positive and significant, the addition of internally developed intangible assets as a predictor reduces the model fit in H4 versus H2. This initially suggests that multicollinearity may be an issue between externally acquired intangible assets and internally developed intangible assets. Although the correlation is high, $r = .811, p < .001$, the VIF scores are below the threshold value of 5 (Chatterjee & Simonoff, 2013). Another possible explanation is that one of the mediating variables may have a moderating effect on the open innovation participation – firm performance relationship. This possibility is explored in the post-hoc analysis.

Table 9: Mediation Results

Model	Total Effect	Direct Effect	Relationship	Indirect Effect	Confidence Interval		t-statistic	Conclusion
					Lower Bound	Upper Bound		
H2 N = 502 *R^2*: 0.289	1.549*** (0.224)	1.270*** (0.195)	OI → EXT IA → TOBINSQ	0.279 (0.116)	0.044	0.507	2.399	Partial Mediation
H3 N=1434 *R^2*: 0.247	1.141*** (0.156)	0.968*** (0.132)	OI → INT IA → TOBINSQ	0.172 (0.085)	0.006	0.344	2.037	Partial Mediation
H4 N = 500 *R^2*: 0.287	1.527*** (0.225)	1.325*** (0.183)	OI → EXT IA → INT IA → TOBINSQ	0.220 (0.110)	0.014	0.453	1.998	Partial Mediation

* *Statistically significant at the 0.05 level.*
** *Statistically significant at the 0.01 level.*
*** *Statistically significant at the 0.001 level.*
NOTE: Standardized coefficients for dichotomous X are in partially standardized form

Robustness Checks

Several additional analyses were conducted to assess the robustness of the findings. Following recent open innovation literature examining the effects of intangible assets (Moretti & Biancardi, 2020), two additional firm performance measures were considered: economic performance, measured as firm turnover (SALES) and human capital performance, measured as the number of employees reported at the end of each year (EMP).

Additionally, other time periods were evaluated. The analysis in this chapter considered a two-year lagged model which aligns with previous open innovation literature (Martinez-Conesa et al., 2017; Shin et al., 2018) as well as practitioner expectations on influencing new product development. For robustness, two other time models were considered: (1) current year (CY), where there is no lagging of variables and, (2) one-year lags for both externally acquired and internally developed intangible assets.

A summary of these robustness checks is given in Table 10. H1 is supported in all time periods across all outcome variables. Open innovation ecosystem participation is associated with greater firm performance. H2 – H4 were not significant using the current year and one-year lagged models. When using two-year lags, all firm performance measures were positive and significant. The mediation results of these robustness checks are given in Table 11. These findings support the argument that knowledge gained from open innovation requires time to influence innovation outcomes in firms (Martinez-

Conesa et al., 2017). It also supports the open innovation - firm performance outcomes in the main analysis. When using other outcome variables, similar results are observed.

Table 9: Robustness Checks Summary

Time	Hypothesis	TOBINSQ	SALES	EMP
CY	H1 – Direct Effect	Y	Y	Y
	H2 – Indirect Effect Simple Mediation	N	N	N
	H3 – Indirect Effect Simple Mediation	N	N	N
	H4 – Indirect Effect Serial Mediation	N	N	N
1Y Lag	H1 – Direct Effect	Y	Y	Y
	H2 – Indirect Effect Simple Mediation	N	N	N
	H3 – Indirect Effect Simple Mediation	N	N	N
	H4 – Indirect Effect Serial Mediation	N	N	N
2Y Lag	H1 – Direct Effect	Y	Y	Y
	H2 – Indirect Effect Simple Mediation	Y	Y	Y
	H3 – Indirect Effect Simple Mediation	Y	Y	Y
	H4 – Indirect Effect Serial Mediation	Y	Y	Y

As a further robustness check, high-tech firms were removed from the sample set to evaluate the relationships in firms where technology and/or software are not the primary product or service. Four NAIC sectors were removed, Information Technology Services (NAICS 5415): this sector includes firms that provide software development and other IT services, Software Publishers (NAICS 5112): this sector includes firms that develop software applications, Computer Equipment Manufacturing (NAICS 3341): this sector covers the manufacturing of computer hardware, electronic components, and communication equipment and Data Processing and Hosting (NAICS 5182): this sector includes data centers and cloud computing services.

Lastly, an additional control was added to the reduced sample to account for firm M&A activity. The balance sheet entry for externally acquired intangible assets may be influenced by firms who are highly acquisitive. To control for M&A activity an M&A Intensity measure is added using the ratio of Goodwill to Total Assets (Colley & Volkan, 1988; Lamberti et al., 2015). These results are presented in Table 12. Using the reduced sample and additional control for M&A Intensity, H2 – H4 remain supported. Of note, the model fit for all hypotheses is stronger when compared to the main analysis. For H4 specifically, the inclusion of multiple predictors improves the model fit which was not observed in the main study. This may reflect problems with how high-tech firms value certain internally developed intangible assets, an issue previous authors have argued as being inefficient and lacking in transparency (García-Ayuso, 2003).

Table 11: Robustness Checks Mediation Results – Additional Outcome Variables

Model	Total Effect	Direct Effect	Relationship	Indirect Effect	Confidence Interval		t-statistic	Conclusion
H2 – 2Y					Lower Bound	Upper Bound		
SALES N = 505 R^2: 0.261	1.275*** (0.208)	0.999*** (0.178)	OI → EXT IA → SALES	0.276 (0.114)	0.055	0.502	2.427	Partial Mediation
EMP N=503 R^2: 0.207	0.958*** (0.197)	0.737*** (0.174)	OI → EXT IA → EMP	0.221 (0.098)	0.029	0.420	2.265	Partial Mediation
H3 – 2Y								
SALES N = 1436 R^2: 0.200	1.014*** (0.152)	0.842*** (0.127)	OI → INT IA → SALES	0.172 (0.084)	0.013	0.343	2.051	Partial Mediation
EMP N=1405 R^2: 0.174	0.836*** (0.139)	0.676*** (0.119)	OI → INT IA → EMP	0.160 (0.071)	0.219	0.301	2.242	Partial Mediation

Table 11: Robustness Checks Mediation Results – Additional Outcome Variables

Model	Total Effect	Direct Effect	Relationship	Indirect Effect	Confidence Interval		t-statistic	Conclusion
H4 – 2Y					Lower Bound	Upper Bound		
SALES N = 503 R^2: 0.260	1.253*** (0.209)	1.067*** (0.162)	OI → EXT IA → INT IA → SALES	0.256 (0.120)	0.032	0.512	2.139	Partial Mediation
EMP N=501 R^2: 0.205	0.937*** (0.197)	0.798*** (0.161)	OI → EXT IA → INT IA → EMP	0.214 (0.108)	0.015	0.436	1.980	Partial Mediation

* *Statistically significant at the 0.05 level.*
** *Statistically significant at the 0.01 level.*
*** *Statistically significant at the 0.001 level.*
NOTE: Standardized coefficients for dichotomous X are in partially standardized form

Table 12: Robustness Checks Mediation Results – Reduced Sample

Model	Total Effect	Direct Effect	Relationship	Indirect Effect	Confidence Interval		t-statistic	Conclusion
					Lower Bound	Upper Bound		
H2 N = 188 R^2: 0.442	1.208*** (0.327)	1.862** (0.420)	OI → EXT IA → TOBINSQ	0.653 (0.311)	0.025	1.249	2.101	Partial Mediation
H3 N= 506 R^2: 0.343	1.404*** (0.261)	0.918*** (0.217)	OI → INT IA → TOBINSQ	0.487 (0.151)	0.207	0.801	3.219	Partial Mediation
H4 N = 188 R^2: 0.791	1.126*** (0.263)	1.862*** (0.420)	OI → EXT IA → INT IA → TOBINSQ	0.760 (0.368)	0.043	1.507	2.064	Partial Mediation

* *Statistically significant at the 0.05 level.*
** *Statistically significant at the 0.01 level.*
*** *Statistically significant at the 0.001 level.*
NOTE: Standardized coefficients for dichotomous X are in partially standardized form

Post-Hoc Analysis

Though partial mediation was observed in all hypotheses, the addition of internally developed intangible assets as a predictor variable reduced the model fit in H4 versus H2 in the main analysis. When the addition of predictor variables reduces model fit, it can suggest a moderating versus a mediating effect. As a post-hoc analysis, a moderated-mediation relationship was therefore considered. Given in Figure 9, this model depicts internally developed intangible assets as a moderator of the open innovation participation – firm performance relationship that is mediated by externally acquired intangible assets. Previous literature has established that when firms seek out external knowledge, they must possess in-house knowledge (Cohen & Levinthal, 1990; Laursen & Salter, 2006). This internal knowledge is necessary to create the absorptive capacity to evaluate external knowledge (Dahlander & Gann, 2010).

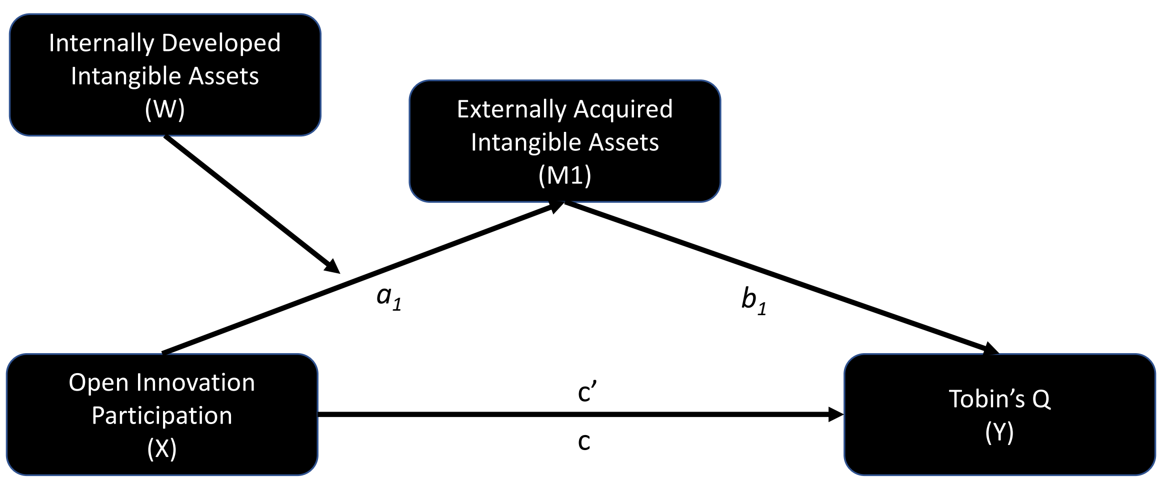
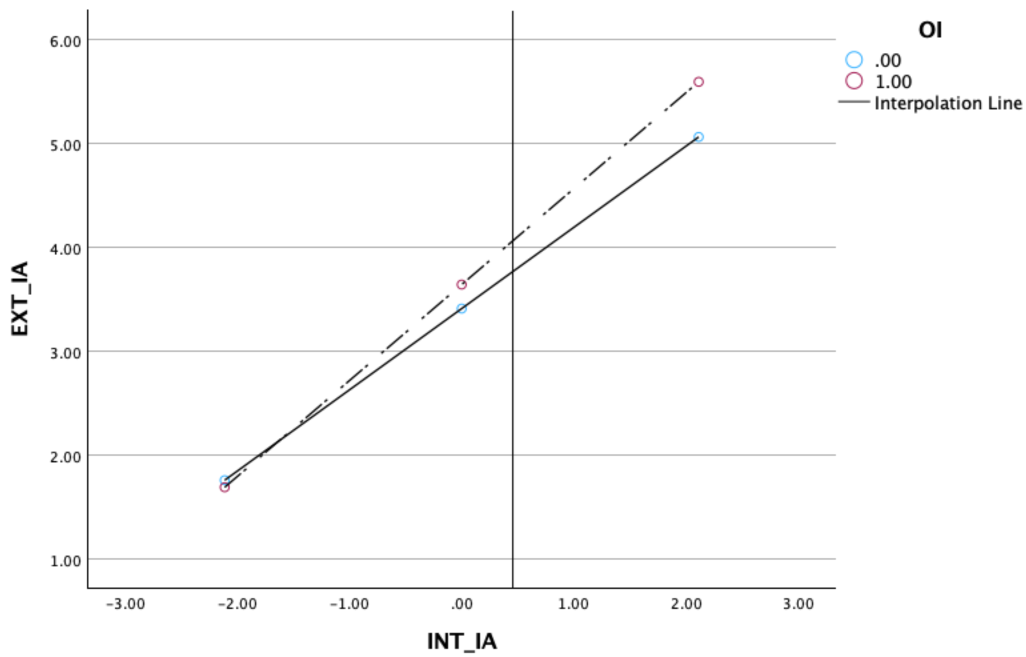


Figure 9: Moderated Mediation Model

The Hayes PROCESS macro model 7 was used for the post-hoc analysis. Tests were conducted using a percentile bootstrap estimation approach (MacKinnon et al., 2004) with 5000 samples at a 95% confidence interval. All continuous predictor variables were mean centered. The results were significant, t(475) = 6.567, $p < .001$, 95% CI[.859,1.593]. In this model, the fit is significantly improved at R^2 =.462. The conditional indirect effects are given in Table 12 and depicted in a Johnson-Neyman plot in Figure 10. In the figure, an OI value of “1” represents open innovation ecosystem participation. The moderating effects are significant only at high levels of internally developed intangible assets with the slope significant at one standard deviation above the mean. The index of moderated mediation (index = .062, 95% CI[.005,.113]) is significant since the 95% CI does not include zero. These findings confirm that internal knowledge plays a role in the absorptive capacity of firms which in turn has a moderating effect on the seizing of external knowledge from open innovation.

Table 10: Moderated Mediation Results

Indirect Relationship	Direct Effect	Indirect Effect (SE)	Conf. Interval (Low/High)	T-Value
OI → EXT IA → TOBINSQ	1.214	0.194	.832/1.595	6.246
Proving Moderated Indirect Relationships	**Effect**	**SE**		
Low level of INT IA	-.030	.085	-.196/.136	-0.353
High Level of INT IA	.231	.086	.050/.390	2.686
Index of Moderated Mediation	.062	.028	.005/.113	2.212



Note: Vertical line (.456) represents the region of significance per the Johnson-Neyman Technique

Figure 10: Moderation Effect of Internal Knowledge on External Knowledge

Discussion

This chapter sought to better understand the role of knowledge in the relationship between open innovation and firm performance within the context of an ecosystem, an area highlighted by (West et al., 2014) as an emerging theme for the coming decade of open innovation research. When controlling for firm age, firm size, R&D intensity, industry sector and panel year specific effects, the direct effects of open innovation ecosystem participation on firm performance were positive and significant. H1 was supported. Open innovation ecosystem participation was associated with greater firm performance. While significant previous literature has considered the positive effects of open innovation on firm performance, these studies leverage self-reported or synthetic measures for openness. To be the best of the author's knowledge, no previous study has leveraged objective measures for open innovation participation specifically within open innovation ecosystems.

When considering the effects of external knowledge on the open innovation ecosystem participation – firm performance relationship, externally acquired intangible assets were shown to partially mediate the relationship in all outcome variables. H2 was supported. This builds on previous literature demonstrating that knowledge spillovers contribute positively to the appropriation of intangible assets (Grimaldi et al., 2017). It also provides a link between open innovation activity and the intangible assets – firm performance relationship previously studied in the open innovation literature (Moretti & Biancardi, 2020). Rather than a proxy for openness, intangible assets act as a partial mediator between open innovation and performance outcomes.

The partial mediating effect of internal knowledge on the open innovation ecosystem participation – firm performance relationship was observed in all outcome variables. H3 was supported. These findings support previous literature that states internal knowledge is a necessary antecedent to a firm's ability to absorb external knowledge and thus precedes the acquisition of external knowledge (Antonelli & Colombelli, 2015). Applied in this situation, this means firms need to build a stock of internally developed intangible assets to be able to exploit intangible assets gained from open innovation ecosystems.

Examining the effects of external and internal knowledge together demonstrated that although serial mediation was observed, the addition of internally developed intangible assets as a predictor variable weakened the model fit. H4 was therefore not conclusively supported. The relationship between external knowledge and internal knowledge in open innovation has been extensively theorized. Previous literature has established that firms must possess in-house knowledge to seek out external knowledge (Cohen & Levinthal, 1990; Laursen & Salter, 2006). The addition of additional mediators that weaken model fit can suggest the relationship is not mediation but rather moderation. Previous literature has established internal knowledge as a necessary antecedent to create the absorptive capacity to evaluate external knowledge (Dahlander & Gann, 2010). Thus, a post-hoc analysis was conducted to explore the internal developed intangible assets as a moderator to the open innovation participation – externally acquired intangible assets – firm performance relationship. These findings demonstrated that internal knowledge as internally developed intangible assets positively moderates the relationship. This effect occurs only at high levels of internally developed intangible assets and the effect strengthens as levels increase. While H4 was not supported, these findings empirically support previous theoretical propositions that knowledge as intangible assets will lead to greater firm performance when using open innovation business models (Harris & Moffat, 2016) and that knowledge flows are necessary to achieve innovation outcomes in open innovation (Chesbrough & Bogers, 2014). These findings also suggest that internally developed intangible assets may be a poor proxy for internal knowledge. While early literature has argued that intangible assets are how knowledge is accounted for in the business enterprise (Green, 2006), more recent open innovation literature has used intangible assets as a proxy for firm openness in open innovation (Moretti & Biancardi, 2020).

For this analysis, two-year lagged variables were used. This is consistent with previous literature that states innovation outcomes from open innovation require time to be performed (Martinez-Conesa et al., 2017; Shin et al., 2018). This also aligns with practitioner perspectives on open innovation ecosystem participation. Successful ecosystems, by their very nature, are large with many participants. Participation in large open innovation ecosystems comes at an expense to firms in both participation fees as well as labor costs of their employees. An open innovation investment will often look like an internal R&D effort, complete with plans, measures of success, timelines, etc. These start-up costs plus the time required to develop ecosystem relationships delay the positive benefits of knowledge acquisition and absorption. Secondly, time is also required for new knowledge to influence new product development. As such, the positive effects of open innovation ecosystem knowledge on new product development lags its acquisition which in turn lags the effects on outcomes in the market.

From these findings, open innovation vis-à-vis intangible assets (knowledge) generates a greater effect on firm performance when given time to diffuse within the organization. This highlights the valuable role that knowledge plays as both a mediator and moderator. This argument is aligned with previous studies that find positive and significant effects from the acquisition of external intangible assets (Chen et al., 2011; Moretti & Biancardi, 2020; Rass et al., 2013). It also supports the argument that within open innovation, internal and external intangible assets are complements rather than substitutes (Denicolai et al., 2016; Moretti & Biancardi, 2020). Firms undertake inbound open innovation through sophisticated external search techniques that require, but do not rely exclusively on, in-house R&D (Chesbrough & Crowther, 2006). As previous researchers have argued, external knowledge acquisition will have a negative effect if not supported by internal R&D (Denicolai et al., 2016; Teece, 1998).

These findings partially support the theoretical propositions introduced in Chapter 2 which describe the transformation of knowledge to intangible assets as a value capture pathway between open innovation and firm performance. During periods of market uncertainty, firms seek out external knowledge and exercise dynamic capabilities to sense, seize and reconfigure (Pavlou & El Sawy, 2011; Teece et al., 1997). This environmental turbulence motivates firms to pursue open innovation strategies where external knowledge can be found in diverse ecosystems. Through these open innovation interactions, knowledge spillovers occur (Han et al., 2012) allowing firms to create value by seizing external knowledge and integrating it with internal knowledge (Chesbrough et al., 2018). Firms reconfigure their organizations to extract the value of the integrated knowledge as unique intangible assets (Grimaldi et al., 2017). Firms then capture value by exploiting these intangible assets (Dell'Era et al., 2020), leading to greater firm performance (Moretti & Biancardi, 2020). This flow of knowledge creates a bridge between value creation and value capture.

Managerial Implications

Maintaining business performance and achieving competitive advantage in dynamic environments places great importance on firm dynamic capabilities. An essential premise of the dynamic capabilities view is that firms must use and renew their intangible resources to sustain competitive advantage in dynamic environments (Easterby-Smith &

Prieto, 2008). From a practice perspective, competitive advantage can be achieved through early mover actions where firms can spot and react to disruptions before they become mainstream. Firms exercise environmental scanning activities to be aware of disruptive innovations and new competitive threats. Open innovation ecosystems present one alternative for external knowledge. Firm participation in open innovation does not come without costs, however, both direct and indirect. Given that open innovation remains a newer business model consideration, measuring the returns from open innovation is increasingly important.

These findings suggest that open innovation ecosystem participation affords firms the ability to discover and transform knowledge from the broader market, allowing them to capture value and generate competitive advantage within their market segment. The state of the environment (market uncertainty) can therefore inform firms of the appropriate mix of both internal development and external acquisition of knowledge required in their overall competitive strategy.

Contributions

Although practice and theory seem to indicate that open innovation is beneficial to firms, scholars are still looking for appropriate measures to evaluate the effects of this business model. Questions still exist on how value is captured from open innovation. This chapter makes several contributions to this literature stream. Firstly, a novel research question is presented that considers the mediating role of knowledge in the open innovation – firm performance relationship. Prior literature has considered the mediating role of knowledge on value creation through innovation performance (Aloini & Martini, 2013; Fu et al., 2019a; Katila et al., 2012; Tsai et al., 2011). To the best of the author's knowledge, no prior study has considered the mediating role of knowledge on value capture. These findings support the mediation hypotheses and further empirical research on open innovation and value creation and capture.

Secondly, the empirical analysis was conducted as an archival study using objective measures with a large panel data set. The sample data includes multiple industrial sectors across multiple observation years. Much of the existing research on performance is dominated by case studies of open innovation implementation in firms, survey studies on open innovation adoption, and self-reported performance implications (Michelino et al., 2015). Recent open innovation scholars have argued that bias predominates these studies due to a reliance on self-assessed measures derived from secondary data (Moretti & Biancardi, 2020). This chapter answers calls for more recent research on open innovation (Gerosa et al., 2021), examining value capture from external sources of innovation (West & Bogers, 2014), and quantitative studies in open innovation using accounting data (Moretti & Biancardi, 2020).

Finally, this chapter leverages accounting measures in new ways to evaluate the role of knowledge in open innovation. It follows the open innovation literature that considers pecuniary measures as a preferred option to be able to objectively compare firms in the context of their competitive markets (Caputo et al., 2016; Lamberti et al., 2015; Michelino et al., 2014; Moretti & Biancardi, 2020) and leverages externally acquired and internally developed intangible assets as measures of external and internal knowledge. Though this relationship has been well researched and prior authors have used these accounting measures, no previous study, to the best of the author's knowledge, has also included an objective measure for open innovation participation. Additionally, no previous study has considered the relationship of external and internal intangible assets as serial mediators in the exploitation of knowledge for value capture. These findings suggest that open innovation participation leads to the acquisition and creation of intangible assets, which are then exploited to capture value.

Limitations

This chapter suffers from four main limitations: firstly, beyond the post-hoc analysis, it does not account for the concept of absorptive capacity. Previous authors in open innovation have argued that firms cannot achieve success in open innovation unless they are able to "exploit, transform and commercialize" external knowledge (Naqshbandi, 2018). This ability is defined as absorptive capacity (Zahra & George, 2002) and would theoretically have a moderating effect on the external to internal knowledge transformation. The limited exploration in the post-hoc analysis supports this theoretical proposition, but further study is required.

Secondly, although the sample used in the empirical study is large, it only contains publicly listed United States firms and as such does not account for global or privately held firms. Additionally, the panel under consideration is during a period where open innovation participation may be undergoing a change and becoming more prevalent. This chapter considered participation as a dichotomous variable whereas measuring participation based on level of activity would account for the effects of different participation levels.

Lastly, a panel regression was used for the empirical analysis. Given the serial mediation hypotheses, a structural equation modeling technique may present deeper findings and specifically allow testing of moderator relationships between the predictor variables. Much is unknown about the relationship between knowledge, intangible assets and firm performance in open innovation and a deep understanding of the mediating and moderating relationships is essential to developing a practical understanding (Vanhaverbeke & Cloodt, 2014).

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Chapter Four: Conclusions

Discussion

This dissertation describes and discusses value capture in open innovation. It first explores the theoretical role of external and internal knowledge from open innovation ecosystems on firm performance. A model and research agenda are presented. A conceptual study was then conducted that answered three key questions: (1) What is the role of knowledge in the management literature on dynamic capabilities and open innovation ecosystems? This research question explained the motivation for firms to pursue open innovation strategies during market uncertainty put forward in Proposition 1, (2) What is the relationship between externally acquired knowledge from open innovation ecosystems and internally developed knowledge? This research question explained how external knowledge is sensed from open innovation ecosystems and seized as internal knowledge as described in Propositions 2 and 4, and (3) How is value created and captured in open innovation? This research question explained the process by which external knowledge is transformed into intangible assets, leading to firm performance as described in Proposition 7.

An empirical study was then conducted to test a subset of the relationships between open innovation, knowledge, and firm performance to answer the research question: Does knowledge from open innovation lead to greater firm performance? These relationships are not well understood and mediators and moderators in open innovation have been understudied (Rubera et al., 2016; Wang & Jiang, 2019). The empirical study considered lag periods to explore the nature of the relationships over time. When controlling for firm age, firm size, R&D intensity, industry sector and panel year specific effects, these findings show that, when expressed as intangible assets, both external and internal knowledge play a central role in open innovation – firm performance relationship. The findings also show that time is an important factor in this relationship as external knowledge diffuses over multiple years before it affects performance outcomes. It also demonstrates that internal knowledge is required for external knowledge to be seized supporting previous arguments that firms that undertake open innovation require in-house R&D (Chesbrough & Crowther, 2006)

Contributions

In Chapter 2, the theoretical interrelation between environmental dynamism, dynamic capabilities, open innovation ecosystems, industry diversity, external and internal knowledge, and intangible assets was researched. Synthesizing these literature streams, a conceptual model was developed that proposes a novel understanding of the mediating role of knowledge in the value creation – value capture process in open innovation. This research makes several contributions to the open innovation literature. Firstly, though significant previous literature has empirically examined the impacts of open innovation on performance (Laursen & Salter, 2006; West et al., 2014), this stream of research has tended to focus on *value creation* versus *value capture*. An often-cited business concern is 'value slippage', when the firm that creates value does not capture it (Lepak et al., 2007). Ignoring firm performance relative to competitors neglects the impact on the downstream portions of the innovation process (West & Bogers, 2014). By examining firm performance with open innovation ecosystems, this study answers calls for more recent research on open innovation (Gerosa et al., 2021) and value capture from open innovation (West & Bogers, 2014).

Secondly, this dissertation challenges previous arguments that knowledge from open innovation is free to all (Hoving et al., 2013). Rather, it demonstrates that firms must participate in open innovation for value capture from knowledge spillovers to occur. Although open innovation has been shown to be a trigger of knowledge spillovers (Gay, 2014; Spithoven et al., 2013), the linkage of knowledge spillovers to performance outcomes is debated (Berchicci, 2013; Jaffe & Lerner, 2001). Borrowing from the literature on technology transfers and alliances, this dissertation put forward an argument that one must participate in open innovation to gain from knowledge. Open innovation ecosystem participation was shown to affect firm performance outcomes positively and significantly. The findings confirm the theoretical assertion by Chesbrough et al. (2018) that firms need to provide resources in addition to partaking to realize value in open innovation. In other words, you have to play to win.

Lastly, this dissertation contributes to the understudied stream of open innovation ecosystems (da Silva Meireles et al., 2022; Franco-Bedoya et al., 2017). By participating in open innovation ecosystems, a firm is better positioned to absorb knowledge spillovers. Open innovation ecosystems facilitate the transfer and exploitation of technology between focal firms and their external partners (Chesbrough & Schwartz, 2007; Huggins, 2010). Such open innovation collaboration can include networks of bilateral alliances, ecosystems, platforms and consortia (West, 2014). However, most of the open innovation literature has focused on bilateral cooperation between two organizations, leaving the opportunity to analyze multilateral collaborations (Vanhaverbeke, 2006). Fewer studies explore an ecosystem focus, where the level of analysis is the entire set of collaborating firms (Rampersad et al., 2010).

Future Research

The conceptual and empirical studies both open new areas for future research. As discussed in the limitations for Chapter 3, the concept of absorptive capacity was not considered in this dissertation beyond the post-hoc analysis. Previous authors have described this as the ability to transform and commercialize external knowledge (Naqshbandi, 2018) or a firm's ability to explore and exploit knowledge (Zahra & George, 2002). Within open innovation, firms require knowledge acquisition capabilities to be effective (Cheng et al., 2016). Absorptive capacity is therefore a prime consideration as moderator in the flow of external to internal knowledge. Greater absorptive capacity would be expected to be associated with greater knowledge acquisition and thus greater firm performance as was observed in the post-hoc analysis. This relationship, however, should be explored more broadly in the context of transaction costs. Like Proposition 3, an inverted U-shaped relationship would be expected to exist where the transaction costs of absorbing greater external knowledge would at some point outweigh the benefits. Internal knowledge development as it relates to absorptive capacity may unfold differently over different time periods and thus future research should continue to explore panel data sets.

Additionally, the concept of openness should be studied more deeply. Extensive previous literature has defined levels of openness using various survey instruments (Bogers et al., 2017; Chesbrough, 2003; Michelino et al., 2015) or synthetic measures (Dahlander & Gann, 2010; Hung & Chiang, 2010; Schäper et al., 2023). While this dissertation considered open innovation participation as a dichotomous event, future studies could examine continuous measures to evaluate the level of openness within an ecosystem on performance outcomes. Expanding on open innovation participation as an observable event, other variables such be considered such as number of contributions made by each firm, the number of employees assigned to the open innovation ecosystem, the number of hours contributed by employees or the number of different open innovation projects a firm participates in. This level of data would come from a combination of archival observations from open innovation ecosystems and self-reported measures from firms. Of particular note would be evaluating the level of openness on performance outcomes using archival data and comparing with previous studies that have used synthetic measures (Michelino et al., 2014).

Lastly, mediating and moderating relationships in open innovation have been understudied (Rubera et al., 2016; Wang & Jiang, 2019) and future researchers should consider additional firm specific factors that would influence open innovation ecosystem participation. Country of origin would be one such consideration. Like this dissertation, several open innovation studies have examined country specific samples. Few studies however have leveraged global data sets to evaluate differences between geographies. Open innovation adoption can be affected by economic conditions such as a firm operations in a developing economy (Kafouros & Forsans, 2012) vs developed economy (Oliveira et al., 2012). Differing accounting principles and lack of global data sets make such a study difficult today, however.

Exploring these future research suggestions will help us expand our theoretical understanding of value capture in open innovation especially in the area of knowledge which is essential to understanding the knowledge-based economy (Alexander & Martin, 2013). Though there is a strong stream of research within the academic literature on open innovation, theoretical weaknesses still exist in understanding the foundation of the relationships from which a practical understanding can be pursued (Vanhaverbeke & Cloodt, 2014). Lastly these future suggestions allow for empirical testing with new measures. Open innovation by its very nature allows for observation of interactions between firms. Combining these with publicly available firm data presents opportunities to develop novel measurement approaches.

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