NON-MARKET INTERMEDIARIES AND GOVERNMENT FINANCIAL SUPPORT AS INNOVATION CATALYSTS

by Jihye Yeo

June 2021

A thesis submitted for the degree of Doctor of Philosophy
of The Australian National University

ABSTRACT

This dissertation aims to improve our understanding of innovation catalysts. Past studies have identified that a variety of industry actors and policy measures can work as innovation catalysts (e.g., David, Hall, & Tool, 2000; Howells, 2006; McDermott, Corredoira, & Kruse, 2009). However, they are still limited in clarifying their roles in boosting innovation, which makes it difficult to understand how their support assists in firms' innovation activities. In this dissertation, I re-examine support programs that are designed to catalyse innovation to improve our understanding of innovation catalysts. I particularly focus on examining non-market intermediaries and government financial support. As these programs are often established by public funding to boost innovation, asking about their actual roles in helping innovation is a fundamental question. To explore these subjects, separate studies for (1) non-market intermediaries and (2) government financial support are conducted.

In the first study, I focus on the emergence of non-market intermediaries, asking where they come from and how they emerge in relation to the roles of innovation catalysts. Past studies have thus far been interested in identifying the effect of non-market intermediaries after their inception, treating them as exogenous variables. However, this perspective can mislead our understanding of their actual roles. By investigating the process of their inception, this study explains (1) how non-market intermediaries emerge, (2) how their roles evolve over time and (3) how different intermediaries can influence firm innovation in unique ways. I use a qualitative methodology to examine the emergence of non-market intermediaries in the Australian advanced manufacturing industry.

My second study focuses on identifying the causal effect of government financial support on firm innovation. Despite a number of scholarly efforts, empirical evidence on this

is mixed. This is partly due to econometric identification challenges. Hence, in this study, I aim to provide evidence that is based on estimates that address the relevant econometric challenges. I focus on specifying how potential sources of bias—endogeneity and sample selection—can mislead the interpretation of the causal effect of government financial support. Using an econometric approach suggested by Semykina and Wooldridge (2010), I estimate the causal effect of Australian government financial incentives on firm innovation. I use the Business Longitudinal Data of the Australian Bureau of Statistics.

My research empirically shows particular roles played by non-market intermediaries and government financial support. More specifically, the first study demonstrates that non-market intermediaries are endogenous actors, showing (1) a process model of sequentially interconnected phases through which intermediaries emerge, (2) the evolution of roles that intermediaries play at different stages of the industry and (3) the different functions of intermediaries in stimulating innovation. The second study, addressing econometric identification challenges, provides empirical evidence from which useful implications can be drawn regarding the effectiveness of government financial support and to what extent government financial support helps the innovation of firms. Taken together, this dissertation contributes to clarifying the roles of innovation catalysts.

DECLARATION

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university, and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

Signed: _____Jihye Yeo_____ On: June / 2021

ACKNOWLEDGEMENTS

I would not have been able to complete this thesis without the support and guidance I received from my mentors, colleagues, friends and family. First and foremost, I thank my supervisor, *Dr. Alex Eapen*, for guidance, interesting discussions and his infinite patience. His consistent, constructive, and sharp feedback has been the main ingredients of this work, and his patient and thoughtful mentorship has given me courage to stick it out and win through the many challenges I had to deal with. The collaborative culture he has cultivated made me redefine 'what makes *good collaborators*, what makes a *team*'. I also thank *Dr. Ian Elsum* and *Dr. Rekha Krishnan* for generously sharing beautiful insights and knowledge with me. Without them, I would have never been able to learn business insiders' perspectives, practical technology and innovation issues, and the uniqueness of the Australian economy and ecosystem. Also, their multidisciplinary expertise motivated me to read broadly from innovation and technology literature to sociology and economics. I truly feel lucky to have them on my supervisory panel and I learn a lot by interacting with them.

I am indebted to everyone in the Research School of Management at the Australian National University. I am very fortunate to be affiliated with this group of kind and wonderful people. I thank those who offered me help, even when I didn't ask for it, and those who were there to help me in any possible way. I will never forget their kindness and encouragement that taught me not to give up but to hold on.

I sincerely thank the many people who have graciously made time for my research, shared their insights with me and sent me encouraging words, like 'your research is interesting!'. Their participation enriched my work and convinced myself that this is an important piece that can make a useful impact for practice. Also, I am thankful for the data

access given by the Australian Bureau of Statistics so I have been able to make this work possible.

Last but not least, I thank my parents and my sister, *Junghee*, for their indescribable support over the many years. They have lifted me up when I was down, they have helped me laugh off all the concerns and worries, they have never failed to show me their unconditional love and support. Especially, thank you, *Junghee*, for travelling to Australia several times for me, for helping me build a healthy mindset and for teaching me important life values. I am exceptionally lucky that you are my sister!

CONTENTS

LIST OF FIGURES

LIST OF TABLES

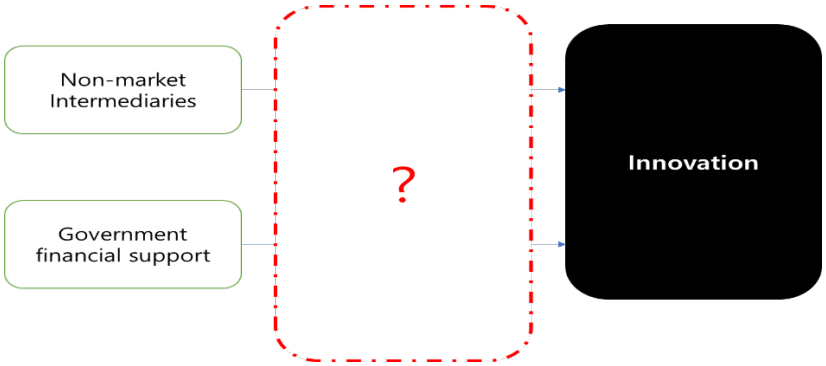
Chapter 1 INTRODUCTION

Innovation is a series of recombinations of existing knowledge, technologies and other resources (Schumpeter, 1942; Nelson & Winter, 1982; Henderson & Clark, 1990; Davis & Eisenhardt, 2011), and recombination outcomes can result in new ideas, new practices and new business models. Innovation is essential for business survival and growth because it enables companies to create value for themselves and to produce benefits for a society. However, innovation can be difficult to achieve, especially if firms face a dearth of resources (e.g. financial constraints, insufficient access to information and lack of new networks). To address such challenges, a range of support programs is available. For instance, governments may offer research and development (R&D) grants to help firms that conduct innovation projects; industry associations may arrange networking events to facilitate businesses' access to information; consulting firms may provide systemic advice to firms experiencing technical problems. These programs commonly aim to stimulate firms' innovation.

However, despite having the shared goal of catalysing innovation, do support programs really increase innovation? A number of scholars have examined the effects of support programs on firm innovation, such as government support institutions (McDemortt, Corredoira, & Kruse, 2009), science parks (Armanios, Eesley, Li, & Eisenhardt, 2017), regional institutions (McEvily & Zaheer, 1999), service intermediaries (Zhang & Li, 2010) and government financial incentives (David, Hall, & Toole, 2000). While they documented that these various support programs can act as innovation catalysts—helping firms increase innovation—they have often failed to clarify the process of which they assist innovation due to predefined perspective and limited evidence. Hence, this dissertation re-examines the

effects of innovation catalysts, aiming to better understand their actual roles in an innovation ecosystem. Figure 1 describes the research question.

Figure 1. Conceptual Map of the Research Question



This dissertation focuses on examining two types of support programs: (1) non-market intermediaries (e.g., industry associations, government support institutions and joint consortiums) and (2) government financial support. Understanding how these non-market programs enable firms to be innovative is fundamentally important for innovation policy, as such programs are often subsidised by governments, politicians or industry leaders using public funding. Hence, this dissertation investigates the roles of non-market intermediaries and government financial aids in an innovation ecosystem, aiming to illuminating the opaque process in which the non-market programs influence firms' innovation and to confirm their effectiveness as innovation policy. Separate studies are conducted: Chapter 2 examines non-market intermediaries, and Chapter 3 examines government financial support.

In Chapter 2, I examine non-market intermediaries in the Australian advanced manufacturing industry. The main focus of this study is on the emergence of non-market intermediaries. While the literature has been interested in identifying their effect on firm innovation, most of the studies have not examined the emergence of the intermediaries. This

is a critical gap in the literature because the origin and development of these organisations can shape their roles differently. Hence, this study incorporates the emergence of non-market intermediaries to better understand their roles as innovation catalysts. I use longitudinal qualitative data on three non-market intermediaries in the advanced manufacturing industry from 2012 to 2019. My qualitative analysis yields three findings. First, I identify a process model of sequentially interconnected phases through which intermediaries emerge: (1) trigger/motivation, (2) involvement of high-status actors and (3) consensus building. Second, the finding portrays the evolution of roles that intermediaries play at different stages of the industry—from legitimisation to popularisation and encouragement. Third, I show how intermediaries with different emergence pathways differ in how they catalyse firms' innovation. Taken together, these findings improve the current understanding of non-market intermediaries.

In Chapter 3, I aim to identify the causal effect of government financial support on firm innovation. Although a number of studies have examined this effect, because of inconsistent empirical evidence, it is hard to settle on a conclusion (e.g. Bronzini & Iachini, 2014; David et al., 2000; Lerner 1999; Wallstern, 2000). I argue that this is partly due to econometric identification challenges. First, endogeneity issues can occur in the model because financial support is not randomly granted. Government agencies may select innovative firms or there may be unobserved variables that can motivate government agencies to select recipient firms. Second, sample selection bias can occur as we observe innovative outcomes only for those firms that have conducted innovative activities, not for those that did not conduct innovative activities. This select set of sample fails to represent the population. I employ the econometric approach suggested by Semykina and Wooldridge

(2010). By doing so, I aim to account for both endogeneity and selection issues. This approach also enables unobserved firm heterogeneity to be addressed simultaneously. The main results suggest that government financial support can increase firm innovation. Further, government financial support can benefit financially vulnerable firms. Multiple robustness tests also support these results.

This dissertation adds further depth to the innovation literature. First, this dissertation clarifies the roles of non-market intermediaries and government financial support as innovation catalysts. In Chapter 2, I explain how non-market intermediaries emerge as innovation catalysts and why different intermediaries take unique approaches to assist innovation. Moreover, this study motivates the view that treats intermediaries as outcomes of endogenous processes, rather than as sudden exogenous phenomena. In Chapter 3, I provide new evidence to the debate on the effectiveness of government financial support. The empirical support lends weight to the argument that public support enables firms to innovate through reducing financial burdens. Second, this dissertation offers useful insights on the effectiveness of non-market support programs based on rigorous empirical research. For instance, the qualitative findings are derived from iterative processes of theory building; the econometric findings are derived from a robust method that controls for major identification challenges in empirical research. Taken together, this dissertation identifies the process through which support programs—such as non-market intermediaries and government financial support—help firms innovate. It provides useful implications for governments, policymakers and firms.

Chapter 2 THE EMERGENCE OF NON-MARKET INTERMEDIARIES

INTRODUCTION

Scholars have long been interested in the effects of intermediaries on firm innovation. Studies on diverse types of intermediaries in various research settings (e.g., McDermott, Corredoira, & Kruse, 2009; McEvily & Zaheer, 1999; Rosenkopf, Metiu, & George, 2001; Zhang & Li, 2010) have largely concluded that intermediaries aid firm innovation, by serving a bridging role between firms and useful resources for innovation (Jandhyala & Phene, 2015; Lynn, Mohan Reddy, & Aram, 1996; McDermott et al., 2009; McEvily & Zaheer, 1999; Zuckerman & Sgourev, 2006).

The focus of existing studies has thus far been on the effects of intermediaries only after their inception. The primary concern of these studies has been to clarify and test mechanisms through which intermediaries exert their effects. As a result, intermediaries and their roles have largely been treated as exogenous. This is potentially problematic, since intermediaries are clearly not exogenous phenomena that manifest without context. More often than not, they are a response to various triggers, processes and biases within the innovation ecosystem. In addition, the roles they occupy likely reflect their founding conditions. However, limited attention has so far been paid to examining where intermediaries come from, how they originate and evolve, and how their development shapes those roles. The only attempts I am aware of in this regard are limited to very brief anecdotal descriptions of intermediaries' origins (e.g., McDermott et al., 2009). Our understanding of intermediaries significantly overlooks 'seeing where the dust came from or how it settled' (Powell, Packalen, & Whittington, 2012: 2).

This is the gap I seek to fill with my research. Focusing on 'non-market' intermediaries—such as government support institutions, hybrid organisations and industry associations—this study adopts an inductive approach to studying the origins and emergence of non-market intermediaries in the Australian advanced manufacturing industry. The method and context are appropriate for my research goal. Given our limited understanding of how intermediaries emerge, qualitative grounded theory (Strauss & Corbin, 1994) and process analysis (Langley, 1999) are suitable approaches to employ. Also the relatively recent appearance of intermediary organisations in the advanced manufacturing industry allowed me to observe these organisations from their beginnings. Qualitative data is drawn from multiple sources, including interviews, direct observation and archives. This enabled me to triangulate the findings I extracted from the data.

My analysis yielded three key findings. The first is a process model of sequentially interconnected phases through which non-market intermediaries emerge. Regardless of the type of non-market intermediary, I found that they tended to emerge over three sequential phases: (1) a trigger, motivation or shock to the industry; (2) the involvement of high-status actors; and (3) consensus. My second finding relates to the evolution of the roles intermediaries played at different stages in the advanced manufacturing industry. Specifically, I found that intermediary roles evolved from raising awareness of the industry to legitimisation and then to popularisation and encouragement as the industry matured. My third finding is that the ways in which intermediaries catalysed innovation differed based on the emergence pathways that characterised those intermediaries' development. For example, I found that while a government-initiative intermediary stimulated incremental innovation, a

hybrid intermediary prompted radical innovation. Conversely, a private-initiative intermediary had an indirect effect on firm innovation.

This research contributes to the literature on intermediaries in several ways. First, I focus on the origin and evolution of intermediaries and their roles, while most existing studies have examined intermediaries in their present form only. Second, my study encourages a shift away from the view of intermediaries as exogenous constructs and towards one that sees them as outcomes of endogenous processes. I posit that this perspective shift aligns the literature closer to reality. Third, as a result of the above findings, I contribute to a better understanding of the processes underlying the origins of intermediaries, the evolution of their roles during industry maturation and the way different intermediaries divide their roles to support innovation.

THEORETICAL MOTIVATION

Intermediaries

Intermediaries are organisations that provide wide-ranging forms of support to help generate firm innovation. These organisations mediate, represent and/or intervene for disseminating useful resources between focal actors in an innovation ecosystem (Howells, 2006). For example, middlemen in the agricultural, wool and textile industries were informal disseminators of knowledge about technical improvements in the industries of 16th, 17th and 18th century Britain, and the networking events that intermediaries usually organise are a prime opportunity for firms to be exposed to new information, technologies or business opportunities. In short, intermediaries are ‘agents that function as a means of bringing about an activity, often connecting other actors while providing value that may not be possible by

direct trading between the actors' (Dutt, Hawn, Vidal, Chatterji, McGahan & Mitchell, 2016: 820).

Non-Market Intermediaries

Non-market intermediaries—such as government support institutions, industry associations and regional institutions—are designed to maximise communal benefits by helping firms generate innovations via diverse support programs. For instance, government support institutions grant financial support to firms that can produce innovative solutions to existing technologies or business models (McDermott et al., 2009). Regional institutions or science parks share business knowledge that they have learned through interacting with firms in the geographical cluster with small- and medium-sized enterprises (SMEs) to help them be exposed to various alternatives to business issues typically occurring in the region (Armanios et al., 2017; McEvily & Zaheer, 1999). Notably, non-market intermediaries pursue altruistic activities, rather than profit-making activities, which differs from for-profit intermediaries (e.g. brokers, consulting firms and professional service providers).

A number of empirical studies of non-market intermediaries in various research contexts suggest that non-market intermediaries can stimulate firms' innovation (Armanios, Eesley, Li, & Eisenhardt, 2017; Corredoira & McDermott, 2014; McDermott et al., 2009; McEvily & Zaheer, 1999), which they have explained with three main reasons. First, non-market intermediaries provide access to information and resources for innovative activities because they, as a 'superstructure' organisation, facilitate and coordinate the flow of information between firms and other key actors (Lynn et al., 1996). Second, non-market intermediaries act as knowledge repositories by disseminating and accumulating knowledge and solutions that may be useful for firms (McDermott et al., 2009; McEvily & Zaheer, 1999;

Zuckerman & Sgourev, 2006). Third, non-market intermediaries provide reliable channels for collective learning. This function is particularly beneficial for firms in resource-constrained and volatile environments where fundamental resources are lacking (Armanios, Eesley, Li, & Eisenhardt, 2017; Corredoira & McDermott, 2014). Hence, the literature has perceived non-market intermediaries as innovation catalysts in an innovation ecosystem (Jandhyala & Phene, 2015). However, is this sufficient for understanding the roles of non-market intermediaries?

Existing studies have mostly clarified the effects of non-market intermediaries only after their inception, primarily focusing on the mechanisms through which intermediaries exert their effects. Consequently, prior studies have largely treated intermediaries as exogenous, dismissing the fact that the organisations are also 'social units' that are established to address certain issues of a society. Further, intermediaries may shape different roles, missions and mandates as they evolve. Hence, a better understanding of 'where intermediaries come from' and 'how they emerge' is fundamental for identifying the roles of non-market intermediaries in an innovation ecosystem. However, the current literature on intermediaries is lacking in this regard. The only attempts I can refer to are limited to very brief anecdotal descriptions of intermediaries' origins (e.g. McDermott et al., 2009). In fact, insufficient understanding of the emergence of non-market intermediaries can lead to misjudgement on their functions. In the 1980s, a politician from Wyoming publicly criticised the Defense Advanced Research Projects Agency (DARPA), which is one of the most successful non-market intermediaries to date, for spending money on technologies such as super computers rather than on weapons. This was terribly short-sighted given the importance of computing to almost all weapons (BBC, 2014) and the changes in the geopolitical context

in which DARPA operated (FCW, 2014). Nevertheless, this myopic view was encouraged because the politician had lost track of how DARPA had evolved into an innovation intermediary.

Additionally, the literature gap is closely linked with the concerns of organisational scholars. They have long noted the lack of organisation science research addressing the emergence of organisations (Aldrich, 1999; Chiles et al., 2004; Olson, 1965; Powell et al., 2012; Young, 1998). Aldrich (1999: 1) contends that we must comprehend organisational emergence to fully understand how organisations evolve in societies: 'Without understanding why and how new social units emerge, we miss the connection between the ongoing creative ferment in human societies and the particular realizations of it in organizations'. Similarly, Young (1998) pointed out that social science scholars conduct their research 'after the dust has settled', which can create a missing gap on 'where the dust came from or how it settled' (Powell et al., 2012: 2). Likewise, without understanding why and how non-market intermediaries emerge, we may not recognise that these intermediaries are constantly moving and being shaped in different ways. In other words, understanding the emergence of non-market intermediaries will help us determine how their functions are formed and evolve over time; in this way, we can amplify the current explanations on the roles of non-market intermediaries as innovation catalysts.

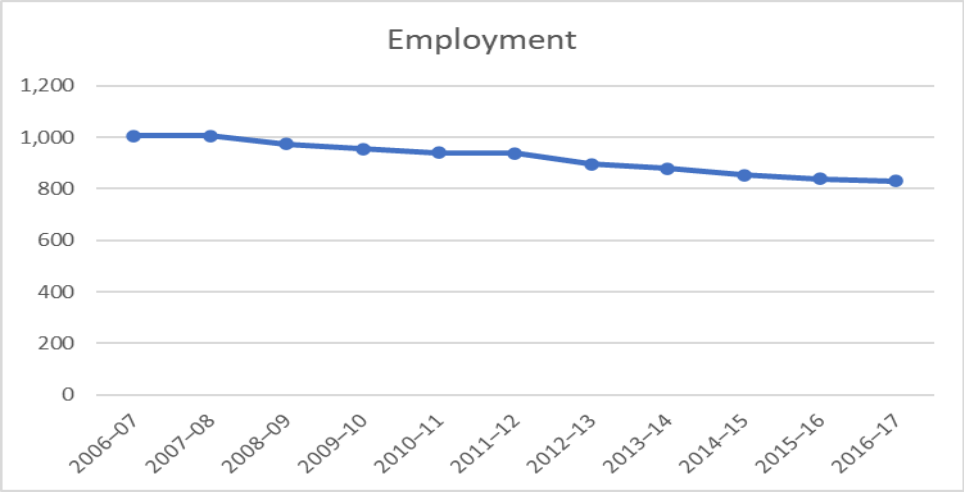
In sum, this study is motivated to understand the emergence of non-market intermediaries—where they come from, how they emerge and how they evolve—which are missing elements in the current scholarship. By doing so, this study aims to produce more concrete explanations on non-market intermediaries, adding further depth to the literature. In the following sections, I discuss the research background, method and context, and findings.

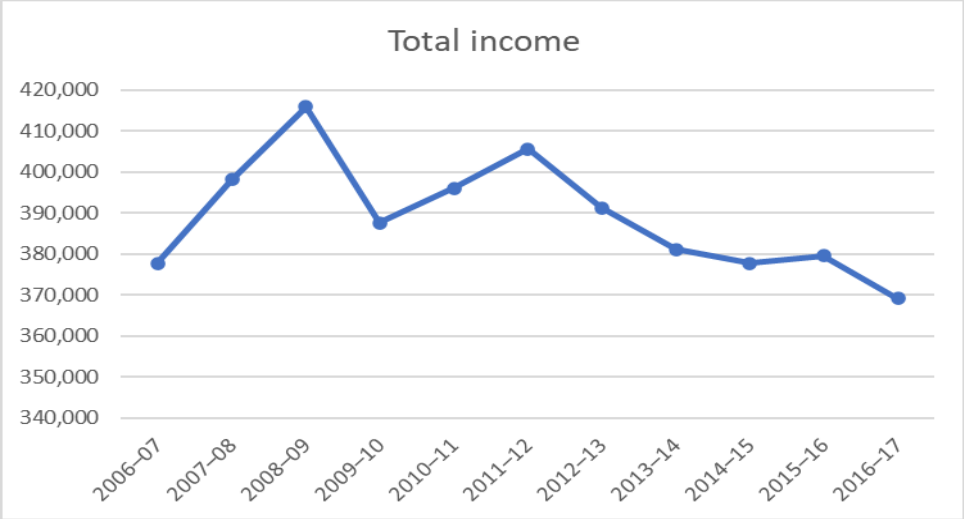
RESEARCH BACKGROUND: AUSTRALIAN MANUFACTURING INDUSTRY

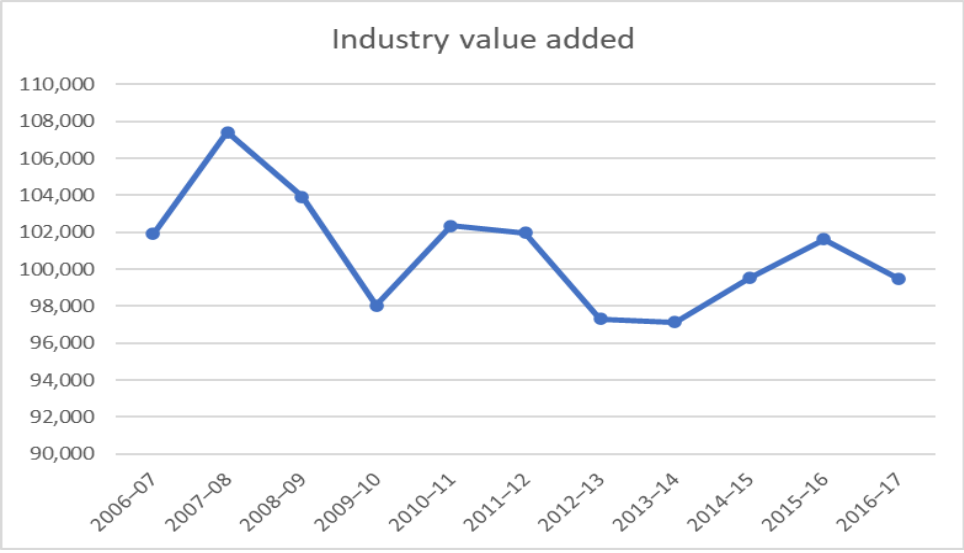
The past few decades have been challenging for the Australian manufacturing industry. Economic indicators such as decreases in manufacturing employment, total income and industry value added have demonstrated the bleak state of the industry (see Figure 2.1[1]). The Commonwealth Scientific and Industrial Research Organisation (2016) identifies several reasons for this industry stagnancy, including lower tariffs, emerging technologies and increasing global competition. However, from 2012 to 2019, two major occurrences particularly affected Australia's manufacturing industry. I classify these occurrences as 'discontinuities' because their effects were so substantial that the industry differences before and after they took place can be clearly observed.

[1] This figure was developed from the ABS 8155.0 Australian industry, 2016-17.

Figure 2.1. Australian manufacturing industry, from 2006 to 2016



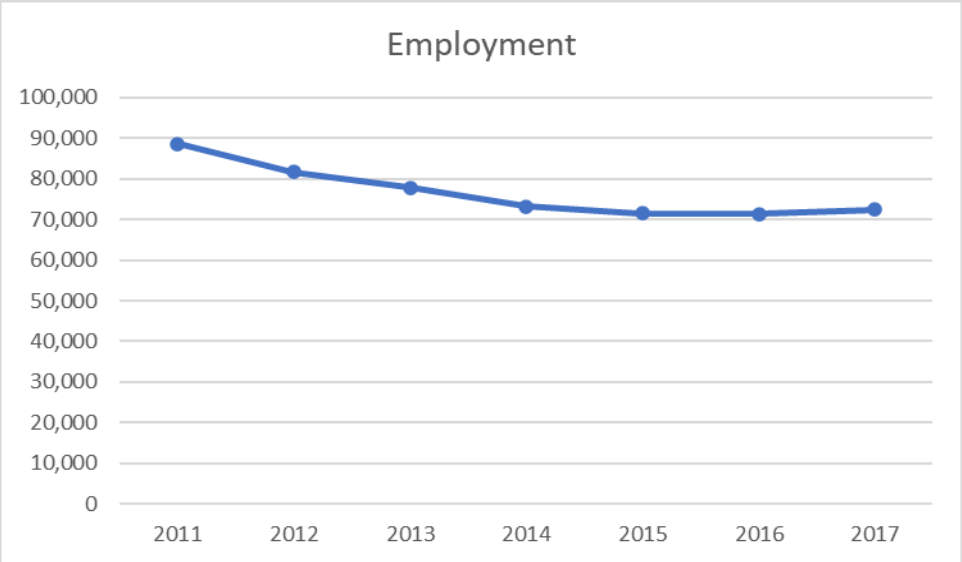




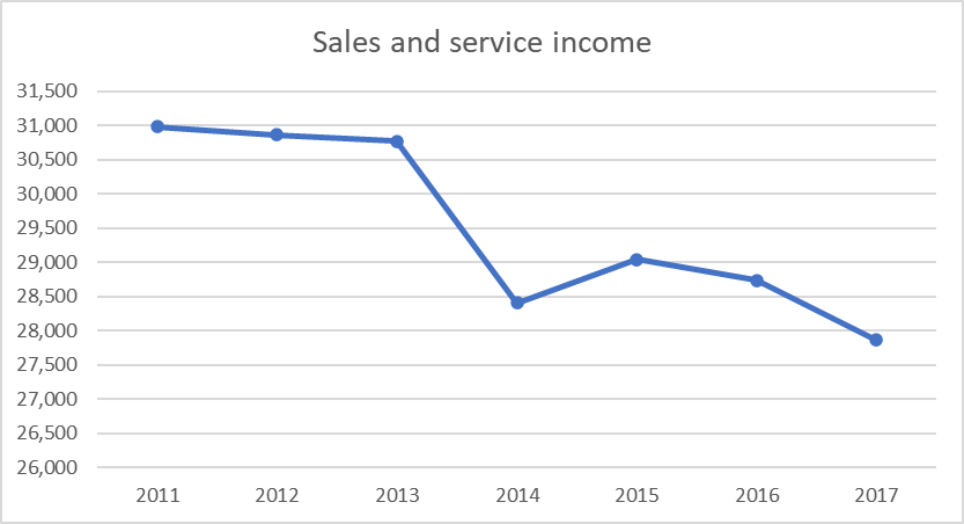
Local Discontinuity

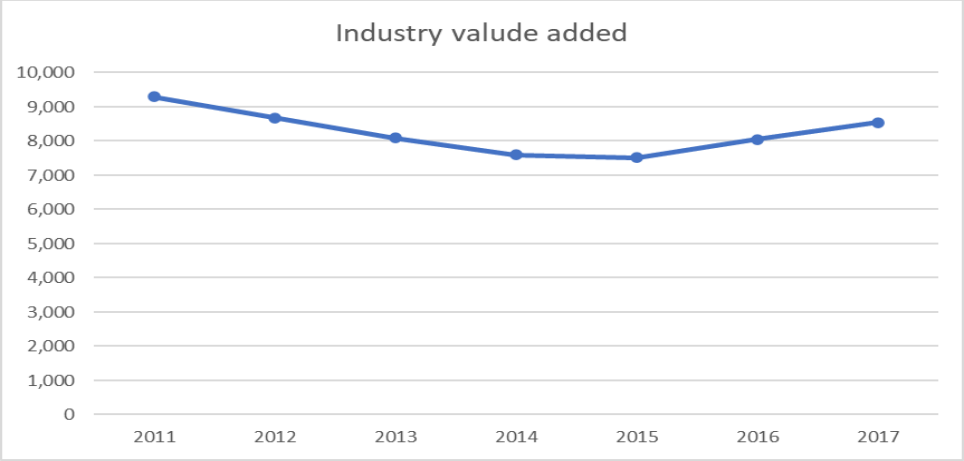
Local discontinuity was the first major factor to affect the manufacturing economy, and was specific to Australia. In 2013 and 2014, global automobile manufacturers Toyota, Ford and General Motors announced the closure of their Australian automobile assembly plants. This immediately generated significant concerns about the job security of their employees. More importantly, the companies' shutdown announcements had flow-on effects for their local supply networks, which comprised a high number of Australian-based manufacturing firms. Their immediate effects on the automobile manufacturing industry manifested as significant decreases, as shown in Figure 2.2[2]: employment decreased by 15,441 jobs from 2011 to 2014; sales and service income decreased by AUD$2,569,000,000 from 2011 to 2014; industry value added decreased by AUD$1,692,000,000 from 2011 to 2014.

Figure 2.2. Australian automobile manufacturing industry, from 2011 to 2017



[2] This figure was developed using merged data from the ABS 8155.0 Australian industry from 2013-14 to 2016-17.





Global Discontinuity

However, the automobile assembly plant shutdowns were also a consequence of the global manufacturing industry's increasing competition. The Australian plants were relatively small scale and not cost competitive. As a result, many global manufacturing companies relocated their production plants to emerging countries. This created the widespread perception that Australian manufacturers were no longer competitive[3].

[3] Despite the automobile shock, some Australian manufacturers outperformed in the global market. They were successful because they embraced industry challenges via innovative business models, advanced technologies and global focus. These manufacturers were value-creating, with a focus on

Especially, technological discontinuity has changed the nature of manufacturing processes. This is also known as Industry 4.0. Emerging technologies (e.g., additive manufacturing, automation and digitalisation) enabled manufacturing processes to be more autonomous and efficient. In addition, these technologies simplify manufacturing processes -- for example, they remove need for transportation and post-manufacturing processes (e.g., dealing with waste). The technology discontinuity has also changed the labour market of manufacturing industry. While traditional manufacturing requires job skills applicable to production processes, Industry 4.0 seeks design, research and development (R&D), and service and maintenance capabilities, which are value creation jobs. So, the global manufacturing industry has faced a whole different scene in the production, competition and employment.

Both local and global discontinuities created substantial uncertainty for Australian manufacturers and for the manufacturing industry as a whole. In response to these challenges, groups of firms, governments and industry leaders suggested 'advanced manufacturing' as an alternative to the conventional manufacturing. This is the starting point for my research[4].

---

pre- and post-manufacturing jobs; they differed from production-oriented manufacturers. Examples are ANCA, Austal, Carbon Revolution, Cochlear, Quickstep, Sutton Tools and Textor Technologies.

[4] Another interesting element of the period 2012 to 2019 is that global governments implemented national initiatives for the advanced manufacturing industry during this time. For example, the German Government launched an Industry 4.0 initiative ('Plattform Industrie 4.0') in 2013; the US Government initiated the National Network for Manufacturing Innovation in 2014; the Japanese Government released a New Robot Strategy in 2015; and the Chinese Government announced the Made in China 2025 and Internet Plus initiatives in 2015 (Organisation for Economic Cooperation and Development [OECD], 2017). Through national initiatives, many countries have established national manufacturing foresight, strategies and roadmaps to prioritise manufacturing technologies and economy. These intentions are coupled with boosting national economy. This is especially the case for developed countries, since their national initiatives may prompt manufacturers to locate their plants domestically. Because of the high costs and strict regulations of doing business in developed countries, many manufacturers have relocated their businesses to emerging countries. However,

RESEARCH METHOD AND CONTEXT

I chose to study the Australian advanced manufacturing industry from 2012 to 2019, having identified this industry as an ideal setting for the study. First, the increased uncertainty caused by the discontinuities affecting the manufacturing industry from 2012 generated space for intermediaries to serve (Benner & Tripsas, 2012; Corredoira & McDermott, 2014; McDermott et al., 2009). Hence, several non-market intermediaries were established for helping the advanced manufacturing industry from 2012 to 2019. Further, this context allowed me to capture and observe detailed information regarding the emergence of non-market intermediaries in the advanced manufacturing industry. I used a qualitative, inductive research approach. This approach is especially useful for understanding 'how a process unfolds, [and] developing insight about a novel or unusual phenomenon' (Edmondson & McManus, 2007: 1161–1162).

In the following subsections, I discuss how I collected/analysed qualitative data and the processes through which I identified/validated my focal group of three non-market intermediaries in Australian advanced manufacturing industry.

Data Collection

I collected longitudinal qualitative data for the period 2012 to 2019. Since the establishment year of intermediaries started from 2013, the baseline year was 2012. My data were from

---

emerging technologies (e.g., the Internet of Things, automation and robotics) allow manufacturers to conduct business onshore with lower costs. Using these technologies, manufacturers can reduce costs for labour and production processes. Accordingly, developed countries like the US, Germany, Japan and Australia see advanced manufacturing as a new pathway to creating jobs, improving the economy and enhancing their competitiveness. In early 2016, the Australian Government has also joined this global movement, forming the Prime Minister's Industry 4.0 Taskforce to make official 'information sharing and collaboration between Australia and Germany on Industry 4.0'.

multiple sources, such as interviews, direct observation and archives (I summarise the data sources in Table A1 in the Appendices). By collecting data from multiple sources, I was able to triangulate the insights that I obtained about the industry. I conducted data collection in three steps: (1) preparation, (2) development and (3) confirmation. The following subsections describe these steps in detail.

Step 1: Preparation I first prepared for data collection. In this step, my main purpose was to identify a focal group of non-market intermediaries in the advanced manufacturing industry. I interviewed three industry experts with extensive experience working on a range of consulting projects for businesses and governments, and experience reviewing industrial policies. The pilot interviews were useful for gaining a better understanding of the industry and the innovation system in Australia. I concurrently collected data from online sources and archives. By triangulating the data from online sources, archives and pilot interviews, I identified three non-market intermediaries actively engaging in the industry. These intermediaries emerged between 2012 and 2019. Based on this pilot research, I also developed interview protocols (see the Appendices for the interview protocols) and built an initial contact roster.

Step 2: Development In this step, I initiated field research between January and December 2018 by conducting interviews, visiting facilities and attending a showcase.

Interview data. I conducted 21 semi-structured interviews (18 individual interviews and three group interviews). Semi-structured interviews were adopted as they 'provided the flexibility to pursue topics related to my research interests as they emerged in the conversation' (Lashley & Pollock, 2020: 444). To improve my sample, I implemented several methods. I started by contacting industry actors using the roster I developed in the first

research stage. However, since this initial roster was likely to miss key actors who might have useful information for the research, I also employed snowball sampling by asking participants at the end of their interview if they could introduce me to other industry actors who might be relevant to my research. In parallel with snowball sampling, I also employed social network analysis to identify prominent industry actors. I collected information on the board members and employees of the three non-market intermediaries, and on members of the Prime Minister's Industry 4.0 Taskforce. As chief executive officers (CEOs) are perceived as being well connected in the industry and with corresponding intermediaries, I also collected information on the CEOs of firms that were showcased on each intermediary's website as an advanced manufacturer. In line with social network theory, if people were central to the network, I identified them as potential informants who might exert sufficient influence within the industry. Therefore, if I managed to make contact with those people, I ensured I could interview them.

Overall, the interviews lasted approximately 55 minutes each, or 19 hours in total, generating 68 total pages of interview transcripts (typed and single-spaced).

Interviewees. My first interview group comprised employees from three non-market intermediaries. Since I was examining the emergence of each organisation, I intentionally interviewed employees who had been with their organisation from its beginning. Therefore, my interviewees were at the executive level in each organisation. I asked them about organisational aspects such as its history, roles, missions, programs and funding system.

My second interview group was firm representatives. I interviewed a range of representatives from small- and medium-sized enterprises (SMEs) to multinational enterprises (MNEs). These firms included those receiving any type of support from the three

non-market intermediaries as well as firms without any connection to these intermediaries. This was to obtain diverse industry insights into the current state of intermediary support for the industry as well as the current state of the industry. I asked the firms about their general perceptions of these intermediaries—for example, how firms perceived them, if they identified any differences between them and whether they found intermediary support helpful in regards to their innovation. As I was asking decision-making–related questions, I interviewed employees who held positions above the level of executive manager (e.g., founder, CEO, vice president, managing director, etc.).

My third interview group consisted of members of a government department, since one of the intermediaries was affiliated with that department. I asked these interviewees about how related industry policies were initiated, what relationship the government had formed with the intermediary, and what role the government intended to play in the sector and in relation to the intermediary.

My fourth interview group comprised individuals from research institutions that my network analysis suggested were actively involved in the industry. My interviewees also recommended these research institutions. Based on the analysis and recommendations, I interviewed people in decision-making positions in these research institutions. I asked them about the intermediaries, their insights into the particular roles of each intermediary and the overall state of the industry.

During all interviews, I double-checked with the interviewees whether there were any other non-market intermediaries of which I may have been unaware. This process allowed me to confirm that the three organisations I had chosen were the main non-market intermediaries in the advanced manufacturing industry.

Interview data reliability. To ensure the data quality, I implemented several strategies. First, I electronically transcribed all interview notes on the same day. Second, I attended majority of the interviews (13 out of 21) with my supervisor. To efficiently organise the interviews, one led the discussion, while the other took extensive notes and observed the interview. For those interviews, the transcripts were always double-checked by me and my supervisor for accuracy.

Observational data. I collected observational data during tours of seven different organisation facilities (one intermediary, two research institutions, four firms). During the tours, I directly observed how support facilities built by research institutions and an intermediary, such as manufacturing business centre and technology test lab, can help firms to be the advanced manufacturers. Further, I observed innovation projects that were funded by the intermediaries. I witnessed each firm's innovation strategies during the manufacturing process. This allowed me to see how intermediary support and innovation strategies were practically implemented in each firm setting. In addition, I collected observational data at an invitation-only showcase that was hosted by a government department. As one of my focal intermediaries presented its innovation support at this showcase, I directly observed this intermediary's support programs and related government programs. Overall, the observational data were useful for gaining an ongoing industry outlook and learning practical examples of the intermediary support.

Step 3: Confirmation I used the final stage of data collection to confirm the reliability of my data. First, I discussed my preliminary findings with the government department employees. This revealed that my understanding of the industry and the history of the intermediaries was similar to their own, which confirmed the accuracy of my research findings. Second, I used

this stage to further verify my findings by collecting supplementary data via a second round of field research. I collected the data at a national manufacturing exhibition in May 2019.

The exhibition was an excellent opportunity for me to collect further data to complement my research to date. The four-day exhibition was the largest manufacturing event in Australia in terms of the number of attendees and exhibitors. More than 200 international exhibitors participated, and more than 11,000 visitors attended. Industry experts gave a variety of talks on subjects such as the prospects of the Australian manufacturing industry and the foresight of Industry 4.0's emerging technologies. The exhibition also gave me a unique opportunity to directly observe how industry actors interacted with one another (Lashley & Pollock, 2020). More importantly, I met my focal intermediaries again at this exhibition. It was thus a prime opportunity for me to follow up on the last discussions with them and to directly observe and compare the distinctive roles these intermediaries intended to play at the exhibition. Although one intermediary had discontinued by this time of the event, I nonetheless managed to meet a former executive from this intermediary.

Interview data. The main source of interview data was obtained from 46 semi-structured interviews. Because of the exhibition's fast-paced nature, these interviews were relatively short, lasting seven hours in total and yielding 29 total pages of interview transcripts (single-spaced)[5]. Since it was difficult to record and transcribe these interviews electronically at the exhibition, I took extensive notes and transcribed these in Microsoft Word on the same day.

[5] The 11 semi-structured interviews with the focal intermediaries, a journalist, and participant firms lasted four hours in total and yielding 14 total pages of interview transcripts (single-spaced). The 35 semi-structured interviews with representatives from firms at the exhibition lasted three hours and yielding 16 total pages of interview transcripts (single-spaced).

Interviewees. I categorise the interviewees into four groups based on the nature of interview. My first interview group consisted of employees from the three intermediaries. I returned to the same individuals I had interviewed during Step 2 to follow up on previous discussions (five interviews). Further, I also managed to meet an employee whom I was not able to interview in Step 2 (one interview). This interview was useful for validation and supplementation.

My second interview group comprised a journalist who specialised, and had more than 10 years' experience, in writing articles for the manufacturing industry. This helped broaden my view on the research and gave me an impartial perspective on the intermediaries' functions.

My third interview group was representatives from firms that had participated in any type of support program (e.g., funding, membership program, etc.) operated by the intermediaries and firms that had no relationship with them. This supplemented the data on firm perceptions of intermediary support and the industry understanding of the advanced manufacturing.

My fourth interview group comprised employees from other intermediaries at the exhibition. Interviews with this group were useful for further validating my supposition that the three intermediaries were an ideal fit for my research.

Observational data. My observational data were mainly from workshops held by each of the two intermediaries during the exhibition. I found these workshops particularly useful for comparing the roles and messages the two intermediaries were intending to carry out and deliver. The workshops lasted two-and-a-half hours and three hours, respectively. As recording was not allowed, I took extensive notes during both sessions.

Archival data. Alongside undertaking the field data collection outlined above, I collected archival data from 2006 onwards. These data included all the publications and news my focal group of intermediaries had disseminated via their websites (e.g., about the industry, their organisations and government policies). This information provided a general outline of the intermediary roles each organisation designed to play. In particular, the documents that each intermediary published in their early years, and their performance reviews by third parties (when available), were especially useful for understanding the intermediary emergence process and the specific goals/outcomes that the intermediaries performed; I then triangulated this information with the field data. In addition, I collected related government publications, including transcripts from the prime ministers, industry publications by third parties, archival data on budget and financial legislation, and industry news. The main archival data were 40 publications (1,953 pages in total). I also gathered additional archival data from a range of newspapers, websites and the mailing services of relevant sources.

The Focal Group

My focal group comprised three non-market intermediaries in the advanced manufacturing industry. For anonymity, I have termed these Intermediary A, Intermediary B and Intermediary C. The alphabetical order matches the order in which these intermediaries were established. As the geographical focus of these intermediaries is nationwide, their support programs were targeted for national manufacturers.

Table 2.1. The Features of the Focal Intermediaries

	Intermediary A	Intermediary B	Intermediary C
Initiator	Private sector	Government	Hybrid (Government, Industry & Research institutions)
Funding	Private funding	Government funding	Joint funding (Government + partnership)
Term	2013-2015	2015-2021(expected)	2016-2022(expected)
Programs	Lobbying Raising awareness of the industry PR channel Networking events Industry news Membership	Grant program (up to AUD 250,000 per project, 6-8months) Raising awareness of the industry PR channel Networking events Industry news Research Free Membership	Grant program (AUD 250,000 to 3 million, 2-4.5yrs) Raising awareness of the industry PR channel Networking events Industry news Industrial transformation workshop

Table 2.1 summarises the features of the three intermediaries in this study. Intermediary A was an industry association that was established in 2013 and discontinued in 2015. It was funded by its members and had no governmental involvement. Thus, Intermediary A was purely initiated by the private sector (i.e. private-initiated intermediary). In addition, Intermediary A's establishment immediately followed the shutdown announcement of Ford in May 2013. It ceased its operations when its funding ran out in 2015.

Intermediary B was a government-initiated organisation. As a part of the Australian Federal Government's industry innovation and competitiveness policy, a new support program for upgrading the manufacturing industry to an advanced level was proposed in 2014. In the following year, 2015, Intermediary B was established and granted funding

support until 2021. Therefore, the federal government was Intermediary B's initiator and major funding source. Accordingly, a close relationship between Intermediary B and the government existed.

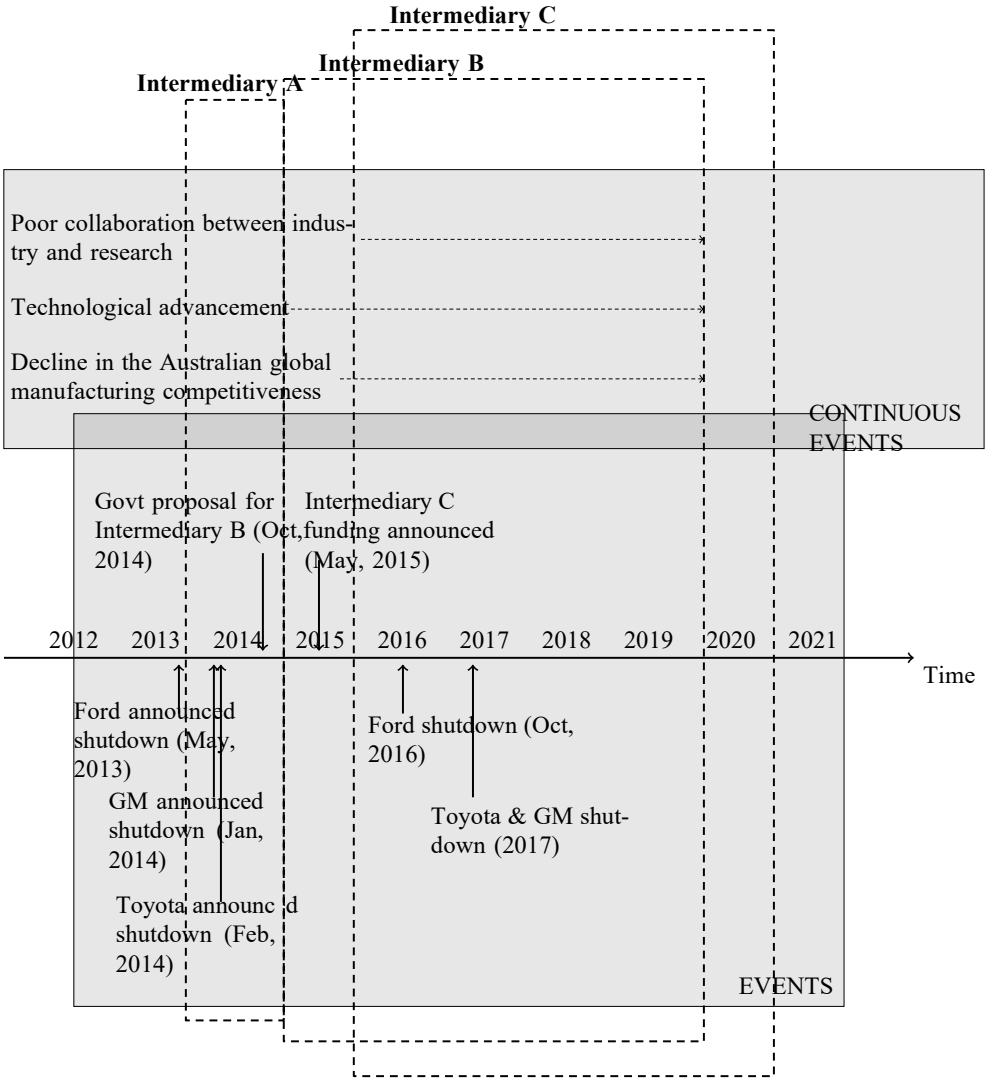
Initiated by joint partnership between industry, the research sector and the government, Intermediary C was a hybrid organisation that incorporated public and private organisation logics together through mission-driven businesses (Jay, 2013). Hence, it was funded by multiple sources, such as governments, firms and research institutions. Intermediary C was established in 2016, after securing governmental funding in 2015, and is expected to run until 2022.

Data Analysis

After reaching data saturation, I consolidated all the data together and checked their validity through triangulating quotes and facts. I analysed the qualitative data by systematically moving between the data and the emerging themes (Gioia, Corely, & Hamilton, 2013; Glaser & Strauss, 1967), and by following a grounded theory methodology (Strauss & Corbin, 1994). My data analysis consisted of several steps.

During the first stage, I developed a chronology of key events for each of the three intermediaries from 2012 to 2019. This chronology allowed me to create a bigger picture of the intermediaries' development during this period. Moreover, it made it easier to understand sequential influences and interactions among the intermediaries (Langley, 1999), and helped me tentatively define the relationships that formed among them. Figure 2.3 represents the chronology of specific events that spurred the establishment of the intermediaries and continuous factors that gradually motivated the idea of the intermediary support.

Figure 2.3. Timeline of the Life of the Intermediaries



In the second stage, I identified the first-order empirical themes. I used NVivo 12 to initially code the interview transcripts, observations and archival data associated with the emergence process of the three non-market intermediaries and their particular functions as intermediaries and innovation catalysts. I reviewed the qualitative data for open coding. I coded the first-order themes using the interviewees' own words (see Gioia et al., 2013 for

more information about the coding processes). This facilitated attaining deeper insights from the research participants and other sources. The first-order themes were related to a range of features that each intermediary presented (e.g., funding, programs, missions, relationship with the government, etc.). In addition, the first-order themes captured the backgrounds of each intermediary (e.g., who initiated what, and how the intermediary started). To clearly compare the three intermediaries, I organised the first-order themes by answering basic 'what, who, how, when, where, why' questions (Flick, 2009). This method was useful for purifying the typology of the intermediaries.

As the analysis progressed, I identified similarities and differences across the coded passages. I reviewed all the qualitative data again to check how the coded passages fit with the emerging second-order themes (Sandhu & Kulik, 2018). For example, when the first-order themes were described as 'the shutdown announcement made by global automobile companies' and 'Australian manufacturing's losing competitiveness', I grouped these into 'Industry shock'. I iterated between the insights I was attaining from the data and the theoretical literature to refine the initial codes.

Next, I aggregated second-order themes into higher level theoretical dimensions. In this stage, I compared the relationships among the second-order themes within and across the intermediaries. First, I was able to identify the commonalities in the emergence process of the three intermediaries. I alternated between the emergent themes and related literature to identify theoretical dimensions. Throughout the analysis, I actively brainstormed alternative conceptual models as to how these themes related to one another and to related theories (Pratt, Rockmann, & Kauffman, 2006). Second, I simultaneously explored any important relationships across the codes in relation to the intermediaries' roles. Using the chronology, I

compared the intermediaries' development over time. During the analysis, I noticed a common role played by all three intermediaries, and thus carefully examined the emerging relationship to infer how the common role might link these intermediaries and influence the industry overall. In addition, I noticed a strong relationship between the intermediaries' origins/development and their roles as innovation catalysts. I then consolidated these codes into higher level conceptual categories (Pratt et al., 2006). Figures 2.4.1 to 2.4.3 represent my data structure, and a more detailed examples of first-order codes appear in the Table A2 in the Appendices.

Establishing Trustworthiness

Since it is important to establish trustworthiness in research, I employed several methods to ensure the trustworthiness of my analysis. First, I triangulated issues and claims across multiple datasets using diverse sources such as interviews, publications, newspapers and observational data. Second, my triangulation was based on multiple perspectives from the field, as I interviewed representatives from SMEs, MNEs, the government and research institutions, and interviewed consultants and journalists. In this way, I did not limit myself to a one-sided perspective of the industry. Third, I checked my findings with my interviewees. This allowed me to confirm that my theoretical frameworks accurately described the way non-market intermediaries operated in the industry. Fourth, I used peer debriefing (Guba, 1981; Lashley & Pollock, 2020; Lincoln & Guba, 1985) by discussing and gaining feedback from a researcher who was skilled in qualitative research, but not involved in the project.

Figure 2.4.1 Data Structure – The Emergence Process

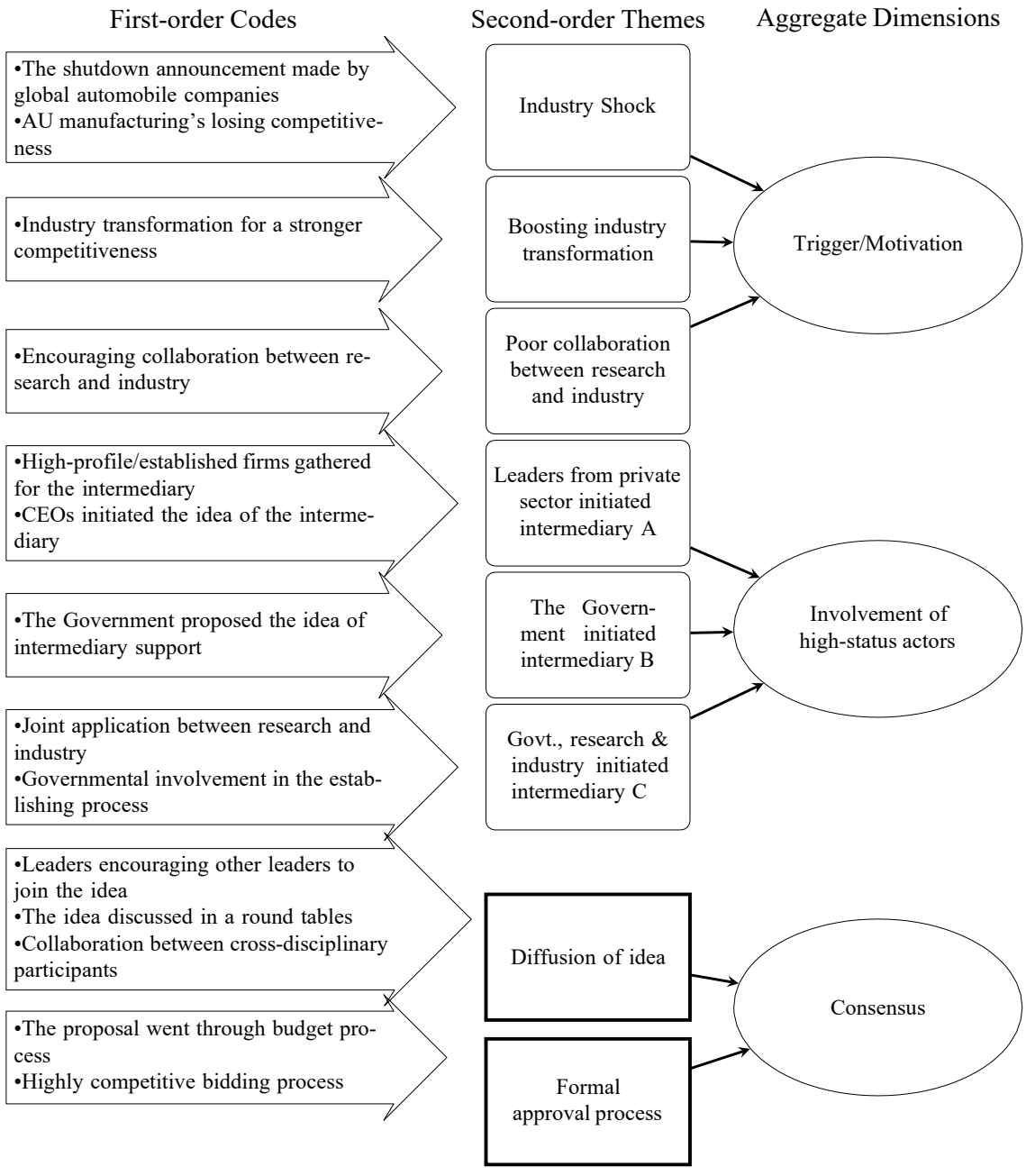


Figure 2.4.2 Data Structure – The Evolution of Intermediary Role

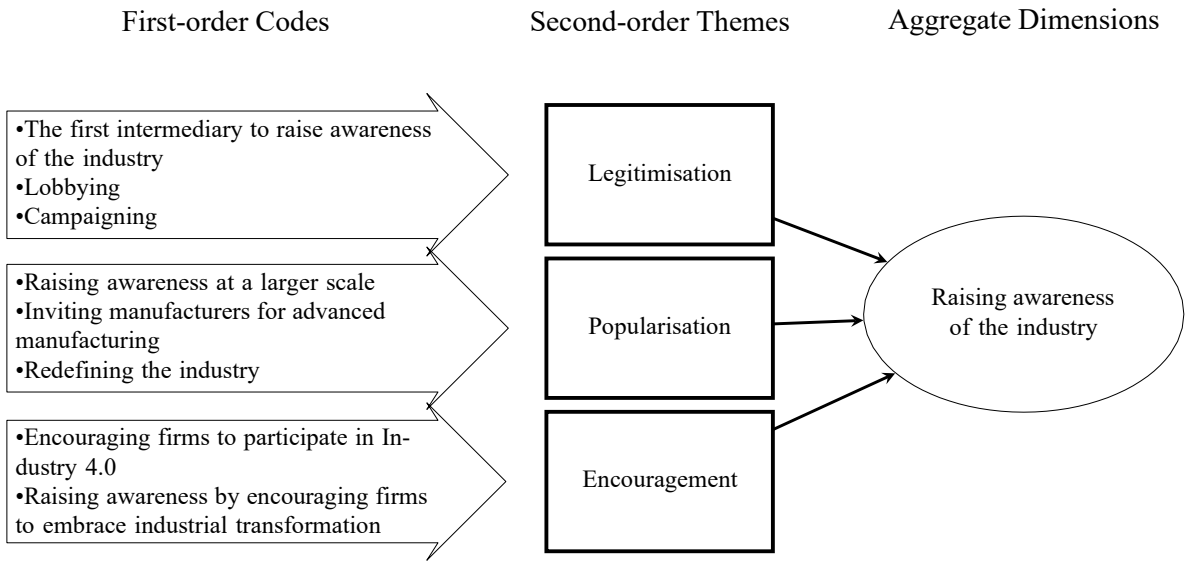
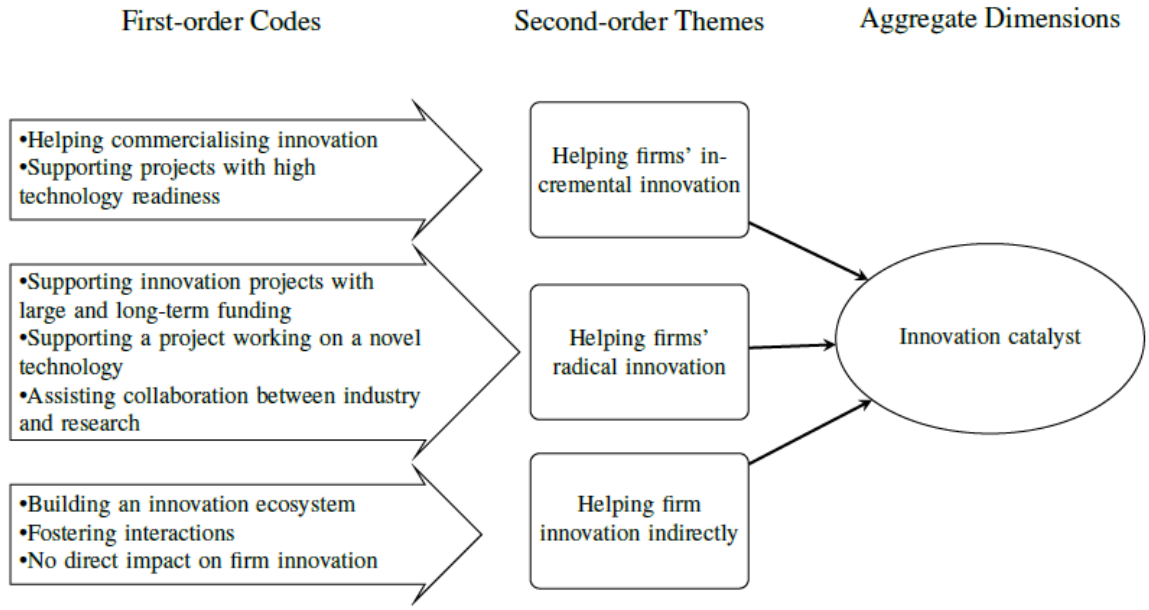


Figure 2.4.3 Data Structure – The Catalysing Roles



FINDINGS

Intermediaries do not simply appear or disappear for no reason; rather, they are a part of an industry. This is particularly the case for non-market intermediaries as they are usually a channel of industry policies or community contributions. In this section, I present three findings that show (1) the process through which the non-market intermediaries emerged, (2) the evolution of the roles the intermediaries played at different stages in the advanced manufacturing industry and (3) the different roles that the intermediaries played in catalysing innovation. These findings together demonstrate that non-market intermediaries are an endogenous construct of an industry as reflected in a quotation of a former Intermediary A executive: '*Intermediaries don't come out of a vacuum*' (#I11[6]).

The Emergence Process

Phase 1: Trigger/motivation. The birth of non-market intermediaries began with a strong demand for action in response to the global and local discontinuities. Before Intermediary A was established in 2013, the Australian manufacturing industry had been struggling heavily from losing competitiveness in the global market. This became a significant concern for local manufacturers. One general manager of an SME pointed out a negative aspect of the industry:

[6] In presenting direct quotations, I use the signifiers to indicate the sources. I use 'I' to identify interviews with intermediaries, 'C' for interviews with consultants, 'F' for interviews with firms, 'G' for interviews with governments, 'J' for interviews with journalists, 'R' for interviews with research institutions, 'AA' for publications of Intermediary A, 'AB' for publications of Intermediary B, 'AC' for publications of Intermediary C, 'AG' for publications of the government, 'PM' for transcripts of the prime minister, 'AI' for publications of third parties and 'AN' for newspapers.

> *I saw shift of social perception about [the] manufacturing industry, [and] because of that, young generations do not want to work in this industry anymore, we were getting concerned if this continues (#F1).*

Adding to this bleak outlook were economic indicators (e.g., employment, sales and service income, and industry value added), which had been dropping for the past years. One interviewee summarised this situation as follows:

> *It started from five years ago, it was obvious, that we cannot compete for cost efficiency with Asian countries where labour is much cheaper, volume is higher and global companies trained the local employees so the labourers' engineering skills are higher too (#R2).*

More importantly, sudden shutdowns of automobile assembly factories immediately caused economic declines for the manufacturing industry. Global automobile manufacturers Ford, Toyota, and General Motors announced closures of their Australian factories in 2013 and 2014, claiming that they were making strategic decisions against the high Australian dollar, a highly competitive market and relatively small production quantities. These announcements directly affected the supply networks of Australian-based manufacturing firms. As a result, concerns about employment, sales and income in the manufacturing industry soared. As the automotive passenger vehicle manufacturing industry was one of the leading employment providers in Australia (especially for regional economies), played a significant role in R&D and substantially contributed to Australia's exports, the announcements also shocked the entire Australian economy as well. Taken together, there were strong calls for action to address this local discontinuity. The formation of Intermediary A was a response to this demand. According to one newspaper: '*The formation of*

[Intermediary A] follows the announcement made by Ford last May 23 that it would cease car production in the country by October 2016.'

A former executive director of Intermediary A also confirmed in an interview that the global and local discontinuities triggered the idea for Intermediary A:

> *In 2013 we (Intermediary A) wanted to start from a campaign that Australian manufacturing industry is still doing well, there are successful advanced manufacturers and Australian manufacturing has good potentials to transform into high-value industry (#I3).*

Certain triggers also preceded the establishment of Intermediary B in 2015. The year prior, a business council published an article that urged the government to pay more attention to supporting sector competitiveness directly and revise an innovation agenda:

> *only if Australia changes its mindsets to acknowledge that unstoppable forces of globalisation and technology have shaken up forever what it means to be competitive at a world standard … If Australia is to stay competitive and support jobs and prosperity, then policy must be more focused on the specific requirements of each sector of our economy to maximise their comparative advantages … Government must also pursue a structural reform agenda that builds the innovation infrastructure to support the agility of the Australian economy (#AI2).*

At the same time, the Liberal federal government proposed a new industry and innovation agenda to further enhance the competitiveness of sectors in Australia because of the economic disturbance caused by international competition, emerging technologies and local discontinuity. The agenda proposed that the government would support five strategic sectors[7] in Australia. The government argued that these sectors were chosen based on the

[7] The five sectors were advanced manufacturing, food and agribusiness, medical technologies and pharmaceuticals, mining equipment, technology and services, and oil, gas and energy resources.

strength of their competitiveness and the size of their contribution to the Australian economy, and supported by industry experts. The advanced manufacturing industry was one of the strategic sectors that the government chose to prioritise through programs of Intermediary B. Particularly, the government drafted this support policy to transform traditional manufacturing businesses into advanced manufacturing businesses, following the initiatives of global governments toward the advanced manufacturing. A prominent research institution backed this idea, stating in one of their industry reports published in 2016: '*Australian manufacturing can and must be a thriving component of Australia's economy through the application of advanced manufacturing technologies, systems and processes' (#AI6)*. Therefore, Intermediary B was motivated by the government's move to garner additional support for the advanced manufacturing industry. This motivation corresponded with the directors of Intermediary B also mentioned in their interviews that Intermediary B was motivated '*to encourage the industry to take a new look at the way industry compete the global market' (#I5)*.

This idea of the government support for advanced manufacturing also motivated the idea of Intermediary C established in 2016. The CEO of Intermediary C mentioned in their interview that their mission was to be a '*catalyst for [the] transformation of [the] manufacturing sector'(#I4)*.

However, there was another important trigger that led to the creation of Intermediary C -- the low level of collaboration between industry and the research sector in Australia. In fact, a 2015 OECD survey revealed that Australia ranked last among OECD countries for its

Cyber security was later added to this list.

collaboration between the research sector and industry. The statistics are reported in a government document:

> *Australia fares poorly on collaboration with research institutions. Australian industry's collaboration with higher education and research institutions ranked the lowest of 27 countries in the OECD, both for large businesses and for SMEs. (#AG10)*

The prime minister at the time was also driven to address the issue of poor collaboration between industry and research. At the 2015 Economic and Social Outlook Conference, he said:

> *There is no doubt that one of our major failures is that we are, as a nation, very poor at collaboration between primary research institutions, universities for the most part, and business. This is—we are, depending on which list, either last or second last in the OECD, apparently. It is widely acknowledged. (#PM2)*

OECD statistics shocked key industry actors, such as the Australian Government, policymakers, academics and key business leaders, and impelled them to develop new ways to boost a collaborative culture[8].

In the following year, as a part of the government's cooperative research program, Intermediary C was established. Collaboration between business and the research sector was a core mission of this intermediary. It documented its goals as '*invest in collaborative research'* and *'collaborative investment, research impact and innovation'. (#AC3)*

[8] As stated in the following quotation of an industry report (2017), the statistic was a 'shock' to the policy-making level of people: '*We have neither the industry systems, nor the management capabilities to facilitate it [collaboration] ... Australia's gross domestic product would increase $8 billion over the next 10 years, if Australia reached just the OECD average for collaboration ...We must challenge and change the way we work. (#AI5)'*

In sum, Intermediary A was triggered by local discontinuity; Intermediary B was motivated by the government's support agenda; Intermediary C was encouraged by the government's agenda and poor collaboration between the industry and the research sectors. Although the triggers/motivations of the intermediaries were different, they explain why new intermediary support is required in an already saturated system of norms or institutions. The motivation represented the first phase of the emergence of Intermediaries A, B and C, and is arguably an important process for establishing non-market intermediaries.

Phase 2: Involvement of high-status actors. While the trigger/motivation spurs the demand for new intermediary support, actors must initiate action to legitimise the idea. Especially, strong leadership from high-status actors is important because such actors can make a new idea more palatable to an industry and the public, and they can effectively organise collective action for the legitimacy of the idea, particularly when industry uncertainty is high (Aldrich & Fiol, 1994). Accordingly, the involvement of high-status actors—such as industry leaders, the government and well-known institutions—is an important element of the emergence process of intermediaries. This generally follows the trigger and motivation phase.

In the case of Intermediary A, the CEOs of established firms in Australia were the main actors in the collective action, which originated from conversations between significant influencers in the Australian manufacturing industry. As a result of the ever-changing industry threats and the automobile crisis, one (widely known) influencer started discussing new intermediary support, especially for the advanced manufacturing industry (i.e., promising alternative for the traditional manufacturing), which snowballed and prompted the CEOs of other established firms to lend their support to the idea. A former executive director of

Intermediary A described the initiation of this conversation as follows: '*One big influencer started and brought those high-profile companies [to] the table. This was like using opinion leaders and influencers to encourage other opinion leaders, peer-to-peer talking*.'*(#I11)*

Similarly, the idea for Intermediary B was also initiated by a high-status actor: the federal government. Although Intermediary B equivocally identified itself as an '*industry-led, not-for-profit organisation' (#AB7)* and *'a not-for-profit organisation, distinct from but supported by the Australian Government' (#AB1)*, the government was the key initiator for the organisation for three reasons. First, as discussed previously, Intermediary B was established as '*as a key plank (#AB1)'* of the government's industry innovation and competitiveness policy. Second, the government was Intermediary B's main funding source, as noted in a government document:

> *[Intermediary B] will receive $3.5 million per year for base activities and services, including establishment, salary and other operational costs and the delivery of activities and services to its sector. (#AG3)*

Third, Intermediary B had to achieve key objectives that were specified and regularly assessed by the government. These objectives were as follows: *'(1) increasing collaboration and commercialization, (2) improving international opportunities and market access, (3) enhancing management and workforce skills, (4) identifying opportunities for regulatory reform*.'*(#AG4)* Therefore, a high-status industry actor, such as the government, was very involved in establishing Intermediary B.

Intermediary C was the outcome of a bidding process that was designed to form a new intermediary and required a joint partnership of research and industry bodies working together to apply. Accordingly, the first main initiators of Intermediary C were research

institutions and companies. More importantly, to win the bidding, applicants needed to be well-known in the field, as the status of participants could signal their capabilities to succeed the projects: prominent research institutions and well-established firms were thus essential component of the process. The government also played a role in the bidding process, by suggesting that two strong proposals combine to form one intermediary. This is noted in a newspaper that '*Intermediary C was a combined re-bid of application 1 and application 2 at the suggestion of the government'*. Hence, high-status actors, such as prominent research institutions, established firms and the government, were also observed in a bidding type of emergence process.

Phase 3: Consensus building. The final phase of establishing a new intermediary entails consensus building. The collective action of high-status actors can only occur when they agree to carry it out. Further, legitimacy of a new idea relies on consensus among actors 'that the features and activities of organisations are appropriate and desirable within a widespread, taken-for-granted system of norms or social codes' (Cattani, Ferriani, Negro, & Perretti, 2008: 146; Hannan, Polos, & Carroll, 2007; Zuckerman, 1999). Accordingly, legitimacy for Intermediaries A, B and C depended on consensus that such support was relevant and preferred in the context. Consensus can be achieved through two channels: (1) the dispersion of an idea and (2) a formal approval process. Consequently, legitimacy is achieved in two forms: (1) cognitive legitimisation and (2) socio-political legitimisation (Aldrich & Fiol, 1994). The former is achieved through the diffusion of knowledge, and the latter is achieved through 'the process by which key stakeholders, the general public, key opinion leaders, or government officials accept' an idea. These patterns are also observed in consensus building among high-status actors.

First, after recognising the need for a new intermediary, high-status actors started to build consensus by informally diffusing the idea. For example, Intermediary A's former executive director noted the initiations of Intermediary A as '*peer-to-peer talking'*. The idea of new support for the advanced manufacturing industry was disseminated from the CEO of an established company to other CEOs. As a result, those executives cognitively agreed that intermediary support was required, especially at that time. This type of idea dissemination was observed in the emergence of intermediaries B and C. First, before the idea for Intermediary B was finalised, it was discussed at a series of informal roundtables. The below quotation shows informal diffusion of the idea at these roundtables:

> *what we're intending to do is to have a series of round tables, which will be led by the ministers before you today—they will be leading these round tables along with a Minister. We will be further refining proposals in a range of areas, such as, for instance, coastal shipping that will add to our competitiveness. (#PM1)*

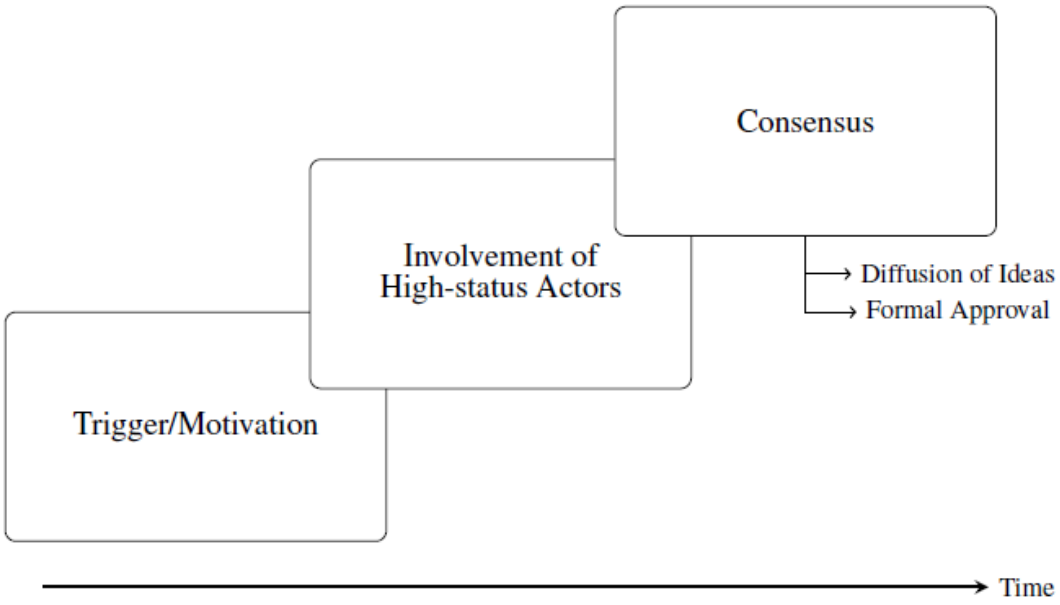
Similarly, participants in all of the applications for Intermediary C also circulated the idea of Intermediary C through internal communication channels. Since Intermediary C was a result of collaboration between cross-disciplinary teams from the research and business sectors, it required a high level of understanding and cooperation between the participants, given their different backgrounds, to reach an agreement. Additionally, as the intermediary was the output of combing two different applications, effective idea diffusion was necessary for ensuring that the key issues from both applications were adequately addressed. Accordingly, the participants were consistently exposed to a situation that necessitated achieving a high level of cognitive consensus during the whole bidding process.

Second, at the same time, high-status actors sought to build socio-political legitimisation through a formal approval process. For instance, an official budget process that

intermediaries B and C went through was a pathway to socio-political legitimisation. This process required a higher level of approval and coordination from multiple authorities, including the prime minister, parliament, the Department of Finance and the government's Expenditure Review Committee. In the case of Intermediary C, it achieved the legitimisation through scrutinization of authorised parties such as the Minister for Industry, Science and Technology and the program advisory committee. Such formal process to attain socio-political legitimisation also took place for Intermediary A -- however, as Intermediary A was a private initiative, it differed from that of intermediaries B and C. Intermediary A made an official announcement of its launch at a media conference to obtain official approval of its establishment.

Figure 2.5 illustrates the process model that led to the emergence of these non-market intermediaries. Although I have described the three phases in a linear fashion, in practice, they partially overlap. In summary, non-market intermediaries tended to emerge from a process of sequentially interconnected phases endogenously derived from an industry: (1) trigger/motivation, (2) involvement of high-status actors and (3) consensus building.

Figure 2.5. The Emergence Process of Non-market Intermediaries



The Evolution of the Intermediary Role: Collective Action of Intermediaries

One common goal that Intermediaries A, B and C aimed at was raising awareness of the advanced manufacturing industry. Despite the differences in organisational missions and life cycle, the contributions by the three intermediaries have collectively improved general awareness of the industry over time. Moreover, the collective action represented how the function of awareness raising evolved over time.

Legitimisation. In 2013, when Intermediary A was launched, there was only scant understanding of what advanced manufacturing was. Legitimising the advanced manufacturing industry was an urgent task for building the cognitive acceptance of the

industry. Accordingly, Intermediary A officially introduced the new concept of the advanced manufacturing, which is manufacturing focusing on advanced technologies and value creations, to key industry stakeholders through lobbying and awareness campaign. It was highlighted in one of the interviews with Intermediary A's member firm representatives:

> *What's [of] value in Intermediary A was the story and message for manufacturers in this country to the politicians. They [Intermediary A] were lobbying … anyone listening. They were trying to bring more attention to the new concept of the manufacturing industry (i.e., advanced manufacturing). That's what they do. That's [what] they value. (#F5)*

Intermediary A's awareness campaign started from having influential CEOs in the sector on board. The CEOs from MNEs to local businesses agreed to support the campaign and admitted the urgency of awareness raising in the field. Intermediary A also collaborated with one of the biggest industry associations, which immediately gave it the opportunity to spread the concept of the advanced manufacturing industry throughout the manufacturing community, and then to other industry communities. Concurrently, the intermediary provided a great deal of information, including the definition of advanced manufacturing, success stories of Australian advanced manufacturers and industry news, through its official website. As such, Intermediary A, as a pioneer of mediation, first legitimised the advanced manufacturing industry in the current form and seeded the cognitive acceptance of the industry to businesses, the government and to public. A former executive of Intermediary A said, '*No one ever talked about "advanced manufacturing" before. We were a catalyst to help*

what the sector is. We were motivated by President Obama's Advanced Manufacturing Partnership'.[9] *(#I11)*

Popularisation. The role Intermediary B played in raising awareness is closely linked to that of Intermediary A. After Intermediary A was discontinued in 2015, Intermediary B took over most of its functions. Specifically, Intermediary B aimed at scaling up the industry legitimacy Intermediary A had built. This function is called 'popularisation' of the industry. While Intermediary A had contributed to improving the industry awareness, it was only targeted at a small group of the community such as CEOs, politicians, and the government. To foster the acceptance of the industry, the intermediaries needed to raise awareness of a boarder group of the manufacturing community, such as SMEs, so that the advanced manufacturing industry could be perceived as 'justified and integrated into the prevalent institutional order' (Rao & Singh, 2001: 264).

Intermediary B executed various programs to realise this popularisation. First, it designed a free membership program that enabled manufacturing firms to join a network of likeminded manufacturers at no cost. This program was possible because, unlike Intermediary A[10], Intermediary B was less dependent on funding from its members. More importantly, this free membership program removed any financial requirement for SMEs to join the network. Intermediary B increased its total membership from 129 (February 2018) to

[9] 'The Advanced Manufacturing Partnership (AMP 2.0) is a national effort appointed by President Obama to secure emerging technologies that will create high-quality manufacturing jobs and enhance America's global competitiveness' (MIT-Massachusetts Advanced Manufacturing Innovation Forum, 2014). See http://web.mit.edu/pie/amp/

[10] Intermediary A charged for membership, which was a significant obstacle for SMEs to join the membership.

920 (November 2019),[11] with the largest member cohort consisting of SMEs. At the same time, this membership program enabled Intermediary B to achieve its mission, defined by the government, of increasing *'collaborative networks'*. A director of Intermediary B commented in their interview that the membership program served one of Intermediary B's distinctive roles: '*While Intermediary A was represented by large corporations and MNEs, we [Intermediary B] are here for SMEs, we help them to be connected*.' *(#I7)*

This free membership program simultaneously enabled Intermediary B to create a communication channel to spread the idea of advanced manufacturing to a wide audience. Through this network, Intermediary B often promoted doing business using advanced technologies and transformative business models. This method was especially effective in the context of the Australian manufacturing industry, as more than 90% of Australia's manufacturers are SMEs and the industry is scattered both physically and economically. Accordingly, by establishing a valid communication channel through a network of likeminded manufacturers, Intermediary B could -- as noted by a member in an interview -- '*start a conversation about the industry' (#F1)*.

Intermediary B also used research to expand industry awareness. A strong example of this is its research about the definition of the advanced manufacturing industry. Using this research, Intermediary B reworked definition of the industry to suit current business practices. This redefinition allowed Intermediary B to resolve any confusion about the industry. In fact, when I asked my interviewees[12], '*What is advanced manufacturing?*', their answers were mixed: '*it's about appliance of smart, connected technology to develop [a] high*

[11] This is from my own observations.

[12] The quotations were from interviews conducted during the first stage of data collection.

value product to meet a global market need' (#R1); '*advanced manufacturing is to expand the service future' (#F3)*; and '*advanced manufacturing is not only about innovation in products, but also innovation in process and innovation in business model[s]' (#F8).*

Intermediary B's work on redefinition -- broadening and simplifying the existing definition of advanced manufacturing -- encouraged traditional manufacturers to become advanced manufacturers. Previously, the Australian Bureau of Statistics has defined 'advanced manufacturing includes chemical and medicinal manufacturing, as well as vehicle and transport, professional and scientific equipment, computer and electronic, and specialised machinery and equipment manufacturing', which is confined to the types of products manufacturers produce. However, Intermediary B stated that advanced manufacturing is characterised by '*advanced knowledge, advanced processes and advanced business models' (#AB6)*. This new definition focuses more on the inputs of manufacturing processes rather than the outputs of manufacturing, allowing more manufacturers to easily conceptualise the definition and readily join the advanced manufacturing industry and, in turn, popularising the category of advanced manufacturing. One of Intermediary B's publications emphasises that there is '*no hard line'* between advanced manufacturers and manufacturers.

Accordingly, Intermediary B's programs were designed to popularise the advanced manufacturing industry and facilitate its acceptance by incumbent manufacturers and existing institutions. This was only possible because of the work Intermediary A undertook to establish the industry legitimacy. Simultaneously, note that this function was also coupled with the direction and support of the government.

Encouragement. Intermediary C also contributed to raising awareness of the advanced manufacturing industry, but adopted a different approach. Intermediary A first initiated the process of raising awareness through legitimisation, and Intermediary B scaled up this awareness through popularisation. Established in 2016 as a 'latecomer', Intermediary C then focused on encouraging firms to practically adopt the tenets and practices of advanced manufacturing. The CEO of Intermediary C mentioned in their interview that '*The goal of our programs is to build an appetite to invest in Industry 4.0'. (#I4)*

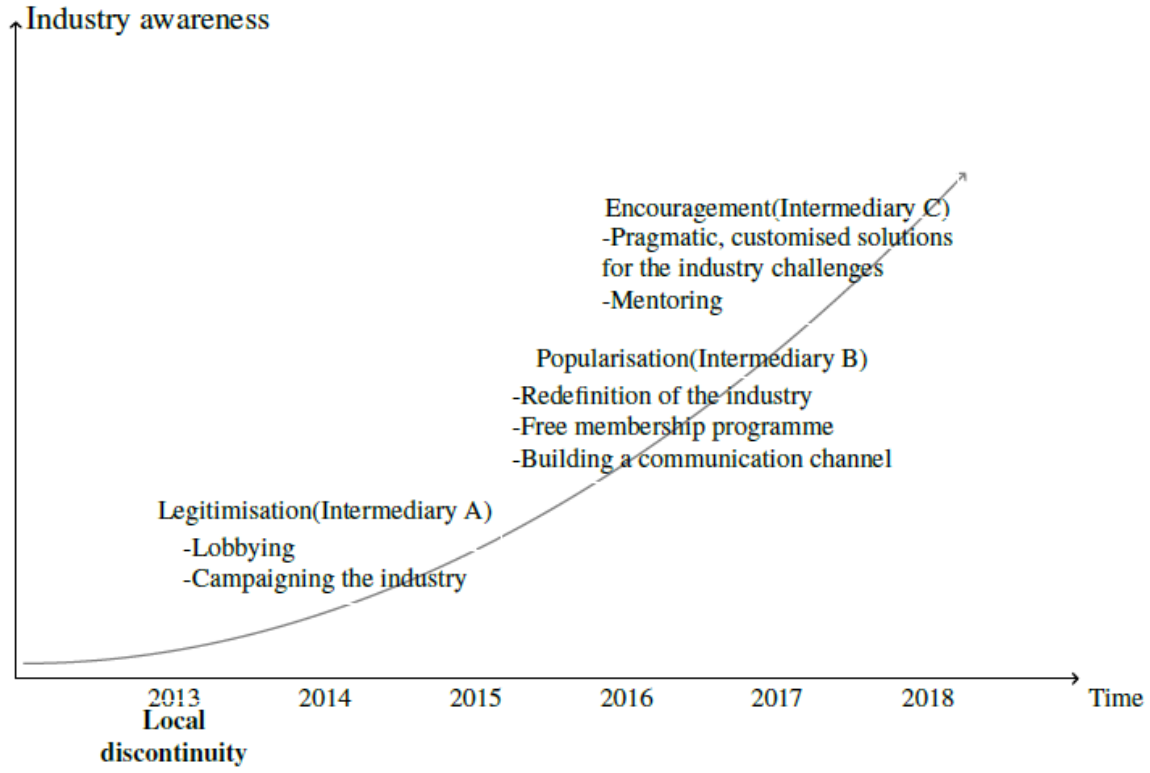
One of Intermediary C's programs, an industrial transformation program, was particularly useful for achieving this goal. The program used input from the research and business sectors, enabling Intermediary C to identify gaps in firms' knowledge regarding current and future business in the context of the advanced manufacturing industry. That is, Intermediary C developed the program to improve firms' understanding of how they could actually benefit from using Industry 4.0. technologies (e.g., additive manufacturing, digital technologies, data analysis, etc.), and how they could enhance their strategies for future business operations.

The program took the form of a workshop in which firms had the chance to assess their current state of affairs and identify areas of improvement in terms of business focus and investment. At the end of the workshop, participants received a business diagnosis. These diagnosis results were customised based on the answers participants gave to questions about market positioning, leadership, strategy and change management, innovation and use of technology, and digital manufacturing (using a five-point Likert scale). During the workshop, business coaches from Intermediary C educated the participants about unfamiliar or unclear concepts, such as 'servitisation', 'value capture in Industry 4.0', 'innovation' and 'emerging

technology trends'. The business diagnosis also included tailored advice on how to embrace industry transition, and introduced firms to other supporting organisations and/or government programs that might be useful to improving their business focus. Through this program, Intermediary C offered manufacturers a practical way to transform their business and embrace Industry 4.0 technologies. This helped the firms become more familiar with new business concepts and provided them with pragmatic, customised solutions for incorporating the new business approaches of the advanced manufacturing industry.

Taken together, as Figure 2.6 summarises, intermediaries A, B and C worked together to raise awareness of the advanced manufacturing industry. Initially, when advanced manufacturing was unfamiliar to the manufacturing industry and the government, Intermediary A legitimised the concept through lobbying and an awareness campaign. Intermediary B then popularised the concept to grow manufacturers' interest in conducting business in the context of advanced manufacturing. Intermediary C encouraged these firms to use advanced technologies and adopt new business strategies by providing practical solutions and mentoring. Furthermore, this intermediary role of awareness raising has been reshaped during the period from 2013 to 2019. In the beginning, it started from legitimisation, and then evolved into popularisation and encouragement as the industry matured and the industry demand changed.

Figure 2.6. The Evolution of the Intermediary Role: Collective Action of Intermediaries



The Different Roles of Intermediaries in Catalysing Innovation

Another interesting pattern I found was that the origins/development of three intermediaries played an essential role in shaping their distinctive roles in stimulating innovation, which in turn implies a strong relationship between the emergence of intermediaries and their catalysing roles. Hence, this section demonstrates how this relationship was formed and explains the different pathways that intermediaries take to influence firms' innovation.

Catalyst of firms' incremental innovation. Intermediary B developed a grant program to directly support firms' innovative projects. However, this grant program was strongly motivated to satisfy the government's expectation of '*increasing collaboration and commercialization*' (#AG4), because of two clear reasons. First, Intermediary B specified that

its goal of the grant program was to '*commercialise innovation*' and to boost '*collaboration with other parties*' (#AB7). Accordingly, Intermediary B granted funding to the innovation projects that were collaborative and market-ready. Second, the grant structure that Intermediary B designed clearly reflected the intention of immediate outcomes of commercialisation as the funding scheme supported only short-term projects that would be completed within a year.

Moreover, the technology domain that Intermediary B nurtured was also incremental, because the innovative projects that Intermediary B supported were likely to produce incremental innovation which extended existing practices, products and services through minor and cumulative changes (Beck, Lopes-Bento, & Schenker-Wicki, 2016; Schilling, 2013). First, the funded projects were not required to develop new technologies. Rather, they were expected to have highly developed technologies that could be easily applied to technologically proximate domains or be commercialised. The following points show the outlines of the funded project[13]. These points indicate that the funded projects involved technologies that the firm had already developed, that used proven models or that used existing models that the firm would redesign, confirming that Intermediary B did not seek new inventions or novel technologies for the projects:

- Project 1: 'Firm1 has already developed scalable and relocatable process …'
- Project 2: 'This project will redesign Firm3's product …'
- Project 7: 'Firm7 now must increase product capacity and manufacturing readiness level from (MRL7) prototype system to MRL8–9 …'

[13] The project descriptions are from Intermediary B's website.

- Project 10: ‘In this project, Firm10 must now develop and validate, at commercial scale …’ and ‘… building on from the prototype machine that they have developed and proven in their laboratory …’
- Project 12: ‘Over the past 2 years, research undertaken by University12 and Firm12 has developed …’

Second, the grant scale that Intermediary B offered to the recipient firms was favourable to incremental innovation. Intermediary B aided innovative projects that would not cost more than AUD250,000. Taking into consideration that innovation projects usually take more than 2 years to accomplish and are expensive to complete, the grant design that Intermediary B promoted was relatively small scale. Hence, it corroborated that Intermediary B only expected incremental innovation rather than transformative technological change. One of its publications highlighted this intent:

> *It was also noted that even an incremental increase in innovation among Australia’s broad mass of small- and medium-sized firms has the potential to deliver big gains for the nation’s economy. (#AB2)*

Catalyst of firms’ radical innovation. A strong influence of the origins/development of intermediaries on their catalysing roles was observed in the practice of Intermediary C as well. Intermediary C’s primary goal was to foster collaboration between research and industry, and its grant program was designed to achieve this goal. Intermediary C, similar to Intermediary B, provided financial grants to fund firms’ new projects. However, these projects had to be collaborations between firms and research institutions, which Intermediary B did not particularly require. Further, the applicants were asked to invite PhD students to join their projects. This also enabled Intermediary C to achieve higher education outcomes, which would contribute to reducing the problems caused by poor collaboration between

research and industry. Thus, the grant programs of Intermediary C and Intermediary B differed because of their heterogeneous origins, missions and support focuses.

Further, such differences resulted in distinguishing features in the size and duration of the projects that Intermediaries B and C funded. While Intermediary B funded small-scale and short-term projects (i.e. those with a timeframe of 6 to 8 months and a cost of up to AUD250,000 per project), Intermediary C funded large-scale and long-term projects '*in the range of AUD250,000 to AUD3 million*' and '*more than 2 years and less than 4.5 years in duration*' (#AC2). These differences in funding design could in turn lead to stimulating different types of innovation.

While the outcomes of the innovation projects that Intermediary B funded were strongly associated with incremental innovation, the innovation projects that Intermediary C funded were likely to generate radical innovation that is 'recombination that combines new components that were previously unconnected and typically originate from distant technological domains' (Keijl et al., 2016: 1062). Therefore, radical innovation may take longer to achieve and cost more to develop (Green, et al., 1995), but Intermediary C's large-scale and long-term funding design could facilitate favourable conditions for generating radical innovation. Further, the recipient firms were more exposed to diverse ideas and advanced technologies because of their requirement to establish collaborative relationships with research institutions. The recombination of knowledge with greater diversity is likely to generate new ideas (Katila & Ahuja, 2002), which in turn can initiate radical innovation (Kobarg, Stumpf-Wollersheim, & Welpe, 2019; Rothaermel, Hitt, & Jobe, 2006). The CEO of Intermediary C explicitly stated that the organisation's focus was on boosting radical

innovation: '*We are less evolutionary, but more transformative. We are not about continuous improvement, but more about getting to the next horizon*' (#I4).

Below are descriptions of Intermediary C's funded projects[14]. The descriptions commonly inform that these projects were associated with developing new technologies or novel solutions to address current technological problems. These support that innovation projects Intermediary C funded are likely to produce radical innovation:

- Project D: 'Yet, today there is no early detection technology available that helps predict the onset, for instance, of a heart attack … In collaboration with UniversityD, FirmD is developing a biomarker sensor technology that will help users …'
- Project F: 'FirmF is engaging UniversityF to research and develop new materials and manufacturing technology …'
- Project H: 'World-first use of kangaroo as a xenograft material in ligament re-construction and repair … FirmH.1, together with FirmH.2 and UniversityH are pioneering a novel solution for the orthopaedic reconstruction of …'
- Project J: 'This project takes a new approach to resolving bacterial biofilm problems in humans and industrial settings …'
- Project K: 'The project seeks to develop a commercially viable Normally OFF fail-safe …'

Indirect catalyst. Intermediaries do not all stimulate firm innovation in the same way. As is evident in the cases of intermediaries B and C, their roles vary depending on how they

[14] The project descriptions are from Intermediary C's website

have developed to satisfy their original missions, suggesting that Intermediary A may have played a different role which suited their emergence pathway.

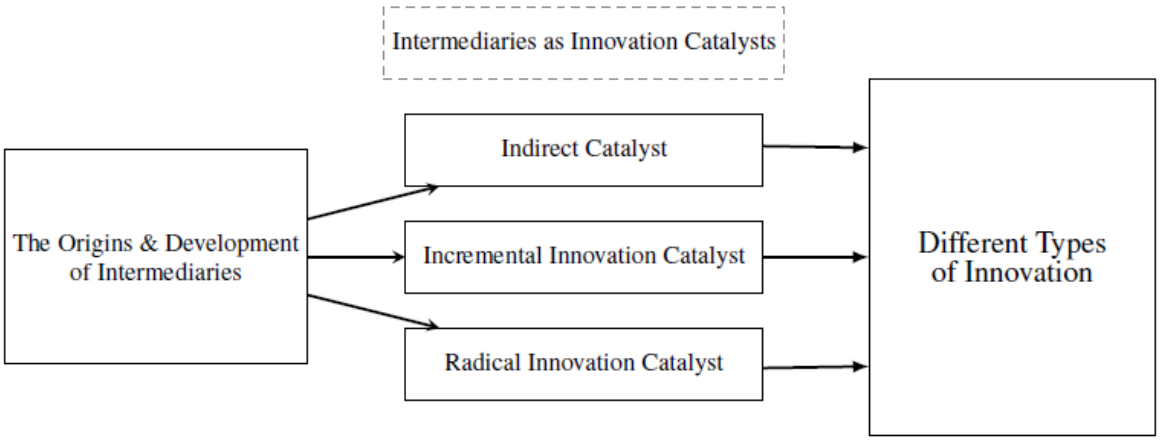
As a private initiative and advocacy group, Intermediary A's primary focus was on bringing more attention to the advanced manufacturing industry from the government and the industry. Ultimately, Intermediary A aimed to create an innovation ecosystem. A former executive director of Intermediary A stated the organisation's goal as follows[15]: '*We ultimately want to build an innovation ecosystem. We want to bring more attention to build business-friendly environment, where a lot of innovation happen.' (#I3)* Therefore, through lobbying and campaigning, Intermediary A was, according to a member firm representative I interviewed, '*developing the need for innovation' (#F5)*. Intermediary A also activated discussions among the CEOs of its member firms. The CEOs shared ideas and discussed strategic directions for innovation that could have an effect on the firms' innovative activities. Despite this, Intermediary A did not provide practical programs to support firm innovation—its role was thus as more of an indirect catalyst than a direct catalyst. It exerted its influence just by fostering interactions and building the need for innovation, not by aiding innovative activities. A former executive director admitted that Intermediary A's function had no direct effect on firm innovation: '*I think companies would probably not admit that they benefited from us, they would not attribute any innovation success to us.*' *(#I3)*

Likewise, the roles in catalysing innovation vary among intermediaries. That is because intermediaries shape its role differently depending on their emergence. For instance, as a government-initiative, Intermediary B was a catalyst of incremental innovation, which

[15] The former executive also provided me a figure to describe the organisational goal of fostering an innovation ecosystem.

met the governmental requirement, while Intermediary C, as a hybrid initiative, was a catalyst of radical innovation due to its prime goal of encouraging collaboration between research and industry. Intermediary A, on the other hand, was an indirect catalyst, prioritising its advocacy role rather than catalysing role. Altogether, this examination demonstrates a strong relationship between the emergence of intermediaries and their catalysing role, which encourages more accurate understanding of the emergence of intermediaries in the literature. Figure 2.7 depicts the heterogeneous impacts of intermediaries on innovation rooted from the origin/development of intermediaries.

Figure 2.7. The Different Roles of Intermediaries in Catalysing Innovation



DISCUSSION AND CONCLUSION

This study attempts to answer fundamental questions of non-market intermediaries—where non-market intermediaries come from, how they originate and evolve, and how their emergence pathways shape the roles they serve. Three main findings emerge from the qualitative analysis. First, regardless of the type, non-market intermediaries tend to emerge from a process model of sequentially interconnected phases. A strong trigger first motivates

demand for new intermediary support; high-status actors then use their industry influence to respond to this demand; finally, consensus among the actors from multiple organisations legitimises the idea for a new intermediary. The second finding relates to the evolution of intermediary roles. Specifically, in this study, I demonstrated this by closely examining their role in raising awareness. This role first appeared in the construct of legitimisation of the advanced manufacturing industry; it then was transformed into popularisation and encouragement sequentially to further raise awareness of the industry. Additionally, this evolution pattern together represents the collective action of the three intermediaries during the period from 2012 to 2019. The third finding highlights a strong relationship between the emergence pathways of non-market intermediaries and their catalysing roles. It demonstrates that the ways in which intermediaries stimulate innovation vary depending on the emergence pathways each has gone through.

This study makes three main contributions to the literature. First, this study highlights the origin and evolution of intermediaries for identifying their roles in an innovation ecosystem. Because intermediaries shape distinctive roles based on their origin, mission and goals, this approach elicits more accurate explanations for the roles of intermediaries. This advances the current tendency of the literature that has examined intermediaries in their present form only.

Second, this study motivates a shift from the view of intermediaries as exogenous constructs and towards one that sees them as outcomes of endogenous processes. For instance, the process model through which intermediaries emerge clearly explains that they are not sudden exogenous phenomena. The process model demonstrates that intermediaries are outcomes of industry justification for specific issues in a given time; their functions

cannot be segregated from business concerns. In addition, the transformation of intermediary roles implies that intermediaries are social entities that actively forge new programs that suit industry changes, and are frequently monitored by the state, individual members of the intermediary or other stakeholders to meet their expectations (King, Felin & Whetten, 2010). This perspective of regarding intermediaries as endogenous actors can surely align the literature closer to reality.

Third, this study contributes to a better understanding of non-market intermediaries. The process model identifies how new intermediaries emerge in an already saturated institution. These sequential phases of trigger, involvement of high-status actors and consensus building are clearly reflected in McDermott et al.'s (2009) anecdote of private–public institutions in the Argentine wine industry. In the late 1980s, Argentina's economic stagnation and the collapse of the wine industry strongly motivated action to revitalise that industry. Consequently, high-status actors in a provincial government devised an idea for a new type of intermediary organisation—the public–private institution— which could respond to demand for a revitalised wine industry, achieving consensus not only from the provincial government but also from thousands of small grape growers and vineries of a federation of cooperatives. Also, this study advances the literature by introducing the evolution of intermediary roles and the collective action of intermediaries. To the best of my knowledge, this study is the first that links the roles of intermediaries in a longitudinal pattern. Additionally, the specification of the catalysing roles supplements prior studies that non-market intermediaries help firm innovation (e.g. Corredoira & McDermott, 2014; McDermott et al., 2009; McEvily & Zaheer, 1999), illuminating that catalyst paths can diverge into several forms, such as radical catalyst, incremental catalyst and indirect catalyst.

This study also has practical implications. First, through this research, firms can attain a better grasp of intermediary roles, which enables them to identify which intermediary programs are suitable for their specific businesses and future plans. As a result, firms can take advantages of those intermediaries' specific strengths -- which also aligns with intermediaries' ultimate goal. Second, this research teaches policymakers, governments and industry leaders the essence of intermediary support – intermediaries are social entities that are established for solving specific issues and evolve as industry changes. Hence, not to waste public money allocated for intermediary support, those leaders must identify clear motivations and gaps that require additional support of non-market intermediaries. A bottom-up approach can serve the goal effectively (McDermott et al., 2009).

Limitations and Future Research

However, this study has several limitations. First, since it involved qualitative inductive research, it is likely that my findings may not be generalisable to particular settings. For instance, as the research is based on the Australian context, other countries may observe different patterns of the emergence process, especially for developing countries, where the state power matters more than other institutions. Nevertheless, I believe the core message this research pitches still applicable to any context. The underlying story of this study is that non-market intermediaries are endogenous actors, and we should take into account their emergence paths for better understanding their roles as innovation catalysts. Additionally, as the findings were derived from examining the heterogeneous types of intermediaries (e.g., private-initiated, government-initiated and hybrid initiated), the findings are still useful and applicable for understanding a different form of intermediary organisation.

Second, this study mainly addresses theory building rather than theory testing. Therefore, it does not provide statistical evidence for the relationship between the effects of intermediaries and firm innovation. However, there are two key reasons why this paper is limited in this manner. First, it was practically impossible to measure the innovation outcomes my focal intermediaries supported. Since these three intermediaries were relatively new organisations, most of their support projects had not produced outputs during my research period, which made it difficult to measure and test the aforementioned relationship. Second, even if I could have measured the innovation outputs, regression models for this study would have encountered empirical challenges due to potential bias issues. For example, the intermediaries may have preferred to give their support to innovative firms -- that is, they could have intentionally selected innovative firms that would generate innovation anyway. Therefore, caution should be applied to estimating the effect. Conversely, if it is possible to estimate the relationship statistically, this would be an interesting way to test the propositions of this research. Future study to undertake this, while proceeding with caution, is encouraged.

Third, to continue investigating the intermediaries' roles as innovation catalysts, future study should focus on the effects intermediaries have on firms' innovation process. This would be important research that could further clarify intermediaries' roles in the innovation system. While this research identifies the different paths three intermediaries took to support innovation outcomes, it does not examine the innovation process stimulated by these intermediaries. Collecting additional data on firms' innovation process, innovation support programs and intermediaries' intentions could identify the intermediaries' roles in the innovation process. For instance, this could help determine whether each intermediary facilitates the process of 'imitating' or 'inventing' firm innovation (Liao, 2020). Also, by

linking the insights gained from the roles with an industry's evolution, future research could also identify how intermediaries collectively improve the innovation system as a whole.

Finally, another interesting angle would involve incorporating intermediaries' governance. McDermott et al. (2009) found that intermediaries with rules stipulating inclusion and participatory governance were particularly helpful in providing useful resources for firm innovation. Adopting this perspective could generate fruitful research about how and why different types of intermediary governance could stimulate innovation.

Chapter 3 GOVERNMENT FINANCIAL SUPPORT AND FIRM INNOVATION

INTRODUCTION

Governments worldwide use financial support—such as grants, subsidies and tax incentives—to accelerate the pace and direction of innovation (David, Hall, & Toole 2000; Fleming, Greene, Li, Marx, & Yao, 2019). However, how much does government financial support really catalyse firm innovation? Prior studies have examined the causal relationships between government financial support and firm innovation. Nevertheless, whether public incentives help firm innovation is far from clear due to contradictory results in the research. For example, while some scholars have argued the positive effects of public aids (e.g., Almus & Czarnitzki, 2003; Hussinger, 2008), others have found the negative effects (e.g., Wallsten, 2000) or no impact at all (e.g., González & Pazó, 2008). Such inconsistent results are partly due to identification challenges in the empirical studies (Bronzini & Iachini, 2014; Guo, Guo, & Jiang, 2016; Hussinger, 2008).

I argue, in this research, that potential bias sources are one of the main sources that lead to the mixed evidence in the literature. First, endogeneity issues in government's selection process can mislead the interpretation of the effects of public support, because government agencies may grant financial support to firms that are already innovative or firms may receive public support based on unobserved variables, such as the social capital of a firm's CEO. Second, sample selection issues can also occur, because innovations usually entail firms' decision-making process; therefore, only the innovative outcomes of firms that have decided to be innovative can be observed, while innovations by firms that have not engaged in innovative activities cannot. Prior studies have addressed endogeneity issues using various econometric approaches (e.g., Almus & Czarnitzki, 2003; Bronzini & Iachini,

2014; González & Pazó, 2008; Guo, Guo & Jiang, 2016; Hussinger, 2008; Wallsten, 2000; Zhao & Ziedonis, 2020), however, they have dismissed that sample selection issues could also disturb the estimation process. This is a critical gap in the literature, especially considering the identification issues have been a major focus of the empirical literature. Hence, in this study, I aim to provide new evidence obtained by controlling for both endogeneity and selection issues, reducing the tension on the effectiveness of government financial support.

I employed the econometric approach suggested by Semykina and Wooldridge (2010) for this study, which is especially useful as it allows me to address endogeneity and selection biases simultaneously and to 'fully exploit the panel dimension' of data (Secchi, Tamagni, & Tomasi, 2016a: 814). I used the Business Longitudinal Database (BLD) from the Australian Bureau of Statistics (ABS) and selected data from 2011/12 to 2015/16. Australia presents an ideal case study for this topic, as Australian government has invested significantly in helping small and medium enterprises (SMEs) innovate. The main results suggested that, after controlling for endogeneity and selection biases along with unobserved firm heterogeneity, government financial support could increase firm innovation. Multiple robustness tests supported this result. In addition, the investigation of the extent to which firms can benefit showed that government financial incentives are particularly beneficial for financially vulnerable firms, which implies that the support programs played a role in lowering market frictions that financially constrained firms may have experienced.

This study contributes to the literature on government financial support. First, this study provides reliable evidence on the long-debated issue of the effectiveness of public financial incentives. As the empirical evidence is based on consistent estimates obtained

when controlling for potential bias sources, this study can resolve the debate over the innovation policy by improving the understanding of fiscal support. Second, this study demonstrates a robust method for identifying the causal effects of fiscal support on firm innovation in the presence of endogeneity and selection biases and unobserved firm heterogeneity. Although prior studies have addressed identification concerns, most have focused on accounting for endogeneity issues only. In contrast, using an econometric approach suggested by Semykina and Wooldridge (2010), this study addresses not just endogeneity issues, but also sample selection and unobserved firm heterogeneity issues. Hence, it improves existing approaches to dealing with the empirical challenges associated with assessing fiscal support. Third, this study provides strong empirical evidence on the heterogeneous effect of government financial aids by showing that financially vulnerable firms can benefit significantly from the support programs. This evidence lends weight to the argument that government financial aid serves a friction-reducing role in inefficient capital markets. Accordingly, this study contributes to clarifying a particular role of public financial support. In addition, this study is one of the first to examine the effects of Australian government financial support. Thus, it provides useful insights on how such support programs have facilitated greater innovation by SMEs in Australia in recent years.

LITERATURE REVIEW

Scholars have questioned whether government financial aids are effective in boosting firm innovation. However, because of inconsistent empirical evidence, a clear answer to this question has not been possible to date. For example, both Lerner (1999) and Wallsten (2000) examined the effects of the Small Business Innovation Research program in the United States on the employment growth of firms and produced conflicting results. Lerner (1999) found

that the grant program helped recipient firms grow their employment, while Wallsten (2000) found that the program did not achieve this.

Further, many scholars have investigated the causal relationships between public R&D support and private R&D investment to determine whether the public funds stimulated or substituted private R&D investment. While some studies found that government R&D support stimulated firms' R&D activities (e.g. Almus & Czarnitzki, 2003; Hussinger, 2008), others found that government R&D support substituted firms' R&D investment (e.g. Wallsten, 2000). In addition, some scholars emphasised the insignificance or heterogeneity in the impacts of public R&D support. For instance, Lach (2002) and Bronzini and Iachini (2014) showed that the impact of public grants differed significantly by firm size, while González and Pazó (2008) showed that R&D subsidies rarely stimulated firms' R&D expenditure. Meanwhile, Görg and Strobl (2007) showed that small grants stimulated private R&D spending by firms but that large grants crowded out the private financing of R&D.

There are several studies on the causal relationships between fiscal support and innovation outcomes of firms. However, their results are still questionable because of inconsistency in the findings of each study. For instance, although Doh and Kim (2014) concluded that government financial assistance helped firm innovation, their findings also showed that government financial support had not been effective in helping some parts of innovation. Similarly, Guan and Yam (2015) showed inconclusive results on the positive effects of government financial support on firm innovation, which further confuses the question: does government financial support help firm innovation?

At the same time, scholars recognise that the mixed results in empirical research are partly due to identification challenges, citing endogeneity issues as a major source of bias.

They addressed the challenge by employing various econometric approaches. Matching methods were the most frequently used technique (e.g., Almus & Czarnitzki, 2003; González & Pazó, 2008; Guo et al., 2016; Lerner, 1999) because this approach allowed scholars to compare the outcomes of recipient firms with those of non-recipient firms with similar firm characteristics to identify the impacts of public aids. However, despite the extensive usage, the matching approach has limitations because non-recipient firms may differ from recipient firms in other unobserved ways, which violates the matching assumption that 'the only difference between the treated and the control group on observables is grant receipt' (Görg & Strobl, 2007: 220-221).

Difference-in-differences (DID) was also used to address endogeneity issues occurring in the government's selection process (e.g., Lach, 2002). This method accounts for firm-specific and time-specific effects. However, it was often criticised for relying on the assumption that both recipient and non-recipient firms react identically to common external shocks (Görg & Strobl, 2007: 220-221) and 'it does not guarantee that, in terms of observables, similar plants are being compared, since OLS estimation implicitly assumes a linear effect across any range of values of a covariate'. In addition, Görg and Strobl (2007: 221) pointed out that the DID approach still fails to account for 'unobserved temporary individual specific components which impact on the participation decision'. As a result, to improve the accuracy of an evaluation study, following Blundell and Costa Dias's (2000) suggestion, Görg and Strobl (2007) employed a combination of a matching and DID analysis. With the similar reasons, instrument variable methods were implemented (e.g., Guo et al., 2016; Wallsten, 2000).

More recently, a regression discontinuity design has been employed in economics papers, such as Bronzini and Iachini (2014), Howell (2017), and Zhao and Ziedonis (2020), to resolve the bias issue in the government's selection process. This method allows scholars to exploit the randomness around the award cut-off as an alternative to experiments.

However, despite their efforts, the main focus of prior studies has been on the problems that can occur in the government's selection process. Such efforts address identification issues partially because the analysis may also suffer from another source of bias -- sample selection issues. González and Pazó (2008: 372), in their study on government financial aids, also noted this bias source, stating that 'most papers (evaluation papers on government financial support) use samples that include only innovating firms'. Further, the unobserved process of a firm's decision to be innovative also contributes to creating the selection issues in the estimation process (I discuss this in further detail later in this paper). Accordingly, neglecting sample selection issues, but accounting for endogeneity issues, for the estimation does not fully resolve potential bias sources. Both endogeneity and sample selection should be controlled for to produce more robust estimates.

I first discuss the theoretical framework used in the literature to understand the mechanisms through which government financial aids exert their influence on innovation.

Theoretical Framework

Government financial support, such as grants, subsidies, and tax concessions, are a widely adopted as policy measures to boost innovation. The rationale for this, from an economic point of view, is that public support to business R&D is desirable to 'fix' market failures related to generating the public-good character of knowledge (Arrow, 1962; David et al., 2000; Hussinger, 2008; Nelson, 1959). Because knowledge is non-exclusive and non-rival, it

can produce positive external effects (Hussinger, 2008). However, because the inventor firms can not entirely internalise its knowledge, firms' R&D investment is likely to be below the socially optimal level. Public support to business R&D may, therefore, propel firms' R&D activity 'closer to the social optimum' (Görg & Strobl, 2008: 215).

Nevertheless, there are conflicting arguments about the effects of government financial support on firm innovation that can more or less be divided into two main groups. One group argues that government financial support can be effective. Due to R&D activities being costly and uncertain in outcomes, firms often hesitate to invest in them. They may also discontinue R&D activities before they have produced any innovation outcomes. In these cases, government financial support could play a significant part by lowering funding costs and enabling these firms to proceed with their R&D activities.

In particular, public incentives can be beneficial for those firms facing difficulties in financing their projects. First and foremost, government funding can resolve problems caused by strong information asymmetries between firms and other external financial intermediaries (Bronzini & Iachini, 2014). Innovation projects are usually riskier and more difficult for nonexperts to understand than are other investment projects. Firms may also be unwilling to share information with external parties, such as financial intermediaries, because of potential knowledge leakages. Financial intermediaries may also prefer to fund tangible assets, which they can use as collateral, over intangible assets that are exclusively associated with future profits. In these circumstances, where firms' innovation projects are rejected from being privately funded, government financial support can be especially helpful. Furthermore, government financial support can serve as an information signal to other investors, narrowing the information gap through the 'certification' of the project or firm (Feldman & Kelley,

2003; Lanahan & Armanios, 2018; Lerner 1999). Receiving government financial support can alleviate doubts over credibility for those firms which face financial constraints, and, in turn, can attract private investment from financial institutions (Meuleman & De Maeseneire, 2012).

Conversely, the other group argues that government financial support does not play a significant role in helping firm innovation. Since government agencies face strong pressure to not waste public funds, they may tend to fund firm projects 'with higher success probabilities and with clearly identifiable results, i.e., projects that are likely to have high private rates of return' (Lach, 2002: 371). These are the projects that would relatively easily secure external financing. Hence, those firms will simply replace their R&D investment with public subsidies to take advantage of the low cost of public funding, which results in government financial support being ineffective. Further, even if government agencies are capable of selecting firms which would be profitable if supported with financial incentives, they may not have all the information to identify which innovation projects could activate private R&D investment marginally or inframarginally (Bronzini & Iachini, 2014: 103). Hence, the subsidies are also likely to be given to inframarginal projects, 'thereby reducing the effectiveness of the subsidies'. These circumstances go against the governmental intention to address market failures by boosting innovation and private R&D activities.

In addition, government financial support might affect the price of inelastically supplied R&D inputs, for example, it may raise the costs of scarce resources such as trained researchers in tight local labour markets (David et al., 2000; Lach, 2002). Because of expensive costs of hiring additional R&D personnel, firms may discontinue an existing profitable project and undertake the subsidised project instead. In this situation too, it is

difficult to see any role played by government where their financial support is helping firm innovation.

Given the plausibility of arguments of both groups, some scholars suggest the effectiveness of government funding on innovation 'is to a large extent an empirical question' (Bronzini & Iachini, 2014: 104). I embrace this line of argument and propose as the baseline hypotheses that:

Hypothesis 1a. Government financial support increases firm innovation.

Hypothesis 1b. Government financial support does not increase firm innovation.

EMPIRICAL MODEL AND ESTIMATION STRATEGY

To start with, I discuss the flaws of using a baseline econometric model for the estimation caused by endogeneity and sample selection issues. I then demonstrate my estimation strategy to deal with these issues.

Equation (1) forms the baseline model for this topic. This is in a fixed effects specification:

$$InnoScale_{i,t} = \gamma GovtAssi_{i,t-1} + \beta Z_{i,t-1} + FE_i + \varepsilon_{i,t-1} \quad (1)$$

where $InnoScale_{i,t}$ is the sum of the number of innovations that firm *i* generated in year t; $GovtAssi_{i,t-1}$ is a dummy variable that captures whether firm *i* received government financial support in year t-1; $Z_{i,t-1}$ is a set of firm-level controls in year t-1; FE_i is a fixed effect term that captures time-invariant, firm-specific unobserved characteristics; and $\varepsilon_{i,t-1}$ is a standard error term. Explanatory variables are all lagged to avoid potential simultaneity. The parameter of the main interest is γ: the effect of government financial support.

This model is likely to produce misleading estimates because of potential bias issues, namely, endogeneity and sample selection. First, endogeneity issues may occur in the model, because the variable $GovtAssi_{i,t-1}$ is correlated with the error term $\varepsilon_{i,t-1}$. Since government financial support is not randomly granted to recipient firms, recipient firms may attract government financial support as a result of unobserved capabilities, such as political influence or the social capital of CEOs. It is also likely that government bureaucrats will have preferred firms that may generate innovation without government support. As such, important firm characteristics that can motivate firms to receive public support are likely to be unobserved, causing some sort of omitted variable bias arising from unobserved and uncontrolled differences in receiving government financial aid between the two groups being compared (Angrist, 2009).

Second, Equation (1) may also reflect sample selection bias because innovation data come from a self-select sample. First, as innovation data are available only for firms that have actually conducted innovations, we only observe innovation outcomes of these firms and not of those that have not either conducted or initiated innovations. This type of data is detrimental in investigating causal relationships, because the data are non-random (Certo et al., 2016). Wooldridge (2010) also pointed out that analyses based on a truncated sample are not generalisable to the population. Second, a firm's decision-making process enables us to observe its innovation outcomes only when it decides to do so. Accordingly, the dependent variable $InnoScale_{i,t}$ is observed only when the innovation dummy variable $Inno_{i,t}$ equals 1[16].

[16] Additionally, Certo et al. (2016) and Sartori (2003) emphasised that the potentially biasing factor of sample selection is that this kind of non-random sample does not only include firms that have

Because of the bias sources of endogeneity and selection, the fixed-effects specification of Equation (1), therefore, is inadequate to estimate the effects of government financial support on firm innovation. In this context, an econometric approach suggested by Semykina and Wooldridge (2010) can be a suitable alternative, because this method is particularly efficient for detecting 'the possible existence of a selection bias in panel data models in the presence of unobserved heterogeneity and endogenous regressors' (Colombo, Giannangeli & Grilli, 2013: 1300). To employ Semykina and Wooldridge's (2010) approach, I closely follow Secchi et al.'s (2016a) implementation strategy, because their estimation procedure explicitly models the selection process via a two-equation, Heckman-type framework. The following are my empirical models:

$$InnoScale_{i,t} = \gamma_1 GovtAssi_{i,t-1} + \beta Z_{i,t-1} + FE_{1i} + \varepsilon_{1i,t-1} \quad (2)$$

$$S_{i,t} = 1\left[\gamma_2 IV_{i,t-1}^{GovtAssi} + \delta_1 W_{i,t-1} + FE_{2i} + \varepsilon_{2i,t-1} > 0\right] \quad (3)$$

Equation (2) is the main estimation equation, equivalent to Equation (1). Thus, the focus of this strategy is to estimate coefficient γ_1, which captures the effects of government financial support.

Equation (3) is a probit selection model. Here, $S_{i,t}$ is a binary indicator of a firm's innovation activities (1 if a firm conducted an innovation activity in year t; 0 if otherwise). In

---

extensive innovation ex- periences, but also those with little innovation experience that have chosen to conduct innovative activities (i.e., choice to enter the innovation sample) because of 'unobserved post-innovation integration capabilities' that they have acquired after completing an innovative activity. Hence, those firms with less experience are likely to con- duct an innovative activity – thus, enter the sample – and to have higher unobserved post-innovation integration capabilities, which offset their lack of experience. Certo et al. (2016) and Sartori (2003) noted that this omitted variable may lead to bias, because it influences (1) the probability of an entering sample and (2) the dependent variable of interest.

the indicator function 1[•] on the right side, $IV_{i,t-1}^{GovtAssi}$ is the instrumental variable for $GovtAssi_{i,t-1}$, $W_{i,t-1}$ includes a set of firm-level controls (i.e., $Z_{i,t-1}$) and an exogenous variable, FE_{2i} is un observed firm fixed-effect term and $\varepsilon_{2i,t-1}$ is a usual error term in this selection model. As in Secchi et al. (2016a), following Procedure 19.2 in Wooldridge (2010), the instrument $IV_{i,t-1}^{GovtAssi}$ was generated as the fitted probability from a probit regression with $GovtAssi_{i,t-1}$, as the dependent variable and taking regressors as instruments capturing exogenous variation in government financial assistance together with the firm-level controls Z_i and their time averages. This procedure sought to address the potentially endogenous variable of $GovtAssi_{i,t-1}$. Further, an exogenous variable in $W_{i,t-1}$ was an exclusion restriction variable, predicting whether an observation would appear in an innovation sample (Angrist, 2001; Certo et al., 2016). This variable must capture factors that influence a firm's decision to engage in innovative activity, but do not directly affect that firm's innovation outcomes. This variable in $W_{i,t-1}$ was incorporated to compute the inverse Mills ratio (IMR), controlling for selection bias in Equation (2) (Secchi et al., 2016a; refer to Heckman, 1979).

The controls of time averages of all the explanatory variables in the main equation (Equation 2) and in the selection equation (Equation 3) were to control for the unobserved heterogeneity of firms. Semykina and Wooldridge (2010) suggested this method for addressing time-invariant and unobserved heterogeneity (i.e., fixed effects) in panel data in the presence of endogeneity and selection bias. This method is much more effective, as 'adding the inverse Mills ratio and using a simple fixed-effects estimator do not produce consistent estimates in the presence of firm-specific unobserved effects' (Komera, Lukose, &

Sasidharan, 2018: 900; Secchi et al., 2016a). Hence, using the revised models, we expected the estimate of γ_1 to be consistent and less exposed to sources of bias.

DATA AND VARIABLES

Data

In this study, I used the BLD from ABS. The BLD is developed by collecting data from the ABS Business Characteristics Survey (BCS) as well as administrative data provided to the ABS by other government agencies. The BCS is an annual ABS survey used to collect the characteristics of SMEs in Australia. Most of the items in the BCS are categorical in nature and cover a range of topics such as innovation practices, market share and competition, business focus, skills utilized within the business, and government financial support. Hence, the BLD allows for the direct measurement of the variables of interest to this research. For the main analysis, we used complete sets of data from five reference periods within the time period 2011/12 to 2015/16. The sample of 1,967 firms was stratified by industry and business size as of 30 June 2012. The selected firms were required to answer the survey annually over five consecutive years, and there were no new participants added during the survey period.

Data Reliability

Since the BLD is a survey-based data, there may be concerns about data reliability as firms might have answered the survey incorrectly or in the interest of the research. Yet, it is unlikely for three main reasons. First, the BLD survey is not a survey to understand the effects of government financial support, but rather a survey to understand the longitudinal firm characteristics of Australian SMEs. Accordingly, survey participants are not likely to have answered questions with knowledge of the research question I pose. Second, the

selected sample of firms 'have a legal obligation to respond and provide accurate information' (Dekker & Hasso, 2016: 298); hence, firms are likely to answer the questionnaire honestly. Third, as the ABS anonymizes data to protect the private or sensitive information of firms, it is likely that firms will answer the survey correctly. Dekker and Hasso (2016: 298) also used the BLD and confirmed data reliability, noting that 'the data representativeness and reliability make it a unique data set that has the potential to inform scholars on a wide range of issues'. In addition, as policy evaluation papers (e.g., Palangkaraya, Stierwald, Webster & Jensen, 2010; Thomson & Skali, 2016) often used the BLD, the data is also considered suitable for this type of research topic.

Variables

Firm Innovation $InnoScale$ is the main dependent variable that measures the level of innovation of a firm in a given year. To construct the variable, I utilized the following items from the BLD: 'whether the firm had introduced any new or significantly improved goods or services, whether the firm had introduced any new or significantly improved operational processes, whether the firm had introduced any new or significantly improved organisational/managerial processes, and whether the firm had introduced any new or significantly improved marketing methods', taking 1 if a firm answered 'Yes' to each item, 0 if otherwise. $InnoScale$ is the sum of these items, capturing the number of innovations a firm produced in a given year. I considered both technological innovation (i.e., product and process) and managerial innovation (i.e., organisational and marketing) for measuring $InnoScale$, because Australian government support assists both types of innovation. Hence, it is plausible to capture both innovations for the dependent variable.

Government Financial Assistance $GovtAssi$ is a dummy variable that takes the value 1 if a firm received government financial assistance in a given year, and 0 if otherwise. I utilized information from the BLD about if a firm received any financial support from the Australian Government (e.g., grants, subsidies, tax concessions, rebates, other government support).

Control Variables I controlled for a number of variables Z_i, following previous studies on the effects of government financial support on firm innovation (e.g., Doh & Kim, 2014; Guan & Yam, 2015; Guo et al., 2016; González & Pazó, 2008). First, I controlled for firm size (size) by measuring the natural logarithm of the annual sales of the firm in a given year since larger firms may have more resources for innovation and be more attractive to governments in providing financial support. Second, similarly, I controlled for firm age (age), as older firms may have more experience in conducting innovation activities and in receiving fiscal support. I used the information about a firm's operation years to measure firm age[17]. Third, a firm's R&D skills (R&D skills) is controlled to account for R&D capabilities of the firm. R&D skills takes the vale 1 if the firm has skills used in scientific and research and 0 if otherwise.

Fourth, two indicators of firm internationalization, export sales and the presence of foreign capital, were also controlled for, as 'they can influence the decisions of the granting agencies due to politico-economical reasons'(González & Pazó, 2008: 379). In fact, included in the eligibility criteria for the Australian government grant schemes is that firms engage in export activities and being domestic. Firm export (exports) is measured by the natural

[17] Since the BLD offers a firm's operation years at the beginning of the survey year, I created firm age in the following years by adding one.

logarithm of the annual export sales of the firm in a given year. Foreign ownership takes the value 1 if the firm indicated that they had some degree of foreign ownership, and 0 if otherwise. Fifth, firm openness (openness) is controlled because it is highly correlated with innovation activities. Previous studies have shown that the more open a firm is, the more innovation it generates or pursues (e.g., Ahuja, 2000; Monteiro, Mol & Birkinshaw, 2017; Powell, Koput, & Smith-Doerr, 1996; Shan, Walker & Kogut, 1994). Further, as openness facilitates a firm's search for external resources, firms with greater openness may be more likely to research how to obtain government support, and hence obtain government financial support more easily. We created a dummy variable to measure openness. The variable takes the value 1 if the firm indicated that they had engaged in some type of collaborative arrangement (e.g., joint R&D, joint buying, joint production of goods or services, integrated supply chains, joint marketing and/or distribution, other collaborative arrangements, and/or business collaboration for innovation) and 0 if otherwise.

Variables for Instrument and Exclusion Restriction The econometric strategy requires a set of variables to address inherent endogeneity and selection issues. First, I had to obtain the instrument variable $IV_{i,t-1}^{GovtAssi}$ for $GovtAssi_{i,t-1}$ in Equation (2). To do so, exogeneous variables were required for a probit regression with $GovtAssi_{i,t-1}$ as the dependent variable. These variables should strongly influence the likelihood of receiving government aids, thereby the instrument variable $IV_{i,t-1}^{GovtAssi}$ can be well predicted from the probit model. I chose two variables for this. The first was a dummy variable of $GovtAssi_{i,t-2}$, taking 1 if the firm had received government financial support in the previous year, and 0 if otherwise. This could strongly influence the likelihood of receiving government aids, improving the model predictability, because it can capture long-term public support,

such as grants that extend throughout several periods and the renewal of previous grants (González & Pazó, 2008). The second variable was the financial constraints experienced by an industry in a given year. I constructed this variable by aggregating information about whether firms had sought debt or equity finance by industry and year. If a significant number of firms in an industry had sought debt or equity finance in a given year, this would indicate that greater financial constraints were experienced in that industry during that year. Consequently, those firms with greater financial constraints were likely to pursue fiscal support, suggesting a strong relationship between the financial constraints and the probability of receiving government financial aid.

Table 3.6 shows the statistical significance of both variables in the probit regression, which indicates that the generated values of $IV_{i,t-1}^{GovtAssi}$ are likely to be predicted well from the model. Following Secchi et al.'s (2016a: 821, 2016b) suggestion that the 'validation of instruments relies upon the goodness of fit of the first step Probit', I further validated the fitted values of the instrument $IV_{i,t-1}^{GovtAssi}$ using several assessments, such as a standard adjusted R^2, the Brier score and the AUC score. First, the high standard adjusted R^2 (0.545) indicates the probit model fit well and produced the higher predictability of receiving government support (i.e., $IV_{i,t-1}^{GovtAssi}$). Second, the low Brier score (0.059) suggests a high accuracy of the model prediction. Third, the high AUC score (0.948) indicates the powerful predictability of the model. Taken together, the assessments suggest that the fitted values were valid as an instrument, as they were obtained from the reliable prediction. More detailed description regarding the three assessments is included in the appendices.

Second, I needed another exogenous variable for exclusion restriction. This variable was incorporated in a probit selection model (i.e., Equation 3) to compute the IMR. As

stronger exclusion restrictions can influence the statistical power of independent variable of interest and the IMR (Certo et al., 2016), I took care in selecting an appropriate variable that would influence a firm's decision to engage in innovative activity, but would not directly influence that firm's innovation outcomes. Firm's interest in environmental measures in a given year -- 0 if the firm was not interested at all, 1 if the firm were interested to a small extent, 2 if the firm were interested to a moderate extent, and 3 if the firm were interested to a major extent – was selected for the exclusion restriction variable. First, this variable is justifiable theoretically. If firms are more interested in environmental issues, they are more likely to consider 'doing things differently' (McEvily & Zaheer, 1999; Porter & van der Linde, 1995). For instance, firms that are highly aware of environmental issues may seek new raw materials/components that are less polluting (De Marchi, 2012). Such firms may also start using renewable energy (e.g., solar, wind or tidal and wave). However, these decisions to change do not necessarily lead to the generation of innovation (e.g., new products, new processes or organisational management or new marketing strategies), but the decisions are certainly an innovative choice in that firms are attempting to operate in different ways.

Second, this variable is empirically strong enough to be exclusion restriction. Certo et al. (2016) and Bushway, Johnson and Slocum (2007) suggested that the low correlation between x and IMR indicates the strength of exclusion restriction strong. Further, they recommended scholars to review the pseudo-R2 values associated with the first stage to better understand exclusion restriction strength. Like other studies did (e.g., Mannucci & Yong, 2018, Roma, Petruzzelli & Perrone, 2017; Zhu & Shen, 2016), I have followed their suggestions and checked that (1) the correlation between $IV_{i,t-1}^{GovtAssi}$ and the IMR (i.e., lambda) was low (i.e., -0.322) and (2) the pseudo-R2 improved after the variable (firm's

interest in environmental measures) was included in the Heckman model. Altogether, firm's interest in environmental issues theoretically and empirically good enough to act as exclusion restriction.

Estimation Procedure

The estimation procedure was as follows:

1. Generate the instrument $IV_{i,t-1}^{GovtAssi}$ as the fitted probability from a probit regression of the binary indicator $GovtAssi$ against government financial support in the previous year and the financial constraints experienced in an industry in the given year, the controls in Z_i (i.e., firm-level characteristics such as size, age, R&D skills, exports, foreign ownership and openness), and their respective time averages;

2. Obtain the IMR $(\widehat{\lambda_{i,t}})$ from a probit estimate of Equation (3) augmented with the time averages of the generated instrument $IV_{i,t-1}^{GovtAssi}$ from Step 1 and the time averages of the controls in W_i (i.e., the firm-level controls Z_i plus the firm's interest in environmental measures);

3. Estimate via pooled 2SLS-IV Equation (2) augmented with the time averages of the generated instrument $IV_{i,t-1}^{GovtAssi}$, the time averages of the controls in Z_i and the IMR $(\widehat{\lambda_{i,t}})$ obtained in Step 2 together with its interactions with time dummies; use Z_i, $IV_{i,t-1}^{GovtAssi}$, all the time averages and $\lambda_{i,t}$ as instruments.

This estimation procedure enables a consistent estimate of the coefficient of the $GovtAssi$ dummy to be obtained. In particular, the estimator is robust to the misspecification of the probit model and it is more efficient than directly including the financial constraints

and government financial support in the previous year as instruments into a usual 2SLS-IV procedure, and it does not need to adjust the 2SLS-IV standard errors (Secchi et al., 2016a).

RESULTS

Descriptive Statistics

Table 3.1 reports descriptive statistics on firm characteristics for all firms (Panel A) and all innovative firms (Panel B). I divided the sample firm years into two subsamples: (1) government financial support recipients and (2) nonrecipients. In column 1, I confirmed the stylized facts that innovative firms are on average larger and more open, and that they invest in R&D skills more readily and more export than other firms. More importantly, columns 2 and 3 confirm the tangible differences between recipient and nonrecipient firms. First, recipient firms are on average larger and older than nonrecipient firms. Second, more recipient firms hire people with R&D skills than nonrecipient firms do. Third, recipient firms export more than nonrecipients do. Fourth, recipient firms have more foreign investment than nonrecipients do.

In sum, Table 3.1 shows that recipient firms are clearly distinguishable from nonrecipient firms. The descriptive statistics also confirm the methodological assumption that recipient firms and nonrecipient firms may differ from each other. Thus, it increases confidence that my estimation strategy fits the research. Table 3.2 reports the descriptive statistics on characteristics for all firm years and the correlation matrix.

Table 3.1. Firm Characteristics

Panel A-All firms

		Government financial support		
Firm characteristic		All firm years	Recipients	Nonrecipients
Size (AUD)	Mean	3,944,116	6,136,007	3,572,881
	Median	831,255	2,419,898	694863.5
Age	Mean	14.355	15.852	14.14
	Median	14	16	13
R&D skills	Mean	0.059	0.124	0.047
	Median	0	0	0
Exports (AUD)	Mean	219,384.20	569,454.90	160,093.70
	Median	0	0	0
Foreign ownership	Mean	0.055	0.073	0.052
	Median	0	0	0
Openness	Mean	0.743	0.979	0.713
	Median	1	1	1
Number of firms		9,835	1,118	8,717

Panel B-Innovative firms

		Government financial support		
Firm characteristic		All firm years	Recipients	Nonrecipients
Size (AUD)	Mean	5,464,592	7,398,641	4,974,585
	Median	1,618,284	3,466,898	1,347,854
Age	Mean	14.248	15.883	13.835
	Median	14	16	13
R&D skills	Mean	0.077	0.133	0.063
	Median	0	0	0
Exports (AUD)	Mean	415,126.60	826,009.60	311,026
	Median	0	0	0
Foreign ownership	Mean	0.067	0.075	0.065
	Median	0	0	0
Openness	Mean	0.98	0.983	0.98
	Median	1	1	1
Number of firms		3,410	686	2,724

Table 3.2. Descriptive Statistics and Correlation Matrix

	Variable	Mean	Std.Dev.	1	2	3	4	5	6	7	8
1	InnoScale	0.699	1.141	1							
2	GovtAssi	0.114	0.317	0.155	1						
3	lnSize	13.694	1.865	0.287	0.185	1					
4	Age	14.355	7.471	-0.038	0.069	0.19	1				
5	R&D skills	0.059	0.235	0.076	0.112	0.003	0.007	1			
6	lnExports	5.372	2.369	0.147	0.082	0.278	0.066	0.143	1		
7	Foreign ownership	0.055	0.227	0.066	0.035	0.126	-0.046	0.121	0.277	1	
8	Openness	0.743	0.437	0.035	0.003	0.04	0.037	-0.002	-0.02	-0.005	1

Note: Firm's Size and exports are measured in natural logarithm.

Main Estimates

Table 3.3. Main Results of Government Financial Support and Firm Innovation

	InnoScale POLS (1)	InnoScale FE (2)	InnoScale Main (3)
$GovtAssi_{i,t-1}$	0.295***	-0.013	0.897**
	(0.046)	(0.055)	(0.411)
$lnSize_{i,t-1}$	0.176***	0.041	-0.028
	(0.010)	(0.033)	(0.039)
Age	-0.013***	-0.034***	0.309**
	(0.002)	(0.012)	(0.133)
$R\&Dskills_{i,t-1}$	0.246***	0.073	0.009
	(0.072)	(0.085)	(0.097)
$lnExports_{i,t-1}$	0.030***	-0.020	-0.014
	(0.008)	(0.017)	(0.019)
$Foreign_{i,t-1}$	0.073	0.072	0.127
	(0.078)	(0.178)	(0.204)
$Openness_{i,t-1}$	0.257**	0.193*	0.314***
	(0.119)	(0.112)	(0.099)
$\hat{\lambda}_{i,t}$			-1.030***
			(0.198)
Constant	-2.053***	0.795	0.505
	(0.185)	(0.499)	(0.689)
Industry fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
Firm fixed effect	No	Yes	Yes
R-squared	0.115	0.004	0.135
Number of observations	5,036	5,036	5,036

Note: Model (1) is POLS and Model (2) is the fixed effect estimates. Model (3) is the main result from the estimation procedure. Robust standard errors are in parentheses.***p < 1%, **p < 5%, *p < 10%

Table 3.3 reports the results from three models: Model 1 from pooled OLS (POLS), Model 2 from fixed effects estimates (FE), and Model 3 from the main estimates. First, POLS identifies the effect of government financial support by comparing recipients and nonrecipients, while the fixed effects model addresses within-firm variation without controlling for selection and endogeneity. However, the coefficients of government financial

support differ substantially, in that while the coefficient is significantly positive in the POLS (Model 1), the coefficient is insignificantly negative in the fixed effects estimates (Model 2). The absolute value is significantly smaller in Model 2 than in Model 1. This indicates that unobserved variables have a strong impact when identifying the effect of government financial support.

Model 3 is the main result generated from the estimation procedure above. It shows that government financial support can positively affect firm innovation, supporting Hypothesis 1a. The result was generated after controlling for the unobserved heterogeneity of firms together with selection and endogeneity issues. Thus, the estimates of Model 3 are more reliable than those of Models 1 and 2. In addition, the significant sign of lambda ($\widehat{\lambda_{i,t}}$) implies the presence of a strong selection issue in the model. This shows that it is critical to address selection issue in this sort of research design. Furthermore, the effect of government financial support is significantly stronger than what I could infer from the simple fixed effects estimates in Model 2. This suggests that the endogenous component of government financial support is associated with an underestimation of the enabling effect of government financial support on firm innovation (Secchi et al., 2016a). Additionally, the improved value of R-squared in Model 3 suggests that Model 3 explains the data better than Models 1 and 2. In terms of controls in the main estimation, firm openness and firm age have significantly positive effects on firm innovation, while other controls, such as size, R&D skills, exports, and foreign ownership, have insignificant effects on firm innovation.

Robustness Tests

This study also explored the robustness of the positive effect of government financial support on firm innovation. First, I conducted subgroup tests to check the robustness of the main

results. The idea is that if the main results are correct, I should be able to consistently see the significant sign of lambda ($\lambda_{i,t}$) under different conditions. Additionally, if the main results are correct, I should be able to see the positive effect of fiscal support; even I should see their stronger effect under financial constrained conditions for firms. I subgrouped the sample firms according to 'changes in profitability' and 'lack of access to additional funds for innovation activities'. The results are all obtained from the estimation procedure.

Table 3.4 reports the subgroup tests. Regardless of the different circumstances presented within the models, the table shows that lambda ($\lambda_{i,t}$) is always significant. This once again confirms the presence of selection issues in the models. Also, the models show the positive effect of public financial support. However, there are different patterns in the effect of government financial support. Models 1-3 represent the results of the subsamples based on information about changes in firm profitability. Model 1 tested for a subsample of firms in which profitability decreased from the previous year, Model 2 tested for a subsample of firms with unchanged profitability from the previous year, and Model 3 tested for a subsample of firms in which profitability increased from the previous year. As seen in the table, while the effect of government financial support is possibly positive in these subgroup tests, government financial support can be of greater help to those firms in which profitability decreased from the previous year (Model 1). Models 4-5 represent the results of the subsamples based on information about insufficient funding for innovation activities. Model 4 tested a subsample of firms which did not experience a lack of financial funding for innovation activities. Model 5 tested a subsample of firms which did experience a lack of financial funding for innovation activities. These results also show that the government financial support can positively affect firm innovation, yet their effect is only significant for

those firms that experienced insufficient funding for their innovation activities. In sum, the subgroup tests confirm the presence of selection issues and the positive effect of government financial support, while also implying that the effect can be more significant for those in vulnerable circumstances for innovation activities.

Second, I checked robustness with respect to possible outliers. I ran the estimation after removing the top 1% of the observations in sales, age, and exports. I considered these variables as they were continuous variables. Model 1 of Table 3.5 reports the results. Results are basically identical to the main estimates, where, after controlling for unobserved firm heterogeneity together with endogeneity and selection issues, the effect of government financial support can be significantly positive on firm innovation. The outliers did not affect the main results.

Table 3.4. Robustness Tests – Subsamples

Variable	(1) compprof=1	(2) compprof=2	(3) compprof=3	(4) hampgfun=0	(5) hampgfun=1
$GovtAssi_{i,t-1}$	0.827*	0.678	0.723	0.540	1.573*
	(0.458)	(1.244)	(1.233)	(0.442)	(0.944)
$lnSize_{i,t-1}$	-0.086	0.148*	0.006	0.002	-0.133
	(0.087)	(0.078)	(0.097)	(0.041)	(0.093)
Age	0.493**	0.075	0.270	0.223	0.956**
	(0.231)	(0.262)	(0.366)	(0.142)	(0.431)
$R\&Dskills_{i,t-1}$	-0.201	0.216	0.245	0.061	-0.240
	(0.184)	(0.199)	(0.194)	(0.111)	(0.225)
$lnExports_{i,t-1}$	-0.012	-0.046	0.039	-0.016	0.008
	(0.033)	(0.045)	(0.043)	(0.020)	(0.052)
$Foreign_{i,t-1}$	-0.260	-0.500	0.901**	0.200	-0.259
	(0.312)	(0.453)	(0.446)	(0.217)	(0.505)
$Openness_{i,t-1}$	0.168	0.337**	0.637**	0.391***	0.227
	(0.150)	(0.166)	(0.269)	(0.100)	(0.232)
$\hat{\lambda}_{i,t}$	-0.768**	-1.117***	-1.571***	-1.004***	-1.006**
	(0.312)	(0.364)	(0.477)	(0.218)	(0.438)
Constant	-0.118	1.130	1.743	0.558	-0.710
	(1.079)	(1.121)	(1.612)	(0.733)	(1.631)
Industry fixed effect	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes	Yes
R-squared	0.143	0.141	0.142	0.155	0.104
Number of observations	1,901	1,461	1,339	4,031	973

Note: The dependent variable is the number of the innovations that a firm produced in a year. Model 1 to 3 are tested in sub-samples that are grouped by the changes in firm's profitability, Model 4 to 5 are tested in sub-samples that are grouped by whether or not a firm experienced lack of financial funding for innovation. Robust standard errors are in parentheses.***$p < 1\%$, **$p < 5\%$, *$p < 10\%$

Table 3.5. Robustness Tests - Outliers & Innovation Type

	InnoScale Outliers	Innovation type	
		Product/Process	Org Management/Marketing
	(1)	(2)	(3)
$GovtAssi_{i,t-1}$	0.785**	0.455*	0.400*
	(0.379)	(0.235)	(0.242)
$lnSize_{i,t-1}$	-0.000	-0.024	-0.019
	(0.039)	(0.022)	(0.021)
Age	0.112	0.197**	0.173**
	(0.070)	(0.098)	(0.084)
$R\&Dskills_{i,t-1}$	-0.006	-0.040	0.022
	(0.096)	(0.063)	(0.054)
$lnExports_{i,t-1}$	-0.012	0.000	-0.014
	(0.019)	(0.012)	(0.011)
$Foreign_{i,t-1}$	0.142	0.027	0.063
	(0.202)	(0.118)	(0.128)
$Openness_{i,t-1}$	0.280***	0.082	0.144**
	(0.103)	(0.060)	(0.057)
$\hat{\lambda}_{i,t}$	-1.137***	-0.619***	-0.593***
	(0.195)	(0.088)	(0.110)
Constant	1.191**	0.840**	0.573
	(0.578)	(0.364)	(0.397)
Industry fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
Firm fixed effect	No	Yes	Yes
R-squared	0.141	0.117	0.118
Number of observations	5,036	5,036	5,036

Note: Model (1) is the estimation after removing top 1% of sales, age and exports. Model (2) and (3) is the tests on different innovation types. Model (2) tests products and processes innovation and Model (3) tests organizational management and marketing innovation. Robust standard errors are in parentheses.***p < 1%, **p < 5%, *p < 10%

Lastly, I checked if the main results would change depending on innovation type. I ran the estimation separately for technological innovation (i.e., product and process innovation) and for managerial innovation (i.e., organizational management and marketing innovation). In Table 3.5, Model 2 reports the estimation results of product and process

innovation, and Model 3 reports the estimation results of organizational management and marketing innovation. Regardless of the innovation type, the main results were the same. While selection issues are present in both models, the effect of government financial support remains significantly positive.

Table 3.6. First Step – Probit Estimates of Government Financial Support

Variable	(1) $GovtAssi_{i,t-1}$
Financial constraints in an industry in the given year	0.017**
	(0.008)
Government financial support in the previous year	-0.505***
	(0.079)
$lnSize_{i,t-1}$	0.127***
	(0.048)
Age	-0.050
	(0.030)
$R\&Dskills_{i,t-1}$	0.624***
	(0.150)
$lnExports_{i,t-1}$	-0.029
	(0.029)
$Foreign_{i,t-1}$	0.289
	(0.337)
$Openness_{i,t-1}$	0.146
	(0.188)
Constant	-2.425***
	(0.314)
Year fixed effect	Yes
Firm fixed effect	Yes
Number of observations	7,012
Pseudo R^2	0.545
Brier score	0.059
AUC score	0.948

Note: The dependent variable is the dummy variable of government financial support. Standard errors are in parentheses. ***$p < 1\%$, **$p < 5\%$, *$p < 10\%$

DISCUSSION AND CONCLUSION

This study aimed to reduce tension in the literature on the effectiveness of government financial support by providing new empirical evidence. Employing the econometric approach suggested by Semykina and Wooldridge (2010) that explicitly addressed both bias sources of endogeneity and sample selection together with unobserved firm heterogeneity, my main results reveal that government financial support can increase levels of firm innovation. Multiple robustness tests confirm this argument. Additionally, this study confirmed the heterogeneity in the impacts of public R&D support on firm innovation.

This study makes three main contributions to the literature. First, this study fuels the discussion on the causal effects of government financial support on firm innovation with new empirical evidence. The discussion has been stagnant because of inconsistent empirical results in the literature. This study stimulates the discussion with new empirical results on the causal relationships between government financial support and firm innovation, which were obtained from a robust method of controlling for bias sources.

Second, this study is the first study that discusses and addresses both endogeneity and sample selection biases for the estimation of the effects of government support. While prior empirical studies addressed identification challenges, most have focused on endogeneity issues only. However, this study argues that sample selection is an equally important source of bias through an econometric approach, and the results derived from multiple robustness tests consistently support that selection issues are observed in the models. Additionally, this study can be a useful reference for empirical concerns in the literature. For instance, Doh and Kim (2014) and Guan and Yam (2015) only used a POLS, which is an inadequate approach for identifying the causal effects because such a method ignores potential bias sources, such

as endogeneity in the selection process and sample selection in the decision-making process. Their inconclusive results might have been obtained from their mis-specified models. This study informs that endogeneity and sample selection biases can be detrimental when estimating the causal relationship between government financial support and firm innovation. Further, my approach controlling for unobserved firm heterogeneity[18], which was confirmed by the Hausman test, contributes to improving the accuracy of estimation.

Third, this study confirms the heterogeneity in the effects of government financial support and supports the argument that public incentives can play a role in lowering market frictions that financially vulnerable firms may experience (Bronzi & Iachini, 2014; Gonzáles, Jaumandreu & Pazó, 2005; Lach, 2002; Zhao & Ziedonis, 2020). This study tested the argument using more direct conditions for firms' financial constraints, such as profitability decrease and insufficient funding for innovation, while prior tests relied on firm size and firm age. Hence, the additional and direct evidence this study offers establishes solid evidence of the friction-reducing role played by public support programs.

This study has policy implications as well. As one of the first examinations on the effects of Australian government financial aids, this study provides important empirical evidence on support programs. In the past decades, the Australian Government has implemented various financial instruments to boost innovation of SMEs. Nevertheless, only few studies, including policy evaluation papers, have empirically examined whether such efforts were effective in catalysing firm innovation (e.g. Thomson & Skali, 2016). The findings of this study provide useful insight to the government and policymakers for

[18] The variations in the innovation activities of Australian firms are also highlighted in a publication of the Department of Industry Tourism and Resources (2007).

understanding the effectiveness of fiscal support and the extent that public aids help firm innovation. Further, firms can gain a clearer understanding of why and how fiscal support helps their innovation from this study. Accordingly, firms may be able to make strategic decisions of whether and when to seek government financial support.

Limitations and Future Research

Nevertheless, this study has several limitations. First, while it provides useful evidence on the direct relationship between government financial support and firm innovation, it does not provide any evidence on the long-term or indirect effects. As Bronzini and Iachini (2014) noted, it would be worth examining whether and how public incentives affect the economic performance of recipient firms. Additionally, understanding the spillover effects of fiscal support would yield important insights for policy development. For instance, investigation on whether recipient firms would bring positive or negative spillovers that can influence their competitors, suppliers or buyers, or social welfare can offset the cost of unsuccessfully financed firms (Bronzini & Iachini, 2014).

Second, the major limitation of this study is that the findings are not robust to different reference years (e.g. 2010/11–2014/15, 2009/10–2013/14 and 2006/07–2010/11). Although the results of the different reference years support the presence of selection issues, they do no support that public aids can be an enabler of innovation because of insignificance of the results. However, that is because the survey items were not identical and were updated occasionally, so some of the variables were missing and appeared several years after the survey began. Hence, the insignificant results may be partly attributed to incomplete datasets of the reference years.

Third, this study is limited to inferring the causal relationship between government financial support and firms' R&D investment. Investigating the relationship may elucidate the channels by which fiscal support helps firm innovation.

Chapter 4 DISCUSSION AND CONCLUSION

This dissertation re-examines the effects of innovation catalysts to better understand their roles in helping firm innovation. My particular interest is in understanding the actual roles of (1) non-market intermediaries and (2) government financial support. As these types of support programs are established by public funding to stimulate innovation, it is necessary to investigate how they affect firm innovation. I carried out the investigation by conducting separate research for each. I used qualitative research for understanding non-market intermediaries and an econometric approach to evaluate government financial support. Taken together, my findings specify the process of how non-market intermediaries and government financial support play a role as innovation catalysts.

My research is in line with prior studies that also argue that various support programs can help firms improve their innovation (e.g., Howells, 2006; Jandhyala & Phene, 2015; McDermott et al., 2009). However, my research provides additional important insights for understanding their particular roles as innovation catalysts. First, I recommend clarification of the origin and development of support programs to better understand their roles, especially for those that are designed to improve public benefits. As seen in the first study, my findings suggest that non-market intermediaries differ in their roles in stimulating innovation depending on how they emerged. This indicates that there is a strong relationship between the emergence of intermediaries and their roles as innovation catalysts. Second, my research improves our understanding of innovation catalysts. For example, in the first study, I generated explanations of why and how non-market intermediaries emerge and how they can differ in helping innovation. In the second study, addressing econometric challenges that were one of the major issues in empirical research on government financial support, my research

adds weight to the argument that government financial support increases firm innovation, by reducing market frictions such as asymmetric information. Third, this research provides strong empirical evidence of the paths through which non-market intermediaries and government financial support exert their influences on firm innovation. The qualitative evidence is derived from triangulations of multiple data sources and diverse industry perspectives; the quantitative evidence is also confirmed through multiple rounds of robustness checks. Therefore, my empirical results can be useful sources for explaining the roles of non-market intermediaries/government financial support as innovation catalysts.

Nevertheless, this dissertation has several limitations. I discuss the limitations of each study as they are particularly designed to examine specific programs of innovation catalysts. The first study (i.e., the study on non-market intermediaries) is qualitative inductive research. Hence, it is likely that my findings may not be generalisable to other settings. This study also focuses on theory-building rather than theory-testing. Thus, it lacks statistical evidence, which can be of interest to future study. In addition, while this study identifies heterogeneous types of innovation that non-market intermediaries intend to stimulate with their support programs, it does not identify the innovation processes that the intermediaries would stimulate. Identifying different functions that non-market intermediaries may perform in the innovation process would be another interesting topic for future study. The second study (i.e., the study on government financial support) is also limited in several facets. First, this study does not examine the long-term or indirect effects of government financial support. As such effects are likely to influence the performance of firms, this would be worth examining and future research is encouraged. Second, the finding is not robust to different reference years. However, it may have been due to incomplete data set of the reference years.

Third, this study is not useful for inferring the causal relationship between government grants and private R&D investment. Future study is encouraged in this regard.

This dissertation has several practical implications as well. First, this dissertation ultimately evaluates if public funding arranged for innovation catalysts is used effectively. As this research shows that non-market intermediaries and government financial support play a role in catalysing innovation, it in turn implies that funding used for these programs is appropriately used in the research context. Second, this dissertation can be a reference for policymakers, industry leaders and firms. Policymakers or industry leaders can learn how to use such support programs for effective implementation. Firms can also get a clear idea of how the support programs work in the process of helping innovation. Third, this research can be a useful guideline for program evaluation. Practitioners can learn what procedures should be taken into consideration for accurately evaluating the effectiveness of programs.

REFERENCES

Ahuja, G. 2000. Collaboration networks, structural holes, and innovation: A longitudinal study. ***Administrative Science Quarterly***, 45(3): 425–455.

Aldrich, H. E. 1999. ***Organizations Evolving***. Thousand Oaks, CA: Sage Publications.

Aldrich, H. E., & Fiol, C. M. 1994. Fools rush in? The institutional context of industry creation. ***Academy of Management Review***, 19(4): 645–670.

Almus, M., & Czarnitzki, D. 2003. The effects of public R&D subsidies on firms' innovation activities: The case of Eastern Germany. ***Journal of Business & Economic Statistics***, 21(2): 226–236.

Angrist JD. 2001. Estimation of limited dependent variable models with dummy endogenous regressors. ***Journal of Business and Economic Statistics*** 19(1): 2–28.

Angrist, J. 2009. Treatment effects. In S. Durlauf & L. Blume (Eds.), ***Microeconometrics***. London, UK: Palgrave Macmillan.

Armanios, D. E., Eesley, C. E., Li, J., & Eisenhardt, K. M. 2017. How entrepreneurs leverage institutional intermediaries in emerging economies to acquire public resources. ***Strategic Management Journal***, 38(7): 1373-1390.

Arrow, K. J. 1962. Economic welfare and the allocation of resources to invention. In R. Nelson (Ed.), ***The Rate and Direction of Inventive Activity***: 609–625. Princeton: Princeton University Press.

BBC. 2014. For more than 50 years the Pentagon's hi-tech research branch has endeavored to stay ahead of an ever-changing world. ***BBC***. Nov 18. Accessed online at https://www.bbc.com/future/article/20130425-darpa-the-element-of-surprise. Viewed 1 Mar, 2021.

Beck, M., Lopes-Bento, C., & Schenker-Wicki, A. 2016. Radical or incremental: Where does R&D policy hit?. ***Research Policy***, 45(4): 869-883.

Benner, M. J., & Tripsas, M. 2012. The influence of prior industry affiliation on framing in nascent industries: The evolution of digital cameras. ***Strategic Management Journal***, 33(3): 277-302.

Blundell, R. & Cost Dias, M. 2000. Evaluation methods for non-experimental data. ***Fiscal Studies***, 21: 427–468.

Bronzini, R., & Iachini, E. 2014. Are incentives for R&D effective? Evidence from a regression discontinuity approach. ***American Economic Journal: Economic Policy***, 6(4): 100–134.

Bushway, S., Johnson, B.D., & Slocum, L. A. 2007. Is the magic still there? The use of the Heckman two-step correction for selection bias in criminology. ***Journal of Quantitative Criminology*** 23(2): 151–178.

Cattani, G., Ferriani, S., Negro, G., & Perretti, F. 2008. The structure of consensus: Network ties, legitimation, and exit rates of US feature film producer organizations**.** ***Administrative Science Quarterly***, 53(1): 145-182.

Certo, S. T., Busenbark, J. R., Woo, H. S., & Semadeni, M. 2016. Sample selection bias and Heckman models in strategic management research. ***Strategic Management Journal***, 37(13): 2639-2657.

Chiles, T. H., Meyer, A. D., & Hench, T. J. 2004. Organizational emergence: The origin and transformation of Branson, Missouri's musical theaters. ***Organization Science***, 15(5): 499-519.

Colombo, M. G., Giannangeli, S., & Grilli, L. 2013. Public subsidies and the employment growth of high-tech start-ups: Assessing the impact of selective and automatic support schemes. ***Industrial and Corporate Change***, 22(5): 1273–1314.

Corredoira, R. A., & McDermott, G. A. 2014. Adaptation, bridging and firm upgrading: How non-market institutions and MNCs facilitate knowledge recombination in emerging markets. ***Journal of International Business Studies***, 45(6): 699-722.

CSIRO. 2016. ***Advanced Manufacturing: A Roadmap for unlocking future growth opportunities for Australia***. Accessed online https://www.csiro.au/en/Do-business/Futures/Reports/Future-Industries/Advanced-manufacturing-roadmap.

David, P. A., Hall, B. H., & Toole, A. A. 2000. Is public R&D a complement or substitute for private R&D? A review of the econometric evidence. ***Research Policy***, 29(4–5): 497–529.

Davis, J. P., & Eisenhardt, K. M. 2011. Rotating leadership and collaborative innovation: Recombination processes in symbiotic relationships. ***Administrative Science Quarterly***, 56(2): 159-201.

De Marchi, V. 2012. Environmental innovation and R&D cooperation: Empirical evidence from Spanish manufacturing firms. ***Research Policy***, 41(3): 614–623.

Dekker, J., & Hasso, T. 2016. Environmental performance focus in private family firms: The role of social embeddedness. ***Journal of Business Ethics***, 136(2): 293–309.

Department of Industry Tourism and Resources. 2007. ***High variation in R&D expenditure by Australian firms***. Australia: Government of Australia.

Doh, S., & Kim, B. 2014. Government support for SME innovations in the regional industries: The case of government financial support program in South Korea. ***Research Policy***, 43(9): 1557–1569.

Dutt, N., Hawn, O., Vidal, E., Chatterji, A., McGahan, A., & Mitchell, W. 2016. How open system intermediaries address institutional failures: The case of business incubators in emerging-market countries. ***Academy of Management Journal***, 59(3): 818-840.

Edmondson, A. C., & McManus S. E. 2007. Methodological fit in management field research. ***Academy of Management Review***, 32(4): 1246–1264.

FCW. 2014. DARPA in 2014: Director Arati Prabhakar looks ahead. ***FCW***. Jan 17. Accessed online at https://fcw.com/articles/2014/01/17/prabhakar-profile.aspx. Viewed 1 Mar, 2021.

Feldman, MP, & Kelley, MR. 2003. Leveraging research and development: assessing the impact of the US advanced technology program. ***Small Business Economics***. 20 (2): 153–165.

Fleming, L., Greene, H., Li, G., Marx, M., & Yao, D. 2019. Government-funded research increasingly fuels innovation. ***Science***, 364(6446): 1139–1141.

Flick, O. 2009. ***An Introduction to Qualitative Research***. Thousand Oaks, CA: Sage Publications

Gioia, D. A., Corley, K. G., & Hamilton, A. L. 2013. Seeking qualitative rigor in inductive research: Notes on the Gioia methodology. ***Organizational Research Methods***, 16(1): 15-31.

Glaser, B. G., & Strauss, A. 1967. ***The Discovery of Grounded Theory: Strategies for Qualitative Research.*** Chicago, IL: Aldine.

González, X., Jaumandreu, J., & Pazó, C. 2005. Barriers to innovation and subsidy effectiveness. ***RAND Journal of Economics***, 36(4): 930–950.

González, X., & Pazó, C. 2008. Do public subsidies stimulate private R&D spending? ***Research Policy***, 37(3): 371–389.

Görg, H., & Strobl, E. 2007. The effect of R&D subsidies on private R&D. ***Economica***, 74(294): 215–234.

Green, S. G., Gavin, M. B., & Aiman-Smith, L. 1995. Assessing a multidimensional

measure of radical technological innovation. ***IEEE Transactions on Engineering Management***, 42(3): 203-214.

Guan, J., & Yam, R. C. 2015. Effects of government financial incentives on firms' innovation performance in China: Evidences from Beijing in the 1990s. ***Research Policy***, 44(1): 273–282.

Guba, E. G. 1981. Criteria for assessing the trustworthiness of naturalistic inquiries. ***Educational Communication and Technology***, 29 (2): 75–91.

Guo, D., Guo, Y., & Jiang, K. 2016. Government-subsidized R&D and firm innovation: Evidence from China. ***Research Policy***, 45(6): 1129–1144.

Hannan, M. T., Pólos, L. & Carroll, G. R. 2007. ***Logics of Organization Theory: Audiences, Codes, and Ecologies***. Princeton, NJ: Princeton University Press.

Heckman, J. J. 1979. Sample selection bias as a specification error. ***Econometrica***, 47(1): 153-161.

Henderson, R. M., & Clark, K. B. 1990. Architectural innovation: The reconfiguration of existing product technologies and the failure of established firms. ***Administrative Science Quarterly***: 9-30.

Howell, S. T. 2017. Financing innovation: Evidence from R&D grants. ***American Economic Review***, 107(4): 1136-1164.

Howells, J. 2006. Intermediation and the role of intermediaries in innovation. ***Research Policy***, 35(5): 715-728.

Hussinger, K. 2008. R&D and subsidies at the firm level: An application of parametric and semiparametric two-step selection models. ***Journal of Applied Econometrics***, 23(6): 729–747.

Jandhyala, S., & Phene, A. 2015. The role of intergovernmental organizations in cross-border

knowledge transfer and innovation. ***Administrative Science Quarterly***, 60(4): 712-743.

Jay, J. 2013. Navigating paradox as a mechanism of change and innovation in hybrid organizations. ***Academy of Management Journal***, 56(1): 137-159.

Katila, R., & Ahuja, G. 2002. Something old, something new: A longitudinal study of search behavior and new product introduction. ***Academy of Management Journal***, 45(6): 1183-1194.

Keijl, S., Gilsing, V. A., Knoben, J., & Duysters, G. 2016. The two faces of inventions: The relationship between recombination and impact in pharmaceutical biotechnology. ***Research Policy***, 45(5): 1061-1074.

King, B. G., Felin, T., & Whetten, D. A. 2010. Perspective—Finding the organization in organizational theory: A meta-theory of the organization as a social actor. ***Organization Science***, 21(1): 290-305.

Kobarg, S., Stumpf-Wollersheim, J., & Welpe, I. M. 2019. More is not always better: Effects of collaboration breadth and depth on radical and incremental innovation performance at the project level. ***Research Policy***, 48(1): 1-10.

Komera, S., Lukose, P. J., & Sasidharan, S. 2018. Does business group affiliation encourage R&D activities? Evidence from India. ***Asia Pacific Journal of Management***, 35(4): 887–917.

Lach, S. 2002. Do R&D subsidies stimulate or displace private R&D? Evidence from Israel. ***The Journal of Industrial Economics***, 50(4): 369–390.

Lanahan, L, & Armanios, D. 2018. Does more certification always benefit a venture? ***Organization Science***. 9 (5): 931–947.

Langley, A. 1999. Strategies for theorizing from process data. ***Academy of Management Review***, 24(4): 691–710.

Lashley, K., & Pollock, T. G. 2020. Waiting to inhale: reducing stigma in the medical cannabis industry. ***Administrative Science Quarterly***, 65(2): 434-482.

Lerner, J. 1999. The government as venture capitalist: The long-run impact of the SBIR Program. ***Journal of Business***, 72(3): 285–318.

Liao, C. T. 2020. Laggards imitate, leaders innovate: the heterogeneous productivity effect of imitation versus innovation. ***Industrial and Corporate Change***, 29(2): 375-394.

Lincoln, Y. S., & Guba, E. G. 1985. ***Naturalistic Inquiry***. Beverly Hills, CA: Sage.

Lynn, L. H., Reddy, N. M., & Aram, J. D. 1996. Linking technology and institutions: the innovation community framework. ***Research policy***, 25(1): 91-106.

Mannucci, P. V., & Yong, K. 2018. The differential impact of knowledge depth and knowledge breadth on creativity over individual careers. ***Academy of Management Journal***, *61*(5): 1741-1763.

McDermott, G. A., Corredoira, R. A., & Kruse, G. 2009. Public-private institutions as catalysts of upgrading in emerging market societies. ***Academy of Management Journal***, 52(6): 1270-1296.

McEvily, B., & Zaheer, A. 1999. Bridging ties: A source of firm heterogeneity in competitive capabilities. ***Strategic Management Journal***, 20(12): 1133–1156.

Meuleman, M., & De Maeseneire, W. 2012. Do R&D subsidies affect SMEs' access to external financing? ***Research Policy***, 41(3): 580–591.

Monteiro, F., Mol, M., & Birkinshaw, J. 2017. Ready to be open? Explaining the firm level barriers to benefiting from openness to external knowledge. ***Long Range Planning***, 50(2): 282-295.

Nelson, R. R. 1959. The simple economics of basic scientific research. ***Journal of Political Economy***, 67(3): 297–306.

Nelson, R., & Winter, S. 1982. ***An Evolutionary Theory of Economic Change***, Cambridge, MA: Harvard University Press.

OECD. 2017. ***The next production revolution: Implications for governments and business***. Accessed online https://www.oecd.org/governance/the-next-production-revolution-9789264271036-en.htm.

Olson, M. 1965. ***The Logic of Collective Action: Public Goods and the Theory of Groups***. Cambridge, MA: Harvard University Press.

Palangkaraya, A., Stierwald, A., Webster, E., & Jensen, P. H. 2010. ***Examining the Characteristics of Innovative Firms in Australia***. Melbourne: University of Melbourne.

Porter, M.E. & van der Linde, C. 1995. Toward a new conception of the environment–competitiveness relationship. ***Journal of Economic Perspectives***, 9: 97–118.

Powell, W. W., Koput, K. W., & Smith-Doerr, L. 1996. Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. ***Administrative Science Quarterly***, 41(1): 116–145.

Powell, W. W., Packalen, K., & Whittington. K. 2012. Organizational and institutional genesis: The emergence of high-tech clusters in the life sciences. In J. Padgett & W. W. Powell (Eds.), ***The Emergence of Organizations and Markets***, Princeton, NJ: Princeton University Press.

Pratt, M. G., Rockmann, K. W. & Kaufmann, J. B. 2006. Constructing professional identity: The role of work and identity learning cycles in the customization of identity among medical residents. ***Academy of Management Journal***, 49(2): 235–262.

Rao, H., & Singh, J. V. 2001. The construction of new paths: Institution building activity in the early automobile and biotechnology industries. In R. Garud and P. Karnoe (Eds.), ***Path Dependence and Creation***: 243–267. Mahwah, NJ: Lawrence Erlbaum.

Roma, P., Petruzzelli, A. M., & Perrone, G. 2017. From the crowd to the market: The role of reward-based crowdfunding performance in attracting professional investors. ***Research Policy***, *46*(9): 1606-1628.

Rosenkopf, L., Metiu, A., & George, V. P. 2001. From the bottom up? Technical committee activity and alliance formation. ***Administrative Science Quarterly***, 46(4): 748-772.

Rothaermel, F. T., Hitt, M. A., & Jobe, L. A. 2006. Balancing vertical integration and strategic outsourcing: effects on product portfolio, product success, and firm performance**.** ***Strategic Management Journal***, *27*(11): 1033-1056.

Sandhu, S., & Kulik, C. T. 2018. Shaping and being shaped: how organizational structure and managerial discretion co-evolve in new managerial roles. ***Administrative Science Quarterly***, 64(3): 1-40.

Sartori, A. E. 2003. An estimator for some binary-outcome selection models without exclusion restrictions. ***Political Analysis***, 11(2): 111–138.

Schilling, M. A. 2013**.** ***Strategic Management of Technological Innovation***. McGraw-Hill Education: New York.

Schumpeter J. 1942. ***Capitalism, Socialism and Democracy***. Perennial: New York.

Secchi, A., Tamagni, F., & Tomasi, C. 2016a. Financial constraints and firm exports: accounting for heterogeneity, self-selection, and endogeneity. ***Industrial and Corporate Change***, 25(5): 813–827.

Secchi, A., Tamagni, F., & Tomasi, C. 2016b. Export price adjustments under financial constraints. ***Canadian Journal of Economics/Revue canadienne d'économique***, 49(3): 1057-1085.

Semykina, A., & Wooldridge, J. M. 2010. Estimating panel data models in the presence of endogeneity and selection. ***Journal of Econometrics***, 157(2): 375–380.

Shan, W., Walker, G., & Kogut, B. 1994. Interfirm cooperation and startup innovation in the biotechnology industry. ***Strategic Management Journal***, 15(5): 387-394.

Strauss, A., & Corbin, J. 1994. Grounded theory methodology: An overview. In N. K. Denzin and Y. S. Lincoln (Eds.), ***Handbook of Qualitative Research***, 17: 273–285. Thousand Oaks, CA: Sage.

Thomson, R., & Skali., A. 2016. ***The Additionality of R&D Tax Policy in Australia***. Melbourne: Swinburne University of Technology.

Wallsten, S. J. 2000. The effects of government-industry R&D programs on private R&D: The case of the Small Business Innovation Research program. ***The RAND Journal of Economics***, 31(1): 82–100.

Wooldridge, J. M. 2010. ***Econometric Analysis of Cross Section and Panel Data***. Cambridge, MA: The MIT Press.

Young, P. 1998. ***Individual Strategy and Social Structure***. Princeton, NJ: Princeton University Press.

Zhang, Y., & Li, H. 2010. Innovation search of new ventures in a technology cluster: the role of ties with service intermediaries. ***Strategic Management Journal***, 31(1): 88-109.

Zhao, B. & Ziedonis, R. 2020. State governments as financiers of technology startups: Evidence from Michigan's R&D loan program. ***Research Policy***, 49(4): 103926.

Zhu, D. H., & Shen, W. 2016. Why do some outside successions fare better than others? The role of outside CEOs' prior experience with board diversity. ***Strategic Management Journal***, *37*(13): 2695-2708.

Zuckerman, E. W. 1999. The categorical imperative: Securities analysts and the legitimacy discount. ***American Journal of Sociology***, 104(5): 1398–1438.

Zuckerman, E., & Sgourev, S. 2006. Peer capitalism: Parallel relationships in the U.S. economy. ***American Journal of Sociology***, 111(5): 1327-1366

APPENDICES

Table A1. Data Sources and Uses

Interview data	
67 interviews of non-market intermediaries, firms, a government department, research institutions, journalists and consultants.	Conducted between 2018 and 2019. Lasted 26 hours in total. Useful for identifying roles played by intermediaries A, B & C and the industry perceptions of support of intermediaries. Useful for understanding the industry development and firms' innovation.
Archival data	
Intermediaries' publications, 2012-2019	15 publications in total (461 pages). Useful for understanding history, objectives, particular missions and support programmes of each intermediary.
Government's archives, 2006-2019: *Department of Industry, Science, Energy and Resources* (previously *Department of Industry, Innovation and Science*), *Department of the Prime Minister and Cabinet. A prime minister's webpage*.	15 publications in total (938 pages). Useful for understanding government's innovation policies, especially on the advanced manufacturing industry and developing an understanding of governmental support and the research background. Useful for identifying motivations of establishing intermediaries.
Industry reports, 2007-2018: *Business Council of Australis, CSIRO, OECD, PwC.*	10 publications in total (554 pages). Useful for understanding the research background and developing an understanding of the state of the innovation system in Australia.
Newspaper archives, 2013-2019: *Australian Financial Review, Australian Manufacturing, Manufacturers' Monthly, PACE, Sydney Morning Herald, The Australian, The Conversation.*	Useful for identifying events that were highly related to the emergence of intermediaries and understanding how the industry matured.
Other online sources: *Department of Finance, Intermediaries' websites, Intermediaries' mailing service, Open Australia, Parliament of Australia*.	Useful for collecting updates and events currently organized by intermediaries. Useful for gaining an understanding of the budget process.
Direct observations	
Site visits to seven facilities (1 intermediary, 2 research institution, 4 advanced manufacturing firms).	Useful for gaining an understanding of the industry state and observing how intermediary support was being processed in firms' innovation projects.
One showcase. Flyers and extensive notes	Useful for understanding support focus of an intermediary and observing the relationship that the intermediary formed

	with the government.
Manufacturing exhibition. Transcripts of presentations. Flyers and extensive notes. -- Two workshops organised by two intermediaries. Transcripts of presentations. Flyers and extensive notes.	In Melbourne. Lasted four days and supported by two intermediaries. Presentations by individuals acknowledged as industry leaders – including ministers, business owners, academics, etc. Useful for observing development of the advanced manufacturing industry. Useful for observing different support intentions delivered by intermediaries.

Interview Protocol

Intermediaries

1. (Opening) Can you tell me about your organisation?

2. What is 'Advanced Manufacturing'?

3. Could you please elaborate on how your organisation started?

4. What are the goals of your organisation? How did your organisation set up the goals and how is your organisation addressing these goals?

5. What are the roles that your organisation is playing in this industry?

6. Are there intermediary organisations like yours? How are your organisation different from those intermediaries in the advanced manufacturing industry?

7. How did your organisation develop the support programmes?

8. How does your organisation help firm's innovation? How is your approach different from those of other intermediaries?

9. Is there governmental involvement? If so, what kinds of relationship do your organisation form with the government?

10. Is there anything else I should know about the intermediary support in the industry?

Firms

1. (Opening) Can you tell me about your business?

2. What is your understanding of ‘Advanced Manufacturing’? Could you please tell me about how is your business related to ‘Advanced Manufacturing’?

3. How important is ‘innovation’ for your business? How would you describe your innovation strategy?

4. What do you think are the innovation challenges your firm face?

5. Are you aware of intermediaries A, B or C? Is your firm involved with any of the intermediaries?

- (If the firm is involved in) why did you join them? Have you participated any of their support programmes?

- (If the firm is not involved in) why didn’t you join them?

6. Would intermediaries A, B or C help firm innovation? How would they be helpful for firm innovation?

7. Can you find differences between intermediaries A, B and C? If so, how different are they?

8. Are there other government programmes or grants your firm received for building advanced manufacturing capability? If so, how did they help your innovation?

Research Institutions / Government / Journalists

1. (Opening) Can you tell me about your organisation?

2. What is ‘Advanced Manufacturing’?

3. How could you describe the current phase of the advanced manufacturing industry?

4. If you know the story about how intermediaries A, B or C emerged, could you please tell me?

- (If the intermediary was a part of the governmental programmes) could you please tell me how the programme was related to the emergence of the intermediary?

5. How do you define the roles of intermediaries A, B and C in the advanced manufacturing industry?

6. Would intermediaries A, B and C help firm innovation? If so, how could their support be helpful?

7. Is there anything else I should know about the intermediary support in the industry?

Table A2. Examples of Supporting Data for First-order Codes

Trigger/Motivation
"The formation of [Intermediary A] follows the announcement made by Ford last May 23 that it would cease car production in the country by October 2016." (#AN2) **Code – the shutdown announcement made by global automobile companies** "AU manufacturers has been losing competitiveness in the global market." (#I3) **Code – AU manufacturing's losing competitiveness** "The purpose of [Intermediary B] is to transform Australian manufacturing to be more globally competitive and generate the demand for jobs." (#I2) **Code – the industry transformation for a stronger competitiveness** "[Intermediary C] has a mission to catalyse the transformation of Australian manufacturing through collaborative investment, research impact and innovation." (#AC2) **Code – the industry transformation, encouraging collaboration between research and industry**
Involvement of high-status actors
"One big influencer started and brought those high-profile companies [to] the table." (#I11) **Code – High-profile/established firms gathered for the intermediary** "[Intermediary A] was set by some concerns of CEOs of manufacturing group." (#R1) **Code – CEOs initiated the idea of the intermediary** "[Intermediary B] was established by the Australian Government in 2015." (#AB1) **Code – The initiator was the government** "[Intermediary C] programme supports industry-led collaborations between industry, researchers and the community." (Intermediary C's mailing service) **Code – joint application between research and industry** "[Intermediary C] was a combined re-bid of … at the suggestion of the government." (#AN6) **Code -governmental involvement in the establishing process, re-joint of two different applications.**
Consensus
"This is like using opinion leaders and influencers to encourage other opinion leaders, peer-to-peer taking." (#I11) **Code – Leaders encouraging other leaders to join the idea** "what we're intending to do is to have a series of round tables." (#PM1) **Code – the idea discussed in a series of round tables** "[Intermediary B] is almost fully funded by the government." (#I4) **Code – the proposal went through budget process** "Bidding for a [Intermediary C] is a highly competitive process requiring cross-disciplinary teams to come together and collaborate." (Intermediary C's mailing service) **Code – teamwork of cross-disciplinary participants, highly competitive bidding process**
Legitimisation (raising awareness)
"No on ever talked about 'advanced manufacturing' before. We were a catalyst to help what the sector is." (#I11) **Code – first intermediary to raise awareness of the industry, a catalyst to help awareness** "[Intermediary A] was a bit of lobby group, is now a part of an industry association." (#R1) **Code – lobbying** "started from a campaign by showing successful cases in the sector." (#I3) **Code – campaigning**

Popularisation (raising awareness)
"[Intermediary A] replicated by [Intermediary B] at a much larger scale." (#I4) **Code – raising awareness at a larger scale**
"[Intermediary B] believes that all manufacturers can, and should, become more advanced, competitive and resilient." (Intermediary B's website) **Code – inviting manufacturers for advanced manufacturing**
"[Intermediary B] helps define what advanced manufacturing is, and did a good job, helped awareness of the term." (#J2) **Code – redefining the industry, raising awareness of the industry**
Encouragement (raising awareness)
"The goal of our programmes is to build an appetite to invest in Industry 4.0." (#I4) **Code – encouraging firms to participate in Industry 4.0**
"We want to see the public perception of a capital and labour intensive 'brand of manufacturing' shift to one that embraces industrial transformation, in which companies leverage digital technologies, including Industry 4.0, to deliver innovative business models and sell new products, services and solutions to a global market." (#AC3) **Code – raising awareness, encouraging firms to embrace industrial transformation**
"An industrial transformation programme is designed to sell the talk, to improve firms' strategies and leadership capability". (#R4) **Code – encouraging firms to incorporating new business practices**
Catalyst of firms' incremental innovation
"[Intermediary B] co-funds industry projects to commercialise innovation." (Intermediary B's website) **Code – commercialising innovation**
"Improving engagement between research and industry, and within industry, to achieve stronger coordination and collaboration of research and stronger commercialisation outcomes." (#AG3) **Code – increasing collaboration and commercialisation**
"[Intermediary B] more focused on market-ready projects with high technology readiness." (#J2) **Code – providing funding to market-ready projects, no need to develop technologies**
Catalyst of firms' radical innovation
"[Intermediary C] provides grants to large & long-term projects." (#I7) **Code – supporting innovation projects with large and long-term funding**
"[Intermediary C] focuses on catalysing large research collaboration with universities." (#I10) **Code – catalysing collaboration between industry and research**
"We are less evolutionary, but more transformative. We are not about continuous improvement, but more about getting to the next horizon." (#I4) **Code – pursuing transformative innovation.**
"World-first use of kangaroo as a xenograft material in ligament reconstruction and repair. .." (Intermediary C's website) **Code – supporting a project working on a novel technology**
Indirect catalyst
"Our goal as an innovation catalyst was to build an innovation ecosystem." (#I3) **Code – building an innovation ecosystem**
"I got great connections from Intermediary, met people that I hadn't met before." (#R2) **Code –fostering interactions**

"[Intermediary A] hasn't had any influence on our innovation, but their role in messaging, lobbying and developing the need for innovation." (#F5) **Code – no direct impact on firm innovation, developing the need for innovation**

Instrument Diagnostics for 2SLS-IV

The method used in the Chapter 3 is different from typical 2SLS-IV methods that directly instrument exogenous variables. I followed Secchi et al.'s (2016a, 2016b) approach to estimate 2SLS-IV using the fitted probabilities (p) as an instrument, because it is robust to mis-specification of the probit model and is more efficient than typical 2SLS-IV. However, because of this, standard weak instrument diagnostics fail in this context (Nichols, 2007). Alternatively, Secchi et al. (2016a, p.821; 2016b) advised that 'validation of instruments relies upon goodness of fit of the first step Probit'. Hence, following Secchi and his colleagues' advice, I assessed the goodness of fit of the probit for validating the instrument (p) using three measures: (1) a standard adjusted R^2, (2) the Brier score and (3) the AUC score. They are reported in Table 6.

(1) Pseudo-R^2: The higher Pseudo-R^2, the better the model fits. In the probit model against *GovtAssi* as the dependent variable, the Pseudo-R^2 value was 0.545, which is considered relatively high. Hence, it indicates the model fits well and is likely to predict the *p* values correctly.

(2) Brier score: This score measures the accuracy of probabilistic predictions, calculated as $1/N\sum(\widehat{GovtAssi} - GovtAssi)$ where $\widehat{GovtAssi}$ is the status predicted by the model and $GovtAssi$ the actual status. Accordingly, the lower the Brier score is, the more accurate the prediction is. In this model, the Brier score was 0.058, suggesting a high accuracy of the prediction of the model.

(3) AUC score: This score measures area under the ROC (receiver operating characteristics) curve, which shows the relationship between the false positive rate (FPR) of the model and its true positive rate (TPR). In practice, if the ROC curve is closer to the border of the unit-length square, it indicates high AUC and that the model forecasts the event well. In this model, the AUC score was 0.948. Accordingly, this model can predict the likelihood of receiving public support (p) with high accuracy.

Additionally, I compared the three assessments of the probit model with the instruments (i.e. government financial support in the previous year and financial constraints in an industry in the given year) with those of the model without them to confirm that these instruments significantly contribute to improving the goodness of fit of the model. The following table clearly shows that the former can predict much better than the latter. In addition, the AUC score graphs confirm the high predictability of the probit model with the instruments.

Table A3. The Goodness of Fit Comparison

	With instruments	Without instruments
Pseudo-R2	0.5447	0.0644
Brier score	0.0594	0.1223

AUC score	0.9477	0.6866

Figure A1. ROC Plots