AN EMPIRICAL EXAMINATION OF THE APPLICABILITY AND EFFECTIVENESS OF THE OPEN INNOVATION PARADIGM

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DECLARATION

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ABSTRACT

While there is a growing trend towards openness between organisations in terms of their knowledge flows and contractual relationships, the applicability and effectiveness of the open innovation paradigm has yet to be fully explored. While the advocates of open innovation point to its considerable benefits, there still remains the need to assess whether firms can, in practice, actually capture these asserted benefits.

This overarching research problem, which forms the foundation of this doctoral research project, leads to two research questions. First, is the open innovation strategy applicable to all types of firms? Second, do the benefits of open innovation outweigh its potential costs and the threats to competitive positions of firms?

These two issues correspond to the two gaps found in the extant literature of open innovation that are elaborated in this thesis. To explore these research questions, this research seeks to provide extensive empirical evidence from five main aspects, with particular reference to the inbound stage of the open innovation paradigm. To do this, five interrelated projects are undertaken, each with a unique contribution to informing the research topic.

These closely related investigative components jointly provide consolidated answers to the two research questions. In response to the first research question, an investigation of the generalisability of open innovation is presented, providing a good application of open innovation strategy in the context of process innovation activities and within regional clusters. However, the applicability of this emerging paradigm within Chinese SMEs and firms in service industries are not observed.

The findings also indicate that some open innovation approaches (such as R&D outsourcing) and some external knowledge sources (from agencies such as universities and research institutes) are not shown to facilitate open innovation effectiveness as strongly as other relational arrangements. Furthermore, over-openness towards external sources might generate some adverse effects on firms. Therefore, it is suggested by this research that the decisions regarding whether and how to adopt an open innovation strategy should be contingent on specific situational factors within focal firms.

In response to the second research question, this research also suggests that the benefits of openness are achievable in many situations, but are not likely to always outweigh its potential costs and threats. It is found that certain organisational attributes (namely the suitable level of investment in absorptive capacity and an effective role of R&D) within firms, and the appropriate degree of knowledge protection/disclosure by firms, are two essential prerequisites for firms' ability to seize open innovation benefits.

This doctoral research makes a valuable contribution to the field of open innovation. From the theoretical perspective, it addresses significant gaps in the existing literature, establishes a comprehensive conceptual framework for this paradigm, extends knowledge and theoretical foundations, and identifies important issues which require further examination. From the practical perspective, it will contribute to improving managerial practice by providing useful suggestions regarding whether to adopt the open innovation strategy and how to implement it successfully in the current business context.

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CHAPTER I

Introduction

1.1 BACKGROUND OF THE THESIS

Innovation has been widely recognised as one of the major performance drivers of organisations. Open innovation, a recently popularised model that contrasts the traditional, closed way to conduct innovation, has been believed as a new source of competitive advantages for firms in the 21st century. While there is a growing trend towards openness, the applicability and effectiveness of this new operational paradigm has yet to be fully explored. That is to say, despite the rising theoretical emphasis and practical initiatives relating to the open mode of innovation, a key question remains unclear: *Does open innovation really improve innovation performance and competitive advantage of firms?* This is the overarching question that guides this research and it is fundamentally important because it leads researchers to examine the applicability and generalisability of this emerging paradigm. It also guides managers to consider whether their firms could really benefit from an open innovation strategy and how to seek the most suitable approaches linking openness to their firms.

Although proponents of open innovation advocate its considerable benefits, a concern might be raised as to whether firms in practice can actually capture these asserted benefits. This concern is supported by a project conducted during the author's Research Master's studies which examined the applicability of open innovation in the context of Australian small and medium-sized enterprises (SMEs). It was shown in this study (Huang and Rice, 2009) that Australian SMEs in the manufacturing sector are not very active open innovators and they have difficulty in capturing real benefits from the open innovation strategy. Therefore, it is of great importance to contemplate whether open innovation is, in fact, a better way to improve innovation performance

or perhaps rather just a management fad or even a barrier to the development of the organisations if it is not used appropriately. Little research has systematically looked into this issue or given satisfactory solutions to the doubt so far.

This overarching research problem forms the foundation of this doctoral research. To explore the problem, this thesis seeks to provide extensive empirical evidence from five unique aspects. These aspects are primarily investigated by five projects presented from Chapter 3 to Chapter 7, each with a unique focus on this problem. These closely related components of this thesis are brought together to contribute to a consolidated answer to the research problem. Details about each project including their inter-relationships and their respective significance are introduced in the Section 1.3.2. Their collective contribution to addressing the research problem and related research questions is thoroughly discussed at the end of the thesis in Chapter 8.

It is believed that to construct the thesis project by an aggregation of sub-projects is a comparatively better way to inform this challenging research problem rather than a traditional style thesis which generally centres on a single focused issue relating to the research topic. Consequently it was felt that the applicability of open innovation could be investigated more thoroughly from a wide range of research contexts rather than a single research project. This approach of building the thesis is also largely determined by the comprehensiveness and complexity of the open innovation paradigm with its various facets which should be more fully examined through a concert of various research projects.

1.2 RESEARCH QUESTIONS

The principle research problem "*Does open innovation really improve innovation performance and competitive advantage of firms?*" can be further explored through the following two research questions. These two research questions are pointed to the two main gaps identified in the current literature — the generalisability issue and the challenges associated with open innovation. Generalisability encompasses issues of firm size, country, industry, and innovation types, while challenges of open innovation comprise both costs likely incurred by openness and potential threats rising from the open strategy. Both of these gaps are elaborated in Section 2.5 (following an overview of open innovation related literature).

1) *Is the open innovation strategy applicable to all types of firms?*

This generalisability question seeks to explore the impacts of open innovation practices on the innovation performance of different types of firms, taking into account the variations across national, industrial and firm size attributes, different types of innovation processes (i.e. product or process innovation), and other institutional settings.

2) *Do the benefits of open innovation outweigh its potential costs and threats?*

This question intends to address whether the challenges associated with openness would affect firms' abilities to capture real values from an open innovation strategy. These challenges essentially include two types: costs potentially arising from open innovation practices, and threats largely originating from two sources (i.e. the reduced competitive distinctiveness and the paradox of open innovation).

In order to answer these questions, a conceptual framework is established to measure openness and determine the key elements that would constitute an open innovation

construct. The effects of open innovation strategy are subsequently tested in different research contexts with different research foci, as introduced in the following sections.

1.3 RESEARCH AGENDA

1.3.1 Conceptual Framework for the Doctoral Research

Although there have been various modes of open innovation (Lazzarotti and Manzini, 2009), the prevalent classification is derived from two primary approaches — inbound open innovation and outbound open innovation (Chesbrough and Crowther, 2006). Inbound open innovation is the process of in-sourcing and absorbing knowledge from external environment to supplement a firm's internal R&D, also known as the outside-in approach; while outbound open innovation refers to the process of searching for external commercialisation mechanisms for innovations internally developed, known as the inside-out approach (Chesbrough, 2003; Christensen, Olesen and Kjær, 2005; Lichtenthaler, 2009a; Spithoven, Clarysse and Knockaert 2010; West and Gallagher, 2006b). Further details about the classification and these two categories of open innovation are provided in Chapter 7.

This doctoral research focuses on Inbound Open Innovation, one of the primary categories of open innovation. Inbound open innovation seeks to be a comprehensive paradigm, embracing various components in regard to its antecedents and consequences, and multiple relationships among them. However, there hasn't been a widely recognised conceptual model which embraces these components and their relationships presented in the literature to date. Given the rich complement of theories which the paradigm draws on, a conceptual framework is developed by this thesis

grounded on the sources of fundamental antecedent theories pertaining to open innovation's principles and core ideas.

According to Dahlander and Gann's (2010) review of current important studies on open innovation, two major processes of inbound open innovation are summarised — sourcing and acquiring (and they also defined two outbound processes: revealing and selling). Sourcing relates to the activities of scanning, accessing and utilising important external knowledge sources such as customers, suppliers, competitors and research institutes, etc. (Arora and Gambardella, 1990; Knudsen, 2007; von Hippel, 1988). Acquiring is associated with the strategic approaches to acquiring knowledge and information from outside to supplement internal innovative abilities, through the use of various collaborative or contractual arrangements such as inter-firm collaboration, technology purchase, licensing in, and outsourcing (Deeds and Hill, 1996; Freeman, 1991; Jones, Lanctot and Teegen, 2001; Lichtenthaler, 2008; Sen and Egelhoff, 2000; Witzeman et al., 2006).

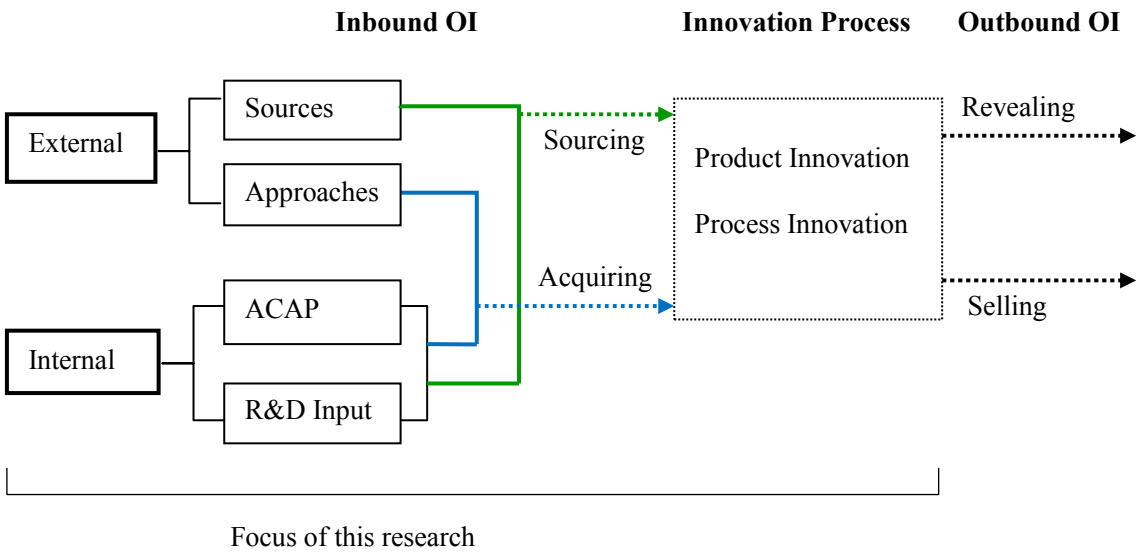
Meanwhile, in addition to those *external* mechanisms mentioned above, both sourcing and acquiring should be facilitated by *internal* configurations involving absorptive capacity (ACAP) of the focal firms and their investment in internal R&D (Cohen and Levinthal, 1989; Lichtenthaler and Lichtenthaler, 2009), to effectively absorb externally-sourced knowledge and integrate it into firms' internal knowledge bases (Bogers and Lhuillery, 2010; Ettlie and Reza, 1992).

Based on these considerations, the conceptual framework for this research is constructed by integrating both external and internal perspectives for the inbound

open innovation processes. As elaborated earlier, the external perspective focuses on external knowledge sources, open approaches, and their respective relationships with innovation performance. The internal perspective underscores the role of in-house research to catalyse the benefits of openness in terms of the development of ACAP and the investment in internal R&D. This incorporation of both external and internal perspectives is consistent with open innovation's integrative principle concerning the complementary rather than substituting relationship between external and internal research (Belderbos, Carree and Lokshin, 2006; Chesbrough, 2003a, 2006; Chesbrough and Crowther, 2006).

FIGURE 1.1

Conceptual Framework for the Doctoral Research



The fundamental conceptual framework for this research and its constructs are illustrated in Figure 1.1. This framework is basically applied to these five projects involved in this thesis although there are some slight variations with regard to the composition of the framework (given the availability of related data for its constructs)

in each project. The specific framework employed by each project seeks to highlight a unique and important facet of Inbound Open Innovation (Inbound OI) and thus each is respectively expounded in each chapter. Outbound Open Innovation (Outbound OI) is beyond the scope of this project, but constitutes a promising area for future research (which will be further discussed at the end of this thesis in Section 8.4.1).

1.3.2 Research Components (Projects) and Their Relative Contributions

This thesis comprises five independent but interrelated projects as presented in Chapter 3 to Chapter 7. Each of them constitutes an independent academic paper and each of which has been either accepted (with revisions) by refereed academic journals or presented (or will be presented) at refereed academic conferences. They collectively inform the topic of this thesis and jointly contribute to the comprehensive investigation of the two research questions put forward earlier.

The third chapter "Openness in Product and Process Innovation: Evidence from Australian Industry" looks into the applicability of inbound open innovation in two primary types of innovation process — product innovation and process innovation (process innovation embraces both technological process innovation and organisational process innovation). This project focuses on basic concepts with regard to general innovation forms and the open innovation pattern and attempts to link the open innovation paradigm to some fundamental innovation notions. It seeks to address the first research question (i.e. is the open innovation strategy applicable to all types of firms?) and enlighten readers on the generalisability of this paradigm based on its application observed in different innovation process patterns.

The fourth chapter "Does Open Innovation Work Better in Regional Clusters? Empirical Evidence from Europe" examines the effectiveness of open innovation in regional clusters — a specific geographic locus which is believed to be a relatively ideal setting for the application of open innovation (Simard and West, 2006). This research also mainly responds to the first research question through the investigation of this paradigm in specific geographical context of European countries where both innovation activities and regional clustering are comparatively prosperous. Moreover, it also intends to partially address the second research question (i.e. do the benefits of open innovation outweigh its potential costs and threats) by thoroughly examining the philosophies of open innovation and highlighting the benefits of open innovation reflected in the European regional clusters. This project tends to make readers reflect on what are the suitable situations for exploring opportunities assumed by open innovation and how to take full advantage of these opportunities to add value to the organisation.

The fifth chapter "Does the Open Innovation Paradigm Apply to China? Empirical Evidence from Chinese Firms" evaluates the effectiveness of open innovation in the context of an important emerging economy — China. This research essentially informs the first research question with the consideration of its generalisability beyond the developed economies. The differential abilities to capture value from openness between Chinese large firms and SMEs, and the interaction effects of external (e.g. various external sources) and internal (e.g. absorptive capacity) open innovation constructs are critically analysed. Furthermore, this research also encompasses some analysis pertaining to the second research question about the

potential costs incurred by some open practices. This project is likely to direct readers to ponder how firms' abilities to benefit from the open strategy are contingent on country, firm size and other contextual factors.

The sixth chapter "Networking and Bribery in China: Assessing Potential Negative Consequences of Firm Openness" which is extended from the fifth chapter further advances the analysis regarding the disadvantages of open strategies. While it takes a broader perspective not only focusing on the openness in innovation, some findings of this study are also expected to be applied to the application of open innovation, as open innovation is one of the most significant forms of firm openness. In particular, a main source of threats resulted from openness, namely the potential possibility of losing distinctive competencies (thereby losing competitive advantages), is fully discussed. By doing this, this project attempts to provide insights into the second research question relating to this potential threat associated with open practices and guide readers to consider probable negative consequences of both open innovation and other relevant open strategies.

The seventh chapter "Openness and Appropriation: Empirical Evidence from Australian Businesses" continues to address the second research question by looking into another significant potential threat for firms adopting the open innovation strategy — the 'paradox of innovation' (which pertains to a fundamental gap in the extant literature explained later in Section 2.5.2). This paradox is found essentially a conflict between knowledge disclosure and knowledge protection in the context of openness. The role of appropriability and the use of IP are among core issues of open innovation assumptions as indicated by Chesbrough (2003a) and his colleagues'

(2006) early studies. Through this project, readers might speculate on the prospect of the open innovation model and firms' genuine propensity to become open innovators revealed by their choices of appropriation strategies.

1.3.3 Research Methodology

The doctoral research focuses on firm-level open innovation activities which means individual firms are adopted as the unit of analysis. This research adopts quantitative research methods on the basis of secondary data respectively provided by the Australian Bureau of Statistics, the DG Enterprise and Industry of the European Commission, and the World Bank. In this sense, this doctoral research seeks to empirically investigate the research topic through quantitative modelling and statistical analysis based on these datasets.

These secondary databases are employed particularly because of three considerations with reference to their advantages to inform research questions. First, as one of the main research objectives of the thesis is to test the generalisability of the open innovation paradigm, these three datasets are built on a wide geographical coverage with large sized samples, a scope which would be unobtainable through primary data collection methods. This doctoral research starts from 4,322 Australian businesses (in Chapter 3), and moves on to 3,468 firms from 32 countries in the relatively innovation advanced continent of Europe (in Chapter 4). Chapter 5 focuses on 874 larger firms and 1,500 SMEs in China, an emerging economy in the Asia-Pacific Region, while Chapter 6 continues to look at these (around 2,400) Chinese firms. The seventh chapter returns to the situation of the sample of 4,322 businesses in Australia.

The major industry emphasis of all these datasets is manufacturing/service industries which are the most common industry categories for firms at large. Moreover, all of these datasets offer useful information about firm size which can be used to compare subgroups with different sizes or systematically control for the effect of size on open innovation performance.

Second, the validity of surveys conducted by these authorities and the quality of data available from these surveys are largely ensured, whereas individual research efforts can rarely obtain equivalent large-volume and high-quality data. Third, these datasets provide extensive information on innovation and open innovation related issues. Thereby numerous operational variables are available to measure open innovation processes and the subsequent performance. The unit record data at firm level are also favourable for quantitative modelling to examine the relationships proposed by the theoretical hypotheses in each chapter.

The statistical models for each chapter are carefully selected depending on the attributes of variables. In addition to the traditional Ordinary Least Squares (OLS) regression which has been widely used in the field of innovation (but only suitable for continuous dependent variable), Logistic Regression (for binary dependent variable), Tobit model (for censored data), Heckman Two-stage Estimation Method (for sample selection bias correction) and Negative Binominal Regression (for non-negative count variable) are respectively employed in different chapters based on the different statistical assumptions of each project. The hierarchical regression form is also adopted wherever necessary to test the non-linear relationships between constructs,

such as the interaction effects and the curvilinear effects. The specific statistical models employed in each project are respectively explained in each chapter.

1.4 STRUCTURE OF THE THESIS

This thesis is organised into 8 chapters. Chapter 1 outlines the research background, research questions and the detailed research agenda of the thesis. Chapter 2 introduces the primary and general literature of open innovation and identifies significant gaps in the extant research. Chapter 3 to Chapter 7 respectively centres on the five previously stated projects involved in the whole thesis project. Chapter 8 consolidates these projects, discusses key findings of them and explains how these findings inform the research questions. Chapter 8 also points out the contributions of this thesis to both theory and practice. It finally states limitations associated with the whole research project and puts forward the directions for future research in the field of open innovation.

CHAPTER II

Theoretical Background

2.1 INTRODUCTION

Although the following chapters of this thesis provide a detailed review of the literature on the specific focus of each project, it is still necessary to introduce general theoretical background relating to the open innovation paradigm. This chapter presents that background through a description of the emergence of the open innovation phenomenon; an outline of pioneering studies in this field; an explanation of some basic concepts of the paradigm; and an overview of research into this paradigm to date. Gaps in the extant literature are then identified and elaborated corresponding to the two main research questions put forward earlier.

2.2 THE EMERGING PARADIGM OF OPEN INNOVATION AND PIONEERING STUDIES

Open innovation, as an emerging paradigm of innovation, has drawn considerable research attention since it was first put forward in 2003 by Chesbrough (2003a, 2003b). The concept of 'open innovation' poses fundamental challenges to the assumptions of 'closed innovation' at all stages of innovation processes and proposes a new manner in which firms conduct innovation and commercialise innovation outcomes in the new knowledge landscape of the 21st century.

Although the term 'open innovation' is relatively recent, the organisational phenomena it describes can be traced to decades ago when the shift in innovation paradigm emerged in the practitioner's field — from the traditional closed pattern to the propensity towards 'openness', reflected by the practices of R&D outsourcing, inter-firm collaboration, and other cooperative or contractual forms of technology

acquisition (Badaracco, 1991; Carr, 1995; Cutler 1991; Freeman, 1991; Jarillo, 1989; March, 1991).

This trend of transition in the practices of research intensive firms was mainly driven by changes in their underlying knowledge environment. Research attention in academia was also shifted with this trend. In Chesbrough's early research (2003a, 2003b), he theoretically contrasted principles of the traditional closed innovation and the emerging open innovation models, and their underlying drivers. He also carried out empirical case studies on firms with different modes of innovation. Innovations were traditionally regarded as the processes of effective internal research and development (R&D) with appropriation of rents through tight control of the product or service newly developed. The closed innovation model was thus characterised by the solid boundary of an organisation, the exclusive rely on internal R&D, the vertical integration of internal functions, and the internalisation of the entire innovation process from materials acquisition, R&D, manufacturing, to the new product commercialisation (Chesbrough, 2003a). This practice was once acknowledged as the most effective way to conduct innovations because of the character of underlying knowledge environment at that time when there were scarce external knowledge sources, tight restriction on knowledge flows and strong control over intellectual property (IP). The examples of close innovators included some leading U.S. corporations at that time who were running their own in-house research laboratories, for instance, AT&T's Bell Laboratories and Xerox's Palo Alto Research Centre (PARC) (Chesbrough, 2003a).

According to Chesbrough's (2003a) observation, despite the tremendous scientific

achievements made in these industrial research laboratories, many once successful companies had faced increasing challenges to their innovation rising from two aspects. First, problems in in-house research and development surfaced due to the inherent weaknesses embedded in the closed innovation system where R&D and downstream functions were uncoupled. Lots of inventions from internal research centres thus should wait for a long time until the downstream functions are ready to manufacture and commercialise them. This might lead to the inefficiency of a firm's overall innovation process. Moreover, the single channel of commercialisation in the closed innovation system could cause increasing difficulty in capturing economic value from innovations internally developed. The potential of many inventions which were not congruent with the firm's overall strategy and thus abandoned halfway might be largely neglected consequently (Chesbrough, 2003a).

Second, as Chesbrough (2003a) pointed out, these corporations also encountered strong competitors who had conducted little in-house R&D on their own but were still very innovative through benefiting from external research provided by others, such as Intel, Microsoft and Cisco. The common characteristics of these firms included the porosity of their knowledge and R&D boundaries, the loosening of constraints on the interaction between firms and their external environment, and the integration of their internal and external research efforts.

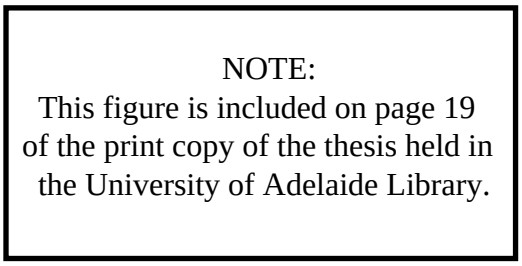
Chesbrough (2003a) believed the struggle of firms with closed innovation approaches might be largely explained by the recent changing knowledge environment. The end of the knowledge monopolies implies a wide distribution of knowledge which is cheaper and more accessible than before. The relatively loosened restriction on IP and

the higher mobility of skilled workers unconsciously advance knowledge 'spillovers' between firms. A strengthened role of government and other institutions such as universities and research institutes also greatly contribute to the innovation of firms especially those who are not internally oriented (Chesbrough, 2003a). Apart from these opportunities the new knowledge landscape brings about, the increasing complexity and rapidly-changing nature of technologies makes the independent R&D conducted all by firms themselves increasingly impossible (Howells, 1999; Tushman and Anderson, 1986).

The differences between closed and open innovation models are illustrated in Figure 2.1 and Figure 2.2 as below. The characteristics and principles of closed and open innovation models as well as the underlying factors driving both models are summarised more fully in Table 2.1.

FIGURE 2.1

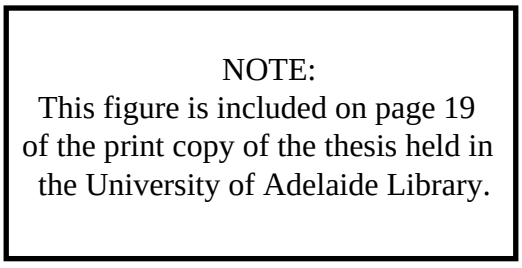
The Closed Innovation Model



Chesbrough, H. (2003b, p. 36)

FIGURE 2.2

The Open Innovation Model



Chesbrough, H. (2003b, p. 37)

TABLE 2.1
Contrasting Closed and Open Innovation

NOTE:
This table is included on page 20
of the print copy of the thesis held in
the University of Adelaide Library.

Adapted from: Chesbrough, H. (2003a, p. xxvi)

In Chesbrough's later contribution with his colleagues in 2006, they explored this paradigm based on a more comprehensive framework, involving the context of open innovation, the business models of open innovation, the appropriability and IP rights associated with open innovation practices, and the knowledge networks and value networks of open innovation, etc. They examined these important issues according to three main foci — firms implementing open innovation, institutions governing open innovation and networks shaping open innovation (Chesbrough, Vanhaverbeke and West, eds., 2006). It is important to note that most of their discussion at that time was constructed conceptually on the basis of axiomatic assumptions relating to definitions, features, boundaries and theoretical foundations of the paradigm, yet in doing so they provided subsequent researchers with valuable insights as to how empirically test the theories of open innovation posed by these pioneering studies in the field.

2.3 Definition and Advantages of Open Innovation

Building upon the belief that innovations are not necessarily always inspired and developed entirely within a single firm, the open innovation paradigm was defined by Chesbrough (2003a, p. xxiv) as "a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology". According to this definition, the open innovation model is fundamentally in accordance with the logic of systems perspective which emphasises the permeability of an organisation's transactional and knowledge boundary (Ashmos and Huber, 1987; Pisano, 1990), and evolutionary theory which stresses an organisation's openness to external environment and its

search strategy for creating new opportunities of development (Nelson and Winter, 1982).

Chesbrough further refined this definition in his later work (2006a, p. 1), "open innovation is the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand markets for external use of innovation, respectively", which has become the most frequently cited definition in the open innovation research. This definition implies two essential approaches opening up a firm's innovation processes: the outside-in approach of incorporating external knowledge and ideas as a supplement to the internal research; and the inside-out approach of developing a broad range of internal and external commercialisation channels, involving not only traditional distribution methods but also new forms such as licensing out, spin-offs and joint ventures (Chesbrough, 2003a). These two approaches have been summarised as Inbound Open Innovation and Outbound Open Innovation by Chesbrough and Crowther (2006).

The advantages of open innovation can be largely realised through both inbound and outbound approaches. The impacts of open innovation strategy on innovative performance are found to be positive and significant by some studies (Dodgson, Gann and Salter, 2006; West and Gallagher, 2006a). Open innovation is beneficial for firms in terms of its role in facilitating information exchange, transmitting complementary expertise, spreading research costs and risks, and generating synergy effects between members engaged in open innovation networks (Chesbrough, 2003a; Christensen, 2006; Negassi, 2004). A technological leadership can also be gained in this way particularly for firms who are more capable of effectively absorbing external

knowledge to overcome existing deficiencies in their knowledge bases and thereby build their own intellectual capital and technological competencies. Open innovation strategy can be also viewed as a source of potential competitive advantage in terms of the successful integration of externally sourced innovations with in-house research capabilities, which could not be easily imitated by competitors (Chesbrough and Crowther, 2006; Lichtenthaler, 2008).

2.4 RESEARCH INTO OPEN INNOVATION TO DATE

The paradigm of open innovation has been receiving growing research attention recently. In addition to Chesbrough and his colleagues' prominent contribution, many other studies have been conducted on a variety of aspects of this emerging paradigm, including the influences of industrial dynamics and environmental factors on open innovation adoption (e.g. Christensen, Olesen and Kjær, 2005; Lichtenthaler, 2009a); the effectiveness of environmental scanning and open search patterns (e.g. Enkel and Gassmann, 2008; Laursen and Salter, 2006); the relationship between internal and external R&D (e.g. Chesbrough and Crowther, 2006; West and Gallagher, 2006a); the role of absorptive capacity in facilitating open innovation performance (e.g. Lichtenthaler and Lichtenthaler, 2009; Spithoven, Clarysse and Knockaert, 2010); the strategic approaches to open innovation (e.g. Lichtenthaler, 2008); the innovation commercialisation and appropriation regimes in the context of openness (e.g. Elmquist, Fredberg and Ollila, 2009; Henkel, 2006); and the business models, management styles and organisational changes in line with open strategies (e.g. Grönlund, Sjödin and Frishammar, 2010; van der Meer, 2007). These studies have greatly contributed to the examination of open innovation principles, especially from

the empirical perspective. Additionally, Dahlander and Gann (2010) provided a comprehensive review of current important research which has been done in this field.

However, other than advocates of the idea of open innovation, there are also some critics. Some of them challenge whether open innovation, which has been widely recognised as a new paradigm for innovation and R&D management, signifies some novel organisational phenomenon or just re-packages the old theories relating to R&D externalisation and R&D collaboration, and re-conceptualises these ideas by the new term (Mowery, 2009; Trott and Hartmann, 2009). The Journal of Technovation recently initiated a discussion on the question "is open innovation a field of study or a communication barrier to theory development?" which received many responses critically reflecting on the rationale and validity of open innovation as a new paradigm (Groen and Linton, 2010, p. 554).

2.5 GAPS IN THE EXTANT LITERATURE

These critics lead us to think about what research efforts should be further made to clarify current understanding of open innovation. Research into this field is still at the beginning stage, leaving many essential issues unresolved. These issues should be carefully investigated given the two fundamental gaps found in the extant literature.

2.5.1 Generalisability of Open Innovation Paradigm

First gap lies in the generalisability of this paradigm, namely the universal applicability of the open strategy to all types of firms. Chesbrough's (2003a) comparison between closed and open models mainly focused on the specific cases of

large or leading industrial corporations in high-technology industries, such as AT&T, IBM and Microsoft, the generalisability of this new paradigm to smaller-sized firms in other industries remains unclear. Although this issue has been tested in several different contexts by other researchers, such as in lower-technology industries (e.g. Chesbrough and Crowther, 2006; Laursen and Salter, 2006) and for SMEs (e.g. Lee, Park, Yoon and Park, 2010; van de Vrande, de Jong, Vanhaverbeke and de Rochemont, 2009), the wider applicability of open innovation hasn't been fully explored by the limited attempts of these studies.

It has been noted that large and small firms conduct their innovations in a quite different pattern with their respective strengths and weaknesses. Large firms enjoy adequate resources and capabilities for R&D while smaller firms are more able to deliver quick responses towards external innovative opportunities. Open innovation seems to be necessary for both large and small firms in theory. Larger firms tend to resort to external linkages as a supplement to their in-house R&D because the high degree of product and technology diversification might make them incapable of conducting innovations by themselves alone (Arora and Gambardella, 1990; Granstrand and Oskarsson, 1994; Veugelers and Cassiman, 1999). On the other hand, the resource disadvantages impel SMEs to pursue external research assistance. Nevertheless, given smaller firms' insufficient resources and capabilities in the management of knowledge flows and their innate inferior positions when challenging larger partners, there might be comparatively more potential problems for them to appropriate benefits from openness (Forrest, 1990; Gomes-Casseres, 1997). Based on this consideration, the effectiveness of open innovation strategy with the contingent factor of firm size deserves further investigation.

In addition, the majority of empirical literature relating to the practice of open innovation is drawn from data of the United States where a higher level of innovation and a more elaborate knowledge diffusion system can be observed (involving government agencies, strong universities, closely collocated firms and industries). Similarly, relatively more research attention has been paid to the high-technology and knowledge-intensive industries which exhibit higher overall level of innovation and greater external knowledge sourcing activities than other industries (Bee, 2003; Grindley and Teece, 1998). Therefore, questions are raised as to the applicability of open innovation outside these jurisdictions (Simard and West, 2006).

Furthermore, extant research on open innovation has predominantly placed emphasis on the product-centric innovation pattern. Process innovation, as another primary form of innovation, has been largely ignored in terms of its relevance to openness (Reichstein and Salter, 2006). The inherently distinctive characteristics between product and process innovation tend to result in differential influences on the open innovation performance. This also constitutes another important domain for the test of the generalisability of this emerging paradigm.

2.5.2 Challenges (Potential Costs and Threats) Associated with Open Innovation

Despite theoretical assumptions on the potential benefits that open innovation is likely to bring, it is pointed out by Dahlander and Gann (2010) that there is a limited understanding about the challenges associated with open innovation in the extant literature. This ambiguity highlights the second gap in the research of open innovation.

These challenges include costs with regard to the engagement in open innovation practices, for example, costs of knowledge search and external sourcing, transactions costs arising from the acquisition of IP or the sponsorship of external development of new products, and costs associated with coordinating open innovation networks (Christensen et al., 2005).

Other than costs, challenges also involve potential risks and threats resulted from openness mainly from two senses. First, while the transmission of complementary knowledge across firm boundaries can create relational benefits, the benefits of an open innovation arrangement might lead to a diminished level of the rarity and uniqueness of a firm‘s resources and capabilities. According to the resource based view, the potential loss of resource and capability heterogeneity is likely to undermine competitive advantages of open innovators in the long run. In light of this form of potential competitive disadvantage, the actual benefits which are supposed to be gained from open innovation practices require scrutiny.

Second, some researchers such as von Hippel (2010) highlighted the need for improving conceptual clarity of the open innovation notion. It has been argued that the theoretical foundations of open innovation paradigm, to some extent, give rise to a ‘paradox’ for firms (Laursen and Salter, 2005). On the one hand, open innovation theories suggest that the generation of innovative outputs is facilitated by more openness towards external sources of knowledge (Chesbrough, 2003a). Such openness encourages the knowledge flows between firms through the less constrained IP and limited appropriation of knowledge royalties. On the other hand, with the concern that the fluid knowledge and information flows are more easily gained by

competitors than before, firms might seek to exert more control over the knowledge transfer process to appropriate future rents and thereby capture value from open innovation (West, 2006). This paradox is essentially driven by the conflict between knowledge sharing and knowledge protection. The difficulty in finding the right balance between disclosing some degree of knowledge to benefit from openness and protecting the core knowledge to maintain an competitive advantage exposes firms to the risks of a failure in the open innovation implementation (Laursen and Salter, 2005; West and Gallagher, 2006b). However, this threat of being trapped in the paradox of openness has been neither theoretically elaborated nor empirically examined so far.

This doctoral research seeks to contribute to the current understanding of open innovation paradigm through addressing these two main gaps existing in the literature. The two research questions put forward earlier (i.e. *first, is the open innovation strategy applicable to all types of firms? second, do the benefits of open innovation outweigh its potential costs and threats*) correspond to these two gaps respectively. Both questions are fully explored throughout the five research projects composing this thesis.

CHAPTER III

Openness in Product and Process Innovation:

Evidence from Australian Industry

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STATEMENT OF AUTHORSHIP

OPENNESS IN PRODUCT AND PROCESS INNOVATION: EVIDENCE FROM AUSTRALIAN INDUSTRY

Journal paper

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For this paper (chapter), Fang Huang developed theoretical framework and hypotheses, performed analysis on data, interpreted data, wrote manuscript and acted as corresponding author. Dr John Rice assisted in guiding theory development, supervised development of work, and provided critical evaluation.

The majority of the work and the primary authorship have been undertaken by Fang Huang.

Fang Huang (Candidate)

I hereby certify that the statement of contribution is accurate.

Signed [redacted] Date 29/8/11

Dr John Rice

I hereby certify that the statement of contribution is accurate and I give permission for the inclusion of the paper in the thesis.

Signed [redacted] Date 17/8/11

THE RELATIONSHIP OF THIS CHAPTER TO THE DOCTORAL RESEARCH

Process innovation, which usually takes the form of new technological processes or new organisational (managerial) processes, is one of the most basic and primary types of innovation activities. While most assumptions around open innovation have been built upon the context of product innovation, the applicability of this new paradigm to process innovation requires further investigation. My doctoral research begins from the most fundamental notions of innovation patterns and their relationships with the ideas of this new innovation mode. Through an examination of open innovation's role in generating new processes and a comparison with its role in driving product innovation, valuable insights are provided into the first research question regarding the generalisability issue of this emerging innovation paradigm.

ABSTRACT

Open innovation has generally been explored in terms of improved innovation performance vis-à-vis product/service innovation performance. However, the process innovation is often ignored in the open innovation literature. In this study, I assess the impact of openness on innovation in products/services, and also on process innovation drawing on a large-scale sample of Australian firms. I assess direct effects, and also examine whether the declining utility of openness noted by previous authors holds for each form of innovation. I extend this declining utility model to explore the impact on innovation performance by investments in absorptive capacity. In essence, I find that open innovation models are useful for firms seeking to innovate in processes as well as products and services. However, I find that openness to external information sources and investments in absorptive capacity may, after a time, lead to decreasing marginal returns as measured by innovation performance. I also observe that, within the sample examined for this paper, the proposed complementarities between internal and external research might be more evident in the introduction of new products and services, and may not be as beneficial in stimulating process innovation. In the case of process innovation, I find that external knowledge and other external stimuli will contribute much more to innovation improvement than will the employment of in-house R&D. It is suggested that more empirical studies are required to explore the generalisability of this emerging paradigm in different innovation contexts.

3.1 INTRODUCTORY BACKGROUND

3.1.1 Product and Process Innovation

Innovation is a multi-faceted phenomenon. Kline and Rosenberg (1986, p. 275) defined innovation as incorporating "a series of changes in a complete system, not only of hardware but also of market environment, production facilities and knowledge". Such a holistic definition implies that innovation adoption can be viewed as a means by which an organisation may facilitate tangible changes in its product or service portfolio, or its means of operation and value creation, in order to adapt to its environment and to sustain effectiveness and competitiveness (Damanpour and Gopalakrishnan, 2001).

Given the great variety of forms of innovation (Edquist, Hommen and McKelvey, 2001), I first seek to clarify the distinctions and relationships between its different types. According to Nelson and Winter (1977, p. 48), innovation is "any nontrivial change in product or process, if there has been no prior [organisational] experience". It shows that 'innovation' essentially takes the form of 'change', which is also indicated within Kline and Rosenberg's (1986) definition mentioned earlier. This change in turn consists of two main elements — changes in the specific products/services offered to the customers or clients, and changes in the mode in which they are created and delivered (Barras, 1986; Damanpour and Gopalakrishnan, 2001). These two correspond to 'product' innovation and 'process' innovation respectively (Tidd, Bessant and Pavitt, 2001, p. 6). Product innovation focuses on *what* is produced, while process innovation is concerned about *how* existing products/services are produced (Edquist et al., 2001).

Organisations with the ability to concomitantly adopt both product and process innovation are in an advantageous position in dynamic and competitive environment (Presley, Sarkis and Liles, 2000; Sen and Egelhoff, 2000). Despite this, product innovation has been found generally to be adopted at a greater rate and speed than process innovation (Damanpour and Gopalakrishnan, 2001). Product innovation can be used to strategically differentiate an organisation's product offerings and determine organisational performance and survival, through the substitution of goods and services that have been superseded in the marketplace, thereby satisfying new market demands and building customer loyalty (Brown and Eisenhardt, 1995; Damanpour, 1991; Damanpour and Gopalakrishnan, 2001; Edquist et al., 2001; Weiss and Birnbaum, 1989). Process innovation has been termed as the "most primitive form of innovation" (Tushman and Rosenkopf, 1992, p. 313), although this is not meant negatively and is a reference to its fundamental developmental importance within organisations. It has been found to be an important driver for firm performance and an essential strategic means to improve a firm's competitive position (Hatch and Mowery, 1998; Reichstein and Salter, 2006; Utterback, 1994). Tidd et al (2001, p. 5) argued "while new products are often seen as the cutting edge of innovation in the marketplace, process innovation plays just as important a strategic role". The strategic advantages of process innovation can be achieved through improving quality, achieving cost leadership, and enhancing efficiency and effectiveness of the organisation (Damanpour and Gopalakrishnan, 2001; Howells and Tether, 2006; Utterback and Abernathy, 1975).

In practice these two main types of innovation always occur together (Gattiker, 1990) because of their interdependent and inseparability nature (Damanpour, 1991; Pisano, 1997). The adoption of product innovation is positively associated with the adoption of process innovation (Damanpour and Gopalakrishnan, 2001). It has been noted that, given the equal importance of their strategic roles and the complementarity between them, successful organisations should employ effective and efficient processes for producing and delivering both forms of innovation simultaneously (Damanpour and Gopalakrishnan, 2001; Reichstein and Salter, 2006). I thus note that it is necessary and important to assess innovation in both of its forms, rather than focusing exclusively on product innovation.

Process innovation typically encompasses both technological and organisational dimensions (Edquist et al., 2001; Reichstein and Salter, 2006). The distinction between these sub-categories emerges from whether the process innovation involves technological elements or only relates to the coordination of human resources or other organisational systems (Edquist et al., 2001). Technological process innovation is reflected by the units of material goods improved through technical changes (Edquist et al., 2001), including the adoption of production processing systems and technologies that are new to the organisation (Ahire and Ravichandran, 2001). Typically, technological process innovation takes the form of improvements in operating procedures (Brown and Karagozoglu, 1989; Damanpour, 1991), consisting both of enhanced manufacturing operations (Davenport, 1993; Reichstein and Salter, 2006), and improved service operations (Damanpour and Gopalakrishnan, 2001). The improved operational processes can in turn improve product/service quality, lower costs of production, and/or enhance the ways of offering products that competitors

cannot follow. Examples of technological process innovation may include faster or more customised product development (Tidd et al., 2001), improvements in a firm's manufacturing efficiency by employing JIT (Just-In-Time) inventory system and lean production (examined within Toyota by Dyer and Nobeoka (2000)).

Firms may also improve their organisational and managerial processes to support technological changes and capture the potential benefits of better market-facing innovation outcomes. According to Ettlie (2006), technological changes in products and operations might concurrently lead to other changes in organisational processes with new administrative procedures, new strategies and new organisational structures. It is also argued that the successful adoption of process technology depends on the successful implementation of changes in the organisation's structure and administrative practices (Ettlie and Reza, 1992; Nasbeth and Ray, 1974). However, as organisational process innovation tends to be intangible in nature, and are directly related to management practices rather than basic production or service operations (Ahire and Ravichandran, 2001), they are often under-reported in the innovation literature, or merely included in the form of technological process innovation (Edquist et al., 2001). Edquist et al (2001) thus emphasised the importance of separating organisational process innovation from the technological type, with the former defined as new ways to organise business activities or organisational changes. Examples of organisational process innovation include six-sigma systems introduced by GE to reduce unintended processual variations that may be a source of concern to its customers (Garg, Narahari and Viswanadham, 2004; Snee, and Hoerl, 2003) and Total Quality Management (TQM) which entails better quality management of organisations (Ahire and Ravichandran, 2001).

3.1.2 The Paradigm of Open Innovation

While earlier innovation literature highlighted the importance of internal capabilities of R&D as drivers of fairly closed and internally-integrated linear patterns of innovation (Collins, 2006; Lichtenthaler, 2008), later empirical research in innovation, especially 'third generation' coupling models, has begun to focus on more interactive processes integrating both internal and external actors and knowledge sources to facilitate new idea creation and to foster innovation (Brown and Eisenhardt, 1995; Hienerth, 2006). These integrative models offer a more holistic and non-linear perspective on innovation that emphasises contextual engagement and responsiveness to a firm's operational environment (Miller and Blais, 1993). This 'open' perspective fundamentally demonstrates the usefulness of the porosity of a firm's knowledge and transactional boundary (Collins, 2006), and the interaction between the firm and its external environment (Pisano, 1990; Pittaway et al., 2004).

This growing literature regarding the benefits of openness has been termed 'open innovation' by Chesbrough (2003a, 2003b). Firms pursuing it are seen to employ the "use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand markets for external use of innovation, respectively" (Chesbrough, 2006a, p. 1). More recently, many researchers have empirically extended the literature exploring issues relating to the shift in innovation practice from closed to open models from various aspects and contexts (e.g. Dodgson, Gann and Salter, 2006; Enkel and Gassmann, 2008; Henkel, 2006; Laursen and Salter, 2006; Lee, Park, Yoon and Park, 2010; Lichtenthaler, 2008; West and Gallagher, 2006a). Despite these

contributions to the open innovation literature, the impacts of openness on the performance of various forms of innovation, especially process innovation, have not been adequately investigated previously (West and Gallagher, 2006a).

Innovations usually have the aim of reducing gaps between a firm's product/service portfolio and market requirements. Less commonly, innovations may have the aim of creating market uncertainty and perturbation as a means of enhancing firm differentiation and competitiveness (Freeman and Soete, 1997). In either of these forms, the value created by innovation tends to be extended by openness in three ways. First, the successful integration of externally sourced knowledge with in-house capabilities can create complexity and differentiation that is inimitable to competitors (Arora and Gambardella, 1990; Cassiman and Veugelers, 2006). Second, open approaches can facilitate the transmission of complementary expertise and resources across organisational boundaries (Chesbrough, 2005; Ciborra, 1991; Mody, 1993). Furthermore, the threats in the traditional innovation marketplaces such as the failure of new products to gain market acceptance can be alleviated through some of the open innovation practices, for example, lead user involvement and inter-firm collaborations (Bilgram, Brem and Voigt, 2008; Negassi, 2004).

However, open innovation is not without its limitations (Elmquist et al., 2009). Several potential disadvantages have been addressed by recent research. First, some open innovation approaches might be associated with high coordination costs resulting from involving external parties in the innovation processes, and transaction costs arising from contractual negotiations (Christensen, Olesen and Kjær, 2005). Furthermore, it is sometimes hard to appropriate values from 'freely revealed'

information facilitated by open innovation practices (Elmquist et al., 2009; von Hippel and von Krogh, 2006).

3.1.3 Openness in the Context of Product and Process Innovation

The potential for openness to increase the positive impact of innovation, both in terms of products and processes, is evident (Davenport, 1993; Rothwell, 1986, 1994; von Hippel, 1988). While the incorporation of external knowledge is most often associated with the potential to improve R&D, other organisational functions like manufacturing and marketing have also been shown to be amenable to such integration (Bogers and Lhuillery, 2010). While the forms and drivers of product and process innovation differ, all can be facilitated, wholly or in part, by a combination of 'in-house' development and the sourcing of external knowledge and technologies, namely the "simultaneous use of external and internal integrating mechanisms to be successful" (Ettlie and Reza, 1992, p. 801). This is consistent with the main principle of open innovation that "external research may function more as a complement than as a substitute in the performance of internal R&D activities" (Chesbrough and Crowther, 2006, p. 235).

3.1.4 Limitations of the Extant Research

Although process innovation's market and economic impacts are as significant as the introduction of new products/services, and while process innovation commands significant attention in innovation research (Reichstein and Salter, 2006), this form of innovation is often downplayed in the innovation literature at large (Ettlie, 2006; Hatch and Mowery, 1998; Pisano, 1997; Reichstein and Salter, 2006). This might be a result of process innovation's attributes which are somewhat 'diffuse and elastic'

(Reichstein and Salter, 2006, p. 655), and evident only within the confines of the 'black box' of the firm, and hence hard to measure (Damanpour and Gopalakrishnan, 2001; Rosenberg, 1982). Indeed, consistent with the wider innovation literature, most measures of innovation performance used in the empirical research on open innovation are related to the product innovation output (e.g. Bahemia and Squire, 2010; Grönlund, Sjödin and Frishammar, 2010; Laursen and Salter, 2006; Lichtenthaler, 2008).

In order to address this important gap in the existing literature, this paper seeks to assess open innovation issues in the context of process innovation as well as product innovation. It then explores innovation performance of process innovation in two sub-areas — in the development and utilisation of new technological processes (especially in terms of operational processes) and in the development and adoption of new organisational and managerial processes. Similar to the studies of Damanpour and Gopalakrishnan (2001) and Reichstein and Salter (2006), this study will also focus on individual firms as the unit of analysis.

The remainder of the paper is structured as follows. In the next section the theoretical framework for this study is presented, with hypotheses extending from this framework developed. Then, issues relating to the sample and measures are stated, followed by a discussion of the statistical methods employed. Finally, the research results are presented with an elaboration and discussion of my findings.

3.2 THEORETICAL FRAMEWORK & HYPOTHESES

Although the term 'open innovation' is relatively recent, the organisational phenomena that it describes are not (Christensen et al., 2005). Open innovation's principles and fundamental ideas are based on rich traditions from prior research. Its essential contribution is to draw together a comprehensive and systematic perspective on R&D externalisation and environmental interaction and engagement (Christensen et al., 2005; Grönlund et al., 2010). The primary sources of antecedent theories for open innovation can be summarised according to the three main dimensions below. These dimensions also form the foundation for the theoretical framework of this study.

The first important literature relates to external knowledge networks and related technology-sourcing activities, including external collaboration, process outsourcing, technology acquisition, licensing, and technology commercialisation (Freeman, 1991; Jones, Lanctot and Teegen, 2001; Mitchell and Singh, 1996; Sen and Egelhoff, 2000; Witzeman et al., 2006). Indeed, various recent studies have focused on how firms utilise external knowledge through the use of various collaborative or contractual arrangements to complement their internal innovative abilities (e.g. Deeds and Hill, 1996; Rothwell, 1992). Such specific means to interacting with external environment have been recently contextualised as the main dimensions of a firm's strategic approaches to openness in the open innovation literature (Lichtenthaler, 2008; Rasmussen, 2007).

The second important body of literature builds on the role of external knowledge inflows and outflows as facilitators of innovation, through a wide range of external

knowledge sources, such as customer, supplier, competitor and research institutes (Arora and Gambardella, 1990; Knudsen, 2007; von Hippel, 1988). Recently, it has been recognised that the breadth of external knowledge and technology sources is important, with this diversity acting as a driver of a firm's internal growth, value creation process and innovation performance (Grönlund et al., 2010; Laursen and Salter, 2006; Lichtenthaler, 2008). The extent of accessing and utilising external knowledge sources comprises one of the central dimensions which indicate the degree of openness — the external search breadth (Laursen and Salter, 2006). It implies those firms with higher numbers of external sources tend to be more 'open' than others.

The third stream of the antecedent research regarding open innovation investigates the importance of internal mechanisms to integrate externally-sourced know-how and technology (Bogers and Lhuillery, 2010; Ettlie and Reza, 1992). This integrative ability is akin to Cohen and Levinthal's 'absorptive capacity' construct — namely an ability to "identify, assimilate, and exploit knowledge from the environment" (Cohen and Levinthal, 1989, p. 569).

Absorptive capacity assists in the development of an endogenous capability-based framework as a means of ensuring sustainable open innovation performance (Chesbrough, 2006b; Lichtenthaler and Lichtenthaler, 2009; West and Gallagher, 2006a). Successful open innovators dynamically develop their capacities to achieve the potentially strong synergies between external research and in-house R&D, hence yield the best results in terms of innovation performance (Belderbos, Carree and Lokshin, 2006; Chesbrough, 2003a, 2006b). In accordance with the open innovation principle concerning the complementary rather than substituting role of openness

(Chesbrough and Crowther, 2006), this new paradigm particularly underscores the internal modes and configurations which are imperative for managing external-oriented innovation processes (Christensen et al., 2005; Grönlund et al., 2010). Therefore not only the external focus but also the internal perspective should be highlighted in the open innovation studies.

Based on readings of the relevant literature, a conceptual framework has been constructed for this study integrating both internal and external elements. This incorporation of the focal firms' external and internal activities and resources is consistent with open innovation's integrative focus, and builds on Lichtenthaler's (2008, p. 156) argument that "the need to understand the relation between the strategic approach to open innovation and a firm's capabilities and culture of managing technology has to be emphasised". Lichtenthaler's (2008) framework is then further extended by integrating the three main streams of underlying theories in the area of open innovation as discussed above.

Hypotheses are built based upon this conceptual framework. The first and the second focus on the respective effects of open innovation approaches and external knowledge sources on innovation performance. The third and the fourth examine the role of in-house research in terms of the investment in R&D and absorptive capacity to catalyse the benefits of openness.

3.2.1 Open Approaches and Innovation Performance

Firms adopt 'openness' by adopting strategies that internalise knowledge via cooperation with other firms or acquisition from the market (Arora and Gambardella, 1990; Cassiman and Veugelers, 2006; Veugelers and Cassiman, 1999). In that sense, the primary processes adopted by open innovators are *collaborative* or *transactional* (Christensen et al., 2005; Igartua, Garrigós and Hervas-Oliver, 2010). Thus, a firm's inter-organisational collaborations, technology acquisitions, and its use of R&D outsourcing arrangements are adopted as relevant measures of a firm's open innovation strategy.

Cooperative R&D arrangements have been shown as optimal arrangements to obtain complementary know-how from partner firms. In addition to enhancing the potential variety and availability of external knowledge, collaborations and alliances also provides the platform for knowledge transfer with a high degree of reciprocity (Belderbos et al., 2004, 2006; Stuart, 2000). Their contribution to innovativeness and firm performance has been widely supported by prior empirical studies (Deeds and Hill, 1996; Faems, Van Looy and Debackere, 2005; Hagedoorn and Schakenraad, 1994; Hoang and Rothaermel, 2005).

Although the partnership of R&D garners most attention in open innovation research (Hagedoorn and Schakenraad, 1994; Presley et al., 2000), this study will also focus on other *collaborative* arrangements between firms that may facilitate the transfer of tacit and/or explicit knowledge. These include manufacturing, marketing and distribution alliances, and other joint ventures arrangements (Belderbos et al., 2004, Faems et al., 2005). The integration between different functions such as R&D and other upstream

and downstream functions has been found to have a more significant role in determining innovation output, especially in terms of the successful commercialisation of newly developed products/services (Ettlie and Reza, 1992).

The acquisition of external technology can also follow *transactional* arrangements, for example, the purchase of technology embodied in patents, trademarks or licenses (Sen and Rubenstein, 1989). Such arrangements facilitate the 'buy' option for firms with 'make or buy' strategic choices ('make or buy' refers to the alternatives of conducting in-house R&D or commercially buying in technology) (Kurokawa, 1997). The increasing importance of technology acquisition to complement firms' internal technology portfolios has been widely acknowledged (Kurokawa, 1997; Veugelers, 1997; Veugelers and Cassiman, 1999). Recently more firms have begun to acquire major elements of their technological inventory from outside sources (Jones et al., 2001; Lichtenthaler, 2008). Another *transactional* form of technology acquisition is R&D outsourcing — outsourcing the innovation activities from a R&D contractor or consulting agency (Veugelers and Cassiman, 1999). Different from direct technology purchase, this form of environmental engagement is usually adopted to obtain specialist skills that a firm does not necessarily need to retain in house because of 'insufficient' or 'lumpy' demand (Howells, 1999).

The common advantages of these open innovation approaches for both product and process innovation can be essentially reflected by the value-creation benefits they can provide which surpass traditional closed innovation arrangements occurring within firm boundaries. Examples of these include the potential for fluid transmission of complementary expertise and resources between firms, the deepening and enrichment

of firms' knowledge bases (Ciborra, 1991; Hagedoorn and Duysters, 2002; Haour, 1992; Mody, 1993); the access to external specialised know-how which the firms may lack to overcome existing technological deficiencies (Ahuja, 2000; Cooke, 1996; Powell, Koput and Smith-Doerr, 1996); and the sharing of risks, costs and rewards (and hence commitment) among collaborators in an open innovation network (Grandori, 1997). Additionally, firms may gain a technological edge or lead time advantage relative to rivals through the realisation of temporal synergies of internal and external research (Chesbrough, 2003a).

Based on this analysis, I propose the following hypothesis:

H1a: Basic open innovation approaches, such as inter-organisational collaboration, technology acquisition and R&D outsourcing, will positively affect (both product and process) innovation performance.

Furthermore, the various use of these different approaches lead to different intermediate outcomes and thus tend to play different roles in acquiring external knowledge and in turn shaping innovation performance. Compared with other approaches, the outsourcing of R&D activities leads to heightened uncertainties vis-à-vis innovation outcomes.

It has been suggested by open innovation theories that firms should not outsource their entire R&D function because the integration of internal R&D and external research could create unique capabilities, which is an important source from which a potential competitive advantage can be derived (Chesbrough and Crowther, 2006). This argument is also supported by Grimpe and Kaiser (2010) who believed that,

R&D outsourcing might be detrimental to innovation performance as excessive external knowledge acquisition through outsourcing might hurt such integrative capabilities.

It has been also noted that an arrangement whereby firms reserve their key technology developments in house while contracting out more peripheral activities to outside R&D suppliers, reduces the spillover of key knowledge and technology from firms to the Contract Research and Technology market (Ulset, 1996). According to Sen and Rubenstein (1989), firms should still focus on the strategic technological areas in which internal R&D can provide the most competitive advantage while contracting out less significant areas. These areas are primarily non-specialised, and may include more routine research tasks (Howells, 1999; Veugelers and Cassiman, 1999).

Thus, as R&D outsourcing is used more selectively and generally only partially, I would expect that it is likely to have a relatively weaker impact on innovation performance:

H1b: Regarding the three basic approaches to open innovation discussed previously, R&D outsourcing tends to have a relatively weaker impact on innovation performance than the other two.

3.2.2 External Knowledge Sources and Innovation Performance

Empirical studies have recognised the strategic importance of the wide range of knowledge sources for open innovation (involving the linkages of customers, suppliers, competitors and research institution linkages), not only for product

innovation success (Laursen and Salter, 2006), but also for process innovation facilitation (Reichstein and Salter, 2006).

While firms' degree of openness has been variously defined, it can be partially operationalised in terms of the scope of external sources of knowledge used by the firm (Katila and Ahuja, 2002; Laursen and Salter, 2006). Studies by these researchers have found empirical support for the existence of a curvilinear (inverse U) relationship between knowledge sourcing and innovation performance. This implies that a certain level of openness towards external knowledge sources is necessary to encourage innovation — this being consistent with the basic assumption in the open innovation literature that some vibrancy of relations between users, suppliers and competitors is often beneficial to achieving innovation effectiveness (von Hippel, 1988).

However, inefficiencies might develop when excessive search actually begins to inhibit the innovation effectiveness of firms. This negative outcome is likely to be driven by the attention allocation problem (Ocasio, 1997; Simon, 1997), excessive knowledge search costs (Kogut and Zander, 1992) or other related factors. A conclusion might be that if the scope of external sources employed (i.e. a firm's search breadth) is too broad, various diseconomies might occur which would be observed when dealing with multiple external partners (Belderbos et al., 2006). Such tendency toward 'over-search' (Katila and Ahuja, 2002) might distract managerial attention from the real priorities in knowledge utilisation and commercialisation (Laursen and Salter, 2006). Therefore, if the benefits originating from incorporating more external sources do not outweigh the problems which over-search and

over-openness create, a negative marginal impact of external knowledge sourcing will occur, eventually detracting from the initial positive returns gained from openness. On this basis, I hypothesize:

H2: The extent of external knowledge sourcing (as defined by the scope of external sources employed) is curvilinearly (taking an inverted U-shape) related to (both product and process) innovation performance.

3.2.3 Internal R&D and Innovation Performance

It might be assumed that under the open innovation paradigm, firms might forego internal R&D and its associated costs and risks, while compensating for its absence by drawing on knowledge and expertise from a broad range of external sources (Laursen and Salter, 2006). This contention tends to ignore potential synergy-based complementarities that may be generated through the successful combination of internal and external know-how and technology, which may yield strong results in terms of innovation and innovation appropriation (Arora and Gambardella, 1990; Cassiman and Veugelers, 2006; Macpherson, 1997). Thus in-house R&D need not become obsolete or declined when open innovation strategies are followed — indeed openness may even stimulate internal research investments in search of such synergies (Howells, 1999; Veugelers, 1997). Further, in addition to the traditional role of generating innovation alone, in-house R&D may act as a catalyst to facilitate the transformative efficiency and effectiveness once the knowledge reaches the focal firm (Cohen and Levinthal, 1989; Lane, Koka and Pathak, 2006).

The overall status of knowledge-based skills within the firm could be improved by such integrative knowledge management (Cassiman and Veugelers, 2006; Lichtenthaler and Lichtenthaler, 2009). This complementarity between internal R&D and external innovation has also been illustrated in some empirical studies on open innovation (e.g. Chesbrough and Crowther, 2006; Lichtenthaler, 2008). Based on these considerations, I predict that internal R&D input can benefit firms' innovation performance as well as the external research efforts in the context of open innovation.

H3a: Internal R&D input will positively affect (both product and process) innovation performance even while firms pursue open innovation arrangements.

However, the role of internal R&D might differ in different forms of innovation. According to Ettlie (2006), in most situations process innovation tends to be 'bought in' from outside rather than developed internally in organisations. Given the innate difficulties in differentiating between product and process related expenditures (Reichstein and Salter, 2006), traditional internal R&D investments tend to focus on the development of new products or services at the expense of new processes. This is supported in Rouvinen's (2002) empirical study which reported an insignificant relationship between investment in R&D and process innovation. According to Hatch and Mowery (1998), technological process innovation is usually facilitated through learning-by-doing within organisations and is therefore not usually dependent on formal R&D activities. In a similar vein, organisational process related innovation expenditures are rarely R&D-centric.

Thus formal R&D investments flow more to product innovation, and consequently will be more closely related to the product innovation performance. This argument can be stated in the following hypothesis:

H3b: Internal R&D input will have a greater impact on product innovation performance than process innovation performance.

3.2.4 Absorptive Capacity and Innovation Performance

Apart from R&D investment, another internal element of the open innovation framework relates to 'absorptive capacity'. This can be observed through the existence of a firm's systems and capabilities to affect absorption, integration and commercial transformation of externally gained knowledge (Cohen and Levinthal, 1989). The potentially positive significance of absorptive capacity in leveraging a firm's own knowledge base and facilitating innovation effectiveness has been asserted by much empirical research (DeSanctis, Glass and Ensing, 2002; Tsai, 2001; Zahra and Nielsen, 2002). The role of absorptive capacity in leveraging the benefits of open innovation stems from its two basic components — first, the identification and acquisition of external know-how, and second, the transformation and incorporation of this newly obtained knowledge into the existing knowledge fabric of the firm so as to generate greater value for innovation (Zahra and George, 2002).

The construct of absorptive capacity has been extended empirically by researchers seeking to contextualise innovation and knowledge management within a firm's internal operational and external competitive contexts. The multidimensional nature of this construct leads to the variety of measures used to capture it in various studies

(Lane et al., 2006; Liao, Welsch and Stoica, 2003). Given the tacit nature of this construct (Godfrey and Hill, 1995; Lane et al., 2006), proxy indicators are usually employed. Among them R&D intensity is most common (e.g. Cohen and Levinthal, 1990; Rocha, 1999; Stock, Greis and Fischer, 2001). This develops from the idea that in addition to the traditional role of generating innovation alone, R&D also contributes to the development of the firm's absorptive capacity, namely the two faces of R&D (Cohen and Levinthal, 1989).

Although R&D spending intensity does reflect some level of absorptive capacity (Reichstein and Salter, 2006), this measure has been frequently criticised as it "treats absorptive capacity as a static resource and not as a process or capability" (Lane et al., 2006, p. 838) and it does not take into account the quality of R&D work undertaken within the firm (Schmidt, 2009). Thus another proxy is usually used to operationalise this construct — R&D human capital (e.g. Gao, Xu and Yang, 2008; Liu and While, 1997; Veugelers, 1997). The validity of this measure can be linked to Cohen and Levinthal's (1990) argument that the absorptive capacity of a firm depends on the individual absorptive capacity of its members. In essence, absorptive capacity, as a kind of knowledge management capacity, needs to be facilitated by human knowledge rather than tools, machines and other tangible assets of a firm's R&D department (Lichtenthaler and Lichtenthaler, 2009). Such capability is especially important when some hidden knowledge and tacit experience need to be transferred between external sources and the firm's internal knowledge base (Bessant and Rush, 1993).

Both of these measures are based on the product innovation perspective. However, as has been discussed in the section above, for most process innovations, R&D is not the

central mechanism to undertake innovation activities or to integrate external knowledge (Arbussa and Coenders, 2007). Hitt et al. (2001) suggested that a firm's entire stock of human capital is required to fully exploit the firm's knowledge base and thus gain competitive advantage. Vinding (2006) also highlighted the importance of a firm's entire human capital to its absorptive capacity, and subsequent innovative performance. This broadened scope of the absorptive capacity measure is also consistent with some empirical studies (Becker and Peters, 2000; Kim and Dahlman, 1992; Luo, 1997). Based on these considerations, the investment in absorptive capacity will be operationalised by the presence of human capital in the whole organisation in this study.

In light of the benefits provided by absorptive capacity, its presence is generally considered an essential requirement for firms pursuing product innovation (West and Gallagher, 2006a) and process innovation (Reichstein and Salter, 2006). Nevertheless, the assertion that investment in absorptive capacity linearly and positively drives innovation performance is moot. First, it is often time-consuming and complex to transform various organisational intangible and tangible assets and routines, into capabilities embodying absorptive capacity (Zahra and George, 2002). Second, it has been suggested that external knowledge can only be assimilated when firms manage to change their organisational structure and culture to facilitate open innovation processes. Overcoming the 'not-invented-here' (NIH) syndrome (Katz and Allen, 1982), both at the level of individual employees' attitudes and at the level of the organisational culture, is imperative (Lichtenthaler and Lichtenthaler, 2009). The NIH syndrome which is usually embedded in the inwardly-focused culture inherited from

relatively closed innovation systems, might become highly resistant to the development of such knowledge absorption capacity (Laursen and Salter, 2006).

Moreover, the 'path-dependent' nature of absorptive capacity, noted by Cohen and Levinthal (1990), indicates that the effectiveness of absorptive capacity depends on the prior accumulation of knowledge (thus could be seen to drive innovation performance cumulatively). As a result, if a firm has lower levels of absorptive capacity due to the lack of previous investment, this might create further costs for them as they seek to achieve the given level of absorptive capacity in subsequent periods (Cohen and Levinthal, 1990).

Such a phenomenon was observed by Stock et al (2001), who reported an inverse-U relationship between absorptive capacity and new product development success. Similar to the discussion above in relation to the declining marginal utility of external knowledge sourcing, Stock et al (2001) found that only up to a certain level did absorptive capacity contribute to the higher performance in innovation.

In summary, the potential costs might bring out a mixed effect on innovation performance with regard to investments in absorptive capacity of the focal firm. If the returns gained from the enhanced absorptive capacity don't increase proportionally with the escalation of diverse potential costs to build and improve this capacity, the initial marginal benefit of absorptive capacity investments will decrease. If with the continued process of developing absorptive capacity, the costs impeding innovative performance keep outweighing benefits driving innovation, a negative effect on innovation performance will eventually be observed.

On the basis of this analysis, I hypothesize that there are declining marginal benefits created by absorptive capacity investments with regard to innovation performance:

H4: The investment in absorptive capacity (as operationalised by the presence of human capital in the organisation) is curvilinearly (taking an inverted U-shape) related to (both product and process) innovation performance in the context of openness.

3.3 METHODS

3.3.1 Sample

The data utilised for this study was collected by the Australian Bureau of Statistics (ABS) through their *2003 Innovation in Australian Business Survey (IABS)* (The Australian Bureau of Statistics, 2003). The data provides evidence on innovation-related activities of Australian businesses for the years 2001-2003. The database provides a rich set of information for the study of the organisational and perceived environmental context within which firms in Australia innovate. The data collected for this survey is largely consistent with concepts and standard questions in the Oslo Manual, prepared by the Organisation for Economic Co-operation and Development (OECD) (OECD, 1997). IABS provides some advantages over other international surveys particularly in terms of separating non-technological innovation from technological innovation (The Australian Bureau of Statistics, 2003). This is especially suitable for my study as I also differentiated between the technological process innovation and the non-technological organisational process innovation.

The population within which the IABS was gathered included all business units in Australia registered with the Australian Taxation Office and employing more than 4 persons, with the exception of government enterprises or businesses in several specific industries (i.e. Agriculture, Forestry and Fishing; Education; Health and Community Services; Personal and Other Services). The final sample of establishment-level data released by the ABS had 4,520 businesses (The Australian Bureau of Statistics, 2003). The sample was then refined by this study to ensure comparability and completeness of data provided by these responding businesses. Through a process of careful screening, a sub-sample of 4,322 Australian businesses (including both innovators and non-innovators) was identified for this study. All firms selected provided data for all items of the survey (i.e. there were no missing values included), and had non-zero total expenditures during the period of survey.

3.3.2 Measures

3.3.2.1 Dependent Variables

For this study, three dependent variables (DVs) are employed for three logistic regression-based models. The DV1 (*Innovtr1*) is akin to a measure of innovation performance often utilised in the innovation literature, namely the dichotomous response to the question of whether a firm has released a new product or service in the period under investigation. The DV2 (*Innovtr2*) marks the response to the question regarding whether the firm has introduced a new operational process internally (this has been indicated earlier as the primary form of technological process innovation). The final DV3 (*Innovtr3*) measures the deployment of new organisational/managerial processes.

Each business was asked whether it had introduced or implemented any of these forms of innovation during the calendar year 2003. The original responses were coded by IABS into dichotomous variables with a value of zero (0) if no such innovation had occurred, and one (1) if it had. Actually DV 2 and DV3 are both encompassed in the main innovation type of process innovation. They are treated as separate processes for modelling here given the distinctive innovative features between them. The IABS questionnaire provided definitions of the different types of innovation, and also gauged the relative degree of novelty for each innovation type. A new product or service was defined on the survey as "any good or service or combination of these which is new to this business", a new operational process was termed as "a significant change for this business in its methods of producing or delivering goods or services" while a new organisational/managerial process was referred to as "a significant change in this business's strategies, structures or routines which aim to improve the performance of this business" (The Australian Bureau of Statistics, 2003, p.15). These definitions are consistent with the terminology used in this study, assisting in the construct validity of the measures.

3.3.2.2 Independent Variables

Open Approaches — The three basic approaches to open innovation, namely inter-organisational collaborations, technology acquisition and R&D outsourcing (the definitions and scope of these concepts have been addressed earlier in this study) are measured as follows.

The use of Inter-organisational Collaborations (*Collaboration*) is measured by aggregating the six survey questions relating to whether the business had engaged in any collaborations (to develop new products/services or new processes during the calendar year 2003) in the form of joint marketing or distribution, joint manufacturing, joint research and development, other joint ventures, licensing agreements, or other forms of collaboration. Each question is a binary variable taking the value of 1 when the business indicates that it has used this type of collaboration and 0 otherwise. Therefore, the aggregate ordinal measure ranges from 0 to 6. This measure embraces various inter-organisational collaboration forms in addition to the R&D cooperation, including manufacturing, marketing and distribution alliances, and other joint ventures arrangements. As discussed in the hypotheses development section, this construct is based on the consideration that other than R&D, upstream and downstream functions also play a significant role in facilitating knowledge transfer, commercialising newly developed products/services, and eventually improving a firm's innovation outputs.

Technology Acquisition (*TechAcquisition)* is constructed in terms of the technology buy-in intensity that is calculated by dividing a firm's total expenditure on all activities by the accumulated expenditure on machinery, equipment, licenses, patents and other intellectual property externally acquired to develop innovation. These actual expenditure values were gathered by the ABS, and thus provide a continuous measure of financial expenditures on external knowledge.

R&D Outsourcing (*Outsourcing*) is measured by the responses to the question relating to whether the business had contracted out R&D to higher education or research

institutions, based either in Australia or overseas. The original responses had been aggregated by the ABS into a dummy variable with the value of 1if the business contracted out R&D to these institutions and 0 otherwise.

The Extent of External Knowledge Sourcing (*Sources*) — It has been defined as the scope of external sources of knowledge or information used by the business. As indicated earlier, it is adapted from Laursen and Salter's (2006) study that tested the impact of the use of a wide range of innovation sources and general institutions operating outside the firm. The IABS listed 11 key external sources of knowledge which help the business to develop new goods/services, new operational or organisational processes, comprising three main categories — market sources (clients, suppliers, consultants and competitors), institutional sources (universities, government agencies, private research institutions, and commercial laboratories) and other sources (professional conferences etc., websites and journals, and others). Each business was asked to indicate the sources it had used. By aggregating their responses, this variable builds on an ordinal scale of measurement, taking the value of 0 with no external sources used and 11 when all these potential sources have been used. Therefore, it is assumed that businesses with the higher values of this variable (i.e. the higher number of using external sources) are relatively more 'open' than others. Unfortunately, despite the potential difference between the effects of external sources on different types of innovation (Reichstein and Salter, 2006), the survey data did not separate product- and process-related sources. Hence this constitutes a limitation of this study.

R&D Input (*R&DInput*) — It has been calculated based on the proportion of the estimated expenditure on research & development activities of new or changed goods (services) or processes controlled by total expenditure of the focal business. These actual expenditure values were gathered by the ABS, and thus provide a continuous measure of financial expenditures on research and development within the firm.

Investment in Absorptive Capacity (*ACAP*) — As elaborated in the hypotheses development section, in this study I use a proxy measure for absorptive capacity, namely the human capital of the whole organisation. This serves two purposes. On the one hand this measure can effectively overcome the biases caused by the traditional measure of R&D intensity, and on the other hand it also take into account the knowledge absorption and exploration in 'process innovation' forms (one of the foci of this study) which involve the whole organisation embodying the development of required absorptive capacity. This variable is built cumulatively by combining three main survey questions — whether the business has employed new skilled staff (either from within 100km, or from elsewhere in same state of territory, or from elsewhere in Australia, or from overseas); whether the business has employed new graduates (either from Australian higher education or research institutions or from overseas institutions); and whether it has employed academic or research staff (either from Australian higher education or research institutions or from overseas institutions). Every question is constructed by a binary variable with 1 for yes, and 0 for no. Therefore, the variable ACAP is built on an ordinal scale of 0-3.

3.3.2.3 Control Variables

In addition to these independent measures drawn from the survey, this study also

controls for the effects of firm size and industry. Firm size (*Size*) is measured by the number of persons working for the business. The responses to this question were released as a categorical variable on a 1-2-3 scale (1 for 5-19 persons, 2 for 20-99 persons, 3 for 100 or more persons). An industry dummy (*Industry*) is also included with the value of 1 if the business is in the manufacturing industry and 0 otherwise (after recoding the original responses regarding 12 different industries) to compensate for the different innovation levels and different propensities towards openness between manufacturing and non-manufacturing firms. As the ABS only provided the aggregate category of manufacturing industry along with other 11 non-manufacturing industries based on Australian and New Zealand Standard Industrial Classification (ANZSIC), a more fine-grained control variable regarding sub-categories of manufacturing industries cannot be explored here. This contributes another limitation of this study.

3.4 RESULTS

Binary logistic regression was employed as all DVs are dichotomous variables coded 0 or 1 respectively (and thus do not meet the assumptions of OLS regression). Additionally, I adopted the hierarchical form in this study with only control variables and the linear term of independent variables included in the basic model, then the squared terms $Sources^2$ and $ACAP^2$ were entered step by step to examine their inverted U-shape effects according to the Hypothesis 2 and Hypothesis 4.

The overall descriptive statistics for variables and correlations between them are presented in Table 3.1. The possibility of multicollinearity was considered for this

study, though rejected as all of the Variance Inflation Factors (VIFs) are less than 1.5 (the maximum VIF is 1.381, and the average is 1.136), thus within the generally acceptable level of less than 5 (Studenmund, 2006) and also below the general threshold 2.5 for logistic regression models (Allison, 1999).

According to the correlation matrix in Table 3.1, my previous discussion that product and process innovation may be mutually supportive and contemporaneous is supported as highly significant and positive correlation coefficients both between *Innovtr1* and *Innovtr2,* and between *Innovtr1* and *Innovtr3* are evident. The interrelationship between the two forms of process innovation — namely between the operational process innovation (the typical form of technological process innovation) and organisational process innovation — is also supported (reported by the significantly positive correlation coefficient between *Innovtr2* and *Innovtr3).*

TABLE 3.1
Means, Standard Deviations and Correlations

Variable	Mean	S.D.	1	2	3	4	5	6	7	8	9	10
1. *Innovtr1*	0.203	0.402										
2. *Innovtr2*	0.250	0.433	.46**									
3. *Innovtr3*	0.241	0.428	.36**	.48**								
4. *Collaboration*	0.335	0.925	.33**	.30**	.35**							
5. *TechAcquisition*	0.009	0.048	.25**	.15**	.11**	.11**						
6. *Outsourcing*	0.019	0.137	.11**	.12**	.09**	.17**	.05**					
7. *R&DInput*	0.012	0.069	.10**	.06**	.03*	.09**	.08**	.01				
8. *Sources*	2.384	2.096	.29**	.31**	.32**	.28**	.09**	.20**	.07**			
9. *ACAP*	0.494	0.927	.27**	.30**	.32**	.26**	.09**	.24**	.09**	.40**		
10. *Size*	1.739	0.793	.18**	.24**	.20**	.14**	-.01	.14**	-.03*	.18**	.35**	
11. *Industry*	0.423	0.494	.10**	.02	-.02	.01	.05**	.03*	.03*	-.02	-.07**	-.08**

n=4322

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

* Correlation is significant at the 0.05 level (one-tailed

The results regarding logistic regression analysis for three dependent variables are demonstrated in Tables 3.2 – 3.4 respectively. All three models provide acceptable fit for the respective dependent variables indicated by the values of Nagelkerke R^2 (around 25% to 32%). Of the control variables, the firm size (*Size*) seems to positively ($p < .001$) influence innovation performance for each of the three types of innovation. It seems within my sample that manufacturing firms are more likely to introduce new products/services and operational processes than service firms ($p < .001$ for product innovation and $p < .01$ for operational process innovation respectively), although this dummy variable is not significantly associated with the organisational/managerial innovation ($p > .10$).

Within all three basic models before inclusion of the squared terms, both *inter-organisational collaboration* and *technology acquisition* co-vary positively and significantly ($p < .001$) with innovation performance (as measured by the introduction of new products/services, new operational processes or new organisational/managerial processes), while *R&D outsourcing* is reported insignificant ($p > .10$) for product/service and operational process innovation and significantly negative for new organisational/managerial processes. I thus note that my first hypothesis H1a is partially supported while my H1b is supported within each of the three types of innovation discussed.

My second hypothesis proposing a curvilinear (inverted U-shape) relationship between the extent of external knowledge sourcing (in terms of the scope of external sources employed) and innovation performance finds support for each of the three types of innovation. It is because (1) the coefficient of the independent variable *Sources* is positive and highly significant ($p < .001$ for all types of innovation), showing that the degree of external knowledge sourcing is important in determining innovation performance (as measured by the introduction of new products/services, new operational processes or new organisational/managerial processes) (2) the $Sources^2$ is negative and highly significant as well ($p < .001$ for all), and there is also an improvement of explanatory power of the model (indicated by Nagelkerke R^2) with the introduction of the squared term, indicating a declining marginal effect of the extent of openness.

My third hypothesis investigates the co-occurrence of internal research and development expenditure and innovation. H3a is also just partially supported because

the findings suggest that the inputs in R&D only affect the product/service innovation performance positively and significantly ($p < .01$), but neither for the introduction of new operational nor organisational/managerial processes ($p > .10$ for both). However, in this sense, its weaker impact on process innovation performance than product innovation performance proposed by H3b is supported.

The same principle for interpreting results regarding H2 can be used to explain the fourth hypothesis which is observed as partially supported as well, as the inverse curvilinear relationship between investments in absorptive capacity and innovation performance is found relating to the introduction of new operational, organisational/managerial processes although not for the first type of innovation (i.e. the introduction of new products/services). This is illustrated statistically due to the results that *ACAP* has a positive and significant coefficient ($p < .001$ for both types of process innovation), while the square of *ACAP* has a negative and significant coefficient ($p < .001$ for both), and there is also an improvement in the model fit (indicated by Nagelkerke R^2) when the square term is introduced — the classic form of an inverse curvilinear equation.

TABLE 3.2
Results of Logistic Regression Analysis for Innovation Performance (New Products or Services)

Independent Variables ↓	**Dependent Variable 1: Innovation Performance of New Products/Services**		
(Constant)	-3.484***	-3.903***	-3.909***
Firm Size (*Size*)	0.365***	0.367***	0.365***
(Manufacturing) Industry Dummy (*Industry*)	0.645***	0.641***	0.644***
Inter-organisational Collaboration (*Collaboration*)	0.490***	0.497***	0.493***
Technology Acquisition *(TechAcquisition)*	17.725***	17.308***	17.283***
R&D Outsourcing (*Outsourcing*)	-0.376	-0.214	-0.188
Knowledge Sourcing (*Sources*)	0.210***	0.575***	0.564***
R&D Input (*R&DInput*)	1.426**	1.397**	1.388**
Absorptive Capacity (*ACAP*)	0.274***	0.292***	0.402**
Knowledge Sourcing Squared ($Sources^2$)		-0.052***	-0.051***
Absorptive Capacity Squared ($ACAP^2$)			-0.031
Chi-square	925.647 ***	967.110***	968.609 ***
-2 Log likelihood	3429.059	3387.596	3386.097
Nagelkerke R Square	30.4 %	31.6%	31.6%

n=4322

+ p < .10

* p < .05

** p < .01

*** p < .001

TABLE 3.3
Results of Logistic Regression Analysis for Innovation Performance (New Operational Processes)

Independent Variables ↓	**Dependent Variable 2: Innovation Performance of New Operational Processes**		
(Constant)	-3.096***	-3.462***	-3.501***
Firm Size (*Size*)	0.486***	0.491***	0.488***
(Manufacturing) Industry Dummy (*Industry*)	0.250**	0.242**	0.251**
Inter-organisational Collaboration (*Collaboration*)	0.431***	0.436***	0.423***
Technology Acquisition (*TechAcquisition*)	5.196***	5.148***	5.205***
R&D Outsourcing (*Outsourcing*)	-0.108	0.041	0.141
Knowledge Sourcing (*Sources*)	0.224***	0.563***	0.521***
R&D Input (*R&DInput*)	0.571	0.526	0.505
Absorptive Capacity (*ACAP*)	0.278***	0.292***	0.730**
Knowledge Sourcing Squared ($Sources^2$)		-0.050***	-0.045***
Absorptive Capacity Squared ($ACAP^2$)			-0.127***
Chi-square	814.833***	859.344***	889.195***
-2 Log likelihood	4044.893	4000.382	3970.532
Nagelkerke R Square	25.4%	26.7%	27.5%

n=4322

+ p < .10

* p < .05

** p < .01

*** p < .001

TABLE 3.4
Results of Logistic Regression Analysis for Innovation Performance (New Organizational/Managerial Processes)

Independent Variables ↓	**Dependent Variable 3: Innovation Performance of New Organizational/Managerial Processes**		
(Constant)	-2.763***	-3.036***	-3.080***
Firm Size (*Size*)	0.303***	0.306***	0.301***
(Manufacturing) Industry Dummy (*Industry*)	-0.013	-0.019	-0.010
Inter-organizational Collaboration (*Collaboration*)	0.613***	0.613***	0.600***
Technology Acquisition (*TechAcquisition*)	3.100***	3.035***	3.075***
R&D Outsourcing (*Outsourcing*)	-0.697*	-0.552*	-0.425
Knowledge Sourcing (*Sources*)	0.220***	0.480***	0.432***
R&D Input (*R&DInput*)	-1.011	-1.099	-1.066
Absorptive Capacity (*ACAP*)	0.377***	0.384***	0.875***
Knowledge Sourcing Squared ($Sources^2$)		-0.039***	-0.033***
Absorptive Capacity Squared ($ACAP^2$)			-0.142***
Chi-square	855.629***	880.562***	917.209***
-2 Log likelihood	3918.759	3893.826	3857.179
Nagelkerke R Square	26.9%	27.6%	28.6%

n=4322
+ p < .10
* p < .05
** p < .01
*** p < .001

3.5 DISCUSSION

In spite of the recent emergence of much empirical research in the open innovation arena, analysis relating to the impact of openness on process innovation has hitherto

been under-explored. This study seeks to provide theoretical understanding, empirical evidence and practical implications regarding this critical issue within open innovation research. The Table 3.5 illustrates a summary of analytical findings relating to the four hypotheses for each of the type of innovation in my sample.

TABLE 3.5
Results of Hypotheses Testing

Hypotheses	**Product Innovation**	**Process Innovation**	
	New Products/Services	New Operational Processes	New Organisational/ Managerial Processes
H1a: Basic open innovation approaches will positively affect (both product and process) innovation performance.	Partially Supported	Partially Supported	Partially Supported
H1b: Regarding the three basic approaches to open innovation discussed previously, R&D outsourcing tends to have a relatively weaker impact on innovation performance than the other two.	Supported	Supported	Supported
H2: The extent of external knowledge sourcing is curvilinearly related to (both product and process) innovation performance.	Supported	Supported	Supported
H3a: Internal R&D input will positively affect innovation performance even while firms pursue open innovation arrangements.	Supported	Not Supported	Not Supported
H3b: Internal R&D input will have a greater impact on product innovation performance than process innovation performance.	Supported		
H4: The investment in absorptive capacity is curvilinearly related to (both product and process) innovation performance in the context of openness.	Not Supported	Supported	Supported

There are a number of interesting findings from the empirical results. First, the external open innovation approaches have significant effects for each of the two main types of innovation (operational and organisational/managerial innovation can be generally called process innovation), except for the impact of outsourcing. I had anticipated that the use of R&D contracting out arrangements, as a basic open approach, would anticipate innovation. In fact I found no support for this item as a contributor to innovation. This might result from the outcome that firms usually subcontract or outsource peripheral or non-core R&D activities which are not of strategic importance in driving innovation (Tidd, Bessant and Pavitt, 2001).

My second hypothesis, regarding the extent of external knowledge sourcing, also finds support for each of the main types of innovation. In this sense, my findings are consistent with those of Laursen and Salter (2006) who pointed out that an over-reliance on open search strategies may in fact hinder innovation performance. This outcome relates to an economic term 'search costs' — the processes involved in seeking external cues for innovation have a variety of direct and indirect costs for the organisation that, in accumulation, will begin to counterbalance any innovation-related benefits and may, through obfuscation and potential distraction, indeed hinder the innovation focus of the firm.

Moreover, internal inputs namely R&D expenditure (a form of the internal formal commitment of innovation resources), and investment in absorptive capacity affect performance of product innovation and process innovation in different ways.

As I anticipated, internal R&D resources commitment enhance innovation performance for firms in their introduction of new goods/services. Interestingly, I do not find support that such expenditures of R&D resources anticipate the introduction of new operational nor organisational/managerial processes. While these results still supports my proposition that internal R&D input has a greater positive impact on product innovation performance compared with process innovation performance, it implies that when external research and external knowledge are used for the adoption of open innovation strategy, internal R&D becomes less important in introducing new processes within the organisation. This, as I predicted earlier, may largely be due to the fact that the investment in formal R&D is generally viewed as expenditures explicitly aimed at the production of traditional product or service innovation, while expenditures on improvement in the way an organisation functions is seen not so much as R&D, but rather as 'business as usual' expenditures.

With reference to my final hypothesis, I observed that there is a curvilinear relationship between investments in absorptive capacity and innovation performance for those types of innovation relating to the introduction of new processes (both

operational and managerial/organisational) although not for the introduction of new products/services. Investment in human capital of the organisation (the proxy for absorptive capacity) anticipates a cumulative and linear fashion innovation performance in the creation of product and service innovation. However, the continued increase in the employment of such personnel may, after a time, tend to diminish introductions of process innovation within the firm. A possible explanation for the stronger diminishing marginal effects on process innovation than on product innovation might still be related to the benefit-cost relationship involved in the development of absorptive capacity.

It is suggested that although the value of process innovation would be also realised through commercialisation (Ettlie and Reza, 1992), there are less commercialisation opportunities for new processes than new products and/or services. Product innovation is mainly triggered by the market with the external focus while process innovation is efficiency driven with an internal focus (Utterback and Abernathy, 1975). For customers, the benefits of process innovation may be two steps removed from the products and services that they purchase, in particular for organisational process innovation. According to Edquist et al (2001), original organisational process innovation is seldom sold and bought on the market. Such discussion is also compatible with Damanpour and Gopalakrishnan's (2001) point of view that new processes are intermediately related to the production and the delivery of more

tangible innovation outcomes, and thus generate relatively less revenues than successful products.

As a result, newly introduced processes are generally not directly commercialised to the market, so the financial returns brought by building their absorptive capacity may not be immediately obtained to justify the investment in this capacity. Consequently, the benefit-cost ratio for process innovation leads to a non-linear, positive but marginally declining impact of absorptive capacity.

Based on the discussion above, I find that, first, open innovation models are generally useful for firms seeking to innovate in processes as well as products and services. This has been illustrated by the positive effects of most open innovation approaches and the benefits of an increasing openness degree towards external environment at initial stages. However, I also observe the limited applicability of internal research for process innovation. This implies that the complementary role of openness might only be applied to the type of product innovation based on my sample results. For other cases, the knowledge and sources from outside will contribute much more than inside R&D effort, leading to a very limited role of in-house R&D in the open introduction of new operational or managerial processes.

These findings provide important insights into the investigation of open innovation's broader applicability, especially in relation to process innovation. Although open innovation is found applicable to process innovation, given the nature and inherent characteristics of process innovation (e.g. processes do not generally rely on internal R&D and are not directly commercialised to the market), process innovation may tend to suffer from higher costs and uncertainties, and face more challenges, in realising the benefits of open innovation strategies.

As an early effort to explore the convergence of open innovation and process innovation, this study also reveals some significant areas for future research, in particular in relation to the collection of empirical data for core open innovation constructs. As discussed earlier, a limitation of this dataset is that the survey questionnaire did not make adequate distinction between process and product R&D expenditures, nor process and product related sources. It is noted that this limitation also exists in other studies (e.g. Laursen and Salter, 2006; Reichstein and Salter, 2006). Hence, more accurate and appropriate survey designs are required in this area to further uncover the various multi-relationships entailed by this emerging paradigm.

3.6 CONCLUSION

This study provides some of the first empirical investigation of the importance of open innovation for process innovation adopted by firms. In many respects, the various dependent variables employed are all anticipated well by my direct effects model (with the exception of the contracting-out item, which is consistently found to be either insignificant or significantly negative in anticipating innovation).

Collaboration between firms and the acquisition of new technology antecede improved performance of both main types of innovation in my sample. As such, I can assume that the open innovation model holds true, in its most essential form, for both product and also process innovation.

The curvilinear relationship between the number of external sources and innovation performance, first observed by Laursen and Salter (2006) is also observed for each type of innovation in my sample. This is true when I extend their model to include the inverse curvilinear form for absorptive capacity, except with regards to product/service innovation, where no 'drop off' in innovation performance can be seen as investments in technically skilled personnel occurs.

Overall, my findings support the idea that firms that are open innovators will see improvements in terms of improved products and processes. As such, my finding

reinforce the importance of open innovation and extend the arguments for its usefulness in terms of improving both the innovations observable by customers in terms of a firm's goods and services, but also in terms of improvements in the efficiency and effectiveness of the processes within the organisation — processual improvements which may build a virtuous cycle of innovation. However, I also suggest that future empirical studies are required to explore the generalisability of this emerging paradigm in different innovation contexts, as well as to refine indicators and measures for core open innovation constructs.

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CHAPTER IV

Does Open Innovation Work Better in Regional Clusters? Empirical Evidence from Europe

Paper will be presented at the *25th ANZAM Conference*, December 7-9, 2011, Wellington, New Zealand.

STATEMENT OF AUTHORSHIP

DOES OPEN INNOVATION WORK BETTER IN REGIONAL CLUSTERS? EMPIRICAL EVIDENCE FROM EUROPE

Conference paper

Fang Huang, John Rice The University of Adelaide Business School

For this paper (chapter), Fang Huang developed theoretical framework and hypotheses, performed analysis on data, interpreted data, wrote manuscript and acted as corresponding author. Dr John Rice assisted in guiding theory development, supervised development of work, and provided critical evaluation.

The majority of the work and the primary authorship have been undertaken by Fang Huang.

Fang Huang (Candidate)

I hereby certify that the statement of contribution is accurate.

Signed [redacted] Date 29/8/11

Dr John Rice

I hereby certify that the statement of contribution is accurate and I give permission for the inclusion of the paper in the thesis.

Signed [redacted] Date 17/8/11

THE RELATIONSHIP OF THIS CHAPTER TO THE DOCTORAL RESEARCH

For the second research question regarding the relationship between the benefits and costs of the open innovation paradigm, it might be better to first focus on the benefits asserted by open innovation theories and the circumstances under which they can be fully captured and utilised. Most benefits proposed by open innovation advocators are grounded on the ideas of interdependence, trust, and mutual reciprocity through which the shared knowledge and information flows can be greatly facilitated. Regional clusters are believed such a relatively ideal setting where these underpinnings of the new innovation paradigm are expected to be largely optimised. This chapter is derived from this intention to partially inform the second research question. Besides, the geographical focus of samples is shifted from Australian observations to European firms (locating both within and outside regional clusters). The first research question concerning the generalisability of open innovation paradigm is also partially addressed in this sense.

Huang, F. and Rice, J. (2011) Does open innovation work better in regional clusters?: empirical evidence from Europe.
25th ANZAM Conference, December 7-9, 2011, Wellington, New Zealand

CHAPTER V

Does the Open Innovation Paradigm Apply to China? Empirical Evidence from Chinese Firms

Paper presented at the *2010 Academy of Management Annual Meeting*, August 6-10, 2010, Montréal, Canada.

STATEMENT OF AUTHORSHIP

DOES THE OPEN INNOVATION PARADIGM APPLY TO CHINA? EMPIRICAL EVIDENCE FROM CHINESE FIRMS

Conference paper

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For this paper (chapter), Fang Huang developed theoretical framework and hypotheses, performed analysis on data, interpreted data, wrote manuscript and acted as corresponding author. Dr John Rice and Dr Lisa Daniel assisted in guiding theory development, supervised development of work, and provided critical evaluation.

The majority of the work and the primary authorship have been undertaken by Fang Huang.

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THE RELATIONSHIP OF THIS CHAPTER TO THE DOCTORAL RESEARCH

In this chapter, the research attention has been paid to the emerging economies (beyond the contexts of developed economies as in the previous chapters), taking China as an example. This study seeks to significantly contribute to the first research question (i.e. the generalisability of this new paradigm) by looking into the application of open innovation in both large firms and SMEs in China. In addition, following the examination of the benefits that are likely to originate from openness (in the previous chapter), the potential costs mainly in terms of direct costs associated with open innovation practices are taken into account in this study providing informative answers to the second research question with regard to whether the benefits of open innovation can outweigh its potential costs.

Huang, F., Rice, J. and Daniel, L. (2010) Does the open innovation paradigm apply to China?: empirical evidence from Chinese firms.
2010 Academy of Management Annual Meeting, August 6-10, 2010, Montreal, Canada

CHAPTER VI

Networking and Bribery in China:

Assessing Potential Negative Consequences of Firm Openness

The revised version of this paper has been accepted by the *Journal of Business Ethics*.

STATEMENT OF AUTHORSHIP

NETWORKING AND BRIBERY IN CHINA: ASSESSING POTENTIAL NEGATIVE CONSEQUENCES OF FIRM OPENNESS

Journal paper

Fang Huang, John Rice The University of Adelaide Business School

For this paper (chapter), Fang Huang developed theoretical framework and hypotheses, performed analysis on data, interpreted data, wrote manuscript and acted as corresponding author. Dr John Rice assisted in guiding theory development, supervised development of work, and provided critical evaluation.

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Signed [redacted] Date 17/8/11

THE RELATIONSHIP OF THIS CHAPTER TO THE DOCTORAL RESEARCH

This chapter extends the investigation into the downsides of open innovation signified by the second research question. Apart from the costs likely incurred by some open innovation practices as suggested by the former chapter, this study looks into an essential threat faced by open innovators, namely the potential loss of distinctive resources and capabilities and subsequently competitive advantages in the context of openness. This study is not confined to the openness in innovation activities but focuses on an organisation's general openness tendency towards its external environment. Findings of this study are also applicable to the open innovation domain, which is one of the most significant forms of openness. Therefore, this study largely corresponds to the second research question with reference to the potential threats resulted from openness.

ABSTRACT

Economic openness, both in terms of increased international trade exposure and enhanced inter-firm networking, has been a key element of China's economic emergence since the implementation of market reforms and the 'open door policy' over 30 years ago. Unfortunately, these changes have also coincided with the increased incidence of bribery and corruption. Both in general, and in the specific context of China, research on the relationship between a firm's tendency towards openness and its propensity to engage in bribery is scarce. This study seeks to fill this gap based on empirical evidence provided by a large sample of Chinese firms. The findings of the study reveal that firms' increased network openness tends to occur contemporaneously with greater bribery and corruption. This study suggests that this may be due to the misuse of guanxi-based networks that coincide with the presence of firms' open network strategies, heightened by the potential loss of resource and capability heterogeneity (and hence reduced competitive advantages) in the context of openness. I further find that firms paying bribes do so as an attempt to overcome unnecessary bureaucratic processes and ineffective institutional support which might tend to hinder their development.

6.1 INTRODUCTORY BACKGROUND

It has been more than 30 years since China launched Deng Xiaoping's 'open door policy' and a series of related market reforms, driving economic reforms that moved China from central planning to a market-driven economy. This economic transition has facilitated China's openness to the world and effectively ensured the integration and prominence of China in the global economic system (Shafer, Fukukawa and Lee, 2007). Influenced by the greater openness evident throughout the nation, individual Chinese firms tended to increase their openness to each other, especially in the form of enhanced business networks and inter-firm collaborations. Recent studies have, however, revealed some tensions within these network arrangements during the economic transition phase, especially from the perspective of ethical and cultural norms (Woodbine, 2004). It has been widely reported that there is a prevalence of unethical business practices and corruption in the current China's business setting (Tam, 2002; Wright, Szeto and Lee, 2003). Bribery, the principle transaction of corruption in the Chinese context, has been observed spreading into many aspects of China's society and economy (Tian, 2008).

Some studies see the social and economics transitions over the last decades in China as fundamental contextual drivers of the increased bribery and corruption (Guo, 2008; Sands, 1990; Shafer et al., 2007). It has been suggested the relative disorder and social inequality that has arisen during the market reform process might, cause a decline in

the level of ethical standards and corporate social responsibility (Shafer et al., 2007; Wang, 2003). The transition and related reforms, to some extent, give rise to increased opportunities and incentives for corruption in the changing environment of China (Guo, 2008). As a result of these changes, longstanding Confucian norms relating to moral behaviour might be under serious strain (Harvey, 1999).

Although the relationship between economic development in transition economies and corruption has been extensively discussed, the specific link between Chinese firms' tendency to networking and openness in the context of the wider 'open door policy', and the emergence of bribery has received limited attention. It has generally been suggested that a reduction in central planning and heightened economic deregulation will raise a great number of investment and collaboration opportunities, thus creating competitive opportunities for Chinese firms. These opportunities are enhanced if firms follow an open strategy, such as open innovation practice put forward by Chesbrough (2003a). Nevertheless, given the distinctive cultural, social, economic, political and institutional features of China's business environment, openness might also bring about some particular negative effects.

Little academic effort has been made to investigate this issue before. Attempting to fill this gap in the extant literature, this research aims to provide some insights into the downsides of open strategies, mainly from the business ethics perspective, based on

the empirical evidence of Chinese firms.

This study seeks to contribute to existing research in three ways. First, China is of great importance in the contemporary economic and business research, given the rapid economic growth it has made and the essential role it has played in the world market since its transition in 1978 (Dunfee and Warren, 2001). However, the increasing pervasiveness of corruption and bribery has been observed as a problematic phenomenon concurrent with this economic transition (Hung, 2008).

Therefore, this study seeks to empirically investigate the underlying determinants of the tendency to, or the tolerance of, corruption and bribery among Chinese businesses. As the traditions of Chinese culture and China's institutional and political conditions significantly differ from those of Western countries (Dwivedi, 1967), many of existing theories found in the Western world cannot be directly applied to the context of China. In order to make contribution to the current understanding of business ethics theories from China's perspective, research on its specific situation is fundamentally important (Whitcomb, Erdener and Li, 1998).

Second, although the uniqueness of China determines that the findings of this study cannot be largely generalised to other economies around the world, they are still likely to provide insights into the experiences of some Asian countries. Similar to China,

formal institutional systems and traditional ties (such as family, kinship and ethnicity) coexist to form the moral norms in many Asian societies (including Malaysia, Indonesia and India) (Dwivedi, 1967).

Moreover, China provides a useful illustrative example of some of the ethical problems that a country undergoing changes might face (Rocca, 1992). According to Whitcomb et al (1998), cultural values in transitional China might present a state of flux while changes in its macro environment are bringing market-oriented influences to bear on traditional values. Implications of the sources and causes of bribery in the rapidly transforming economy of China are expected to provide partial insights for other transitional economies in the world (Cule and Fulton, 2005; Hung, 2008).

This paper proceeds as follows. The following section reviews relevant literature and presents a conceptual framework upon which my hypotheses are developed. Then it presents information relating to the source of empirical data, the sample and the measures of variables used. The results of quantitative modelling are then analysed. Finally, this paper outlines the main findings and provides the assessment of their managerial implications.

6.2 LITERATURE REVIEW & CONCEPTUAL FRAMEWORK

6.2.1 Bribery in Transitional China

The definition of 'bribery' varies in different contexts. This study will confine it to a certain type of bureaucratic corruption whereby public agencies or civil servants attain some legally prohibited favours (Lu, 2000; Quah, 1982). In the Chinese context, this kind of bribery behaviour can be more specifically defined as "the use of public authority and public resources for private interests" (namely "*Yi Quan Mou Si*" in Chinese) (He, 2000, P. 244). Bureaucratic corruption has been noted as an innate characteristic of the current hybrid socialist-market system of China, where some local officials still exercise discretionary power or have monopolised interests stemming from their control of regulatory authority (Lovett, Simmons and Kali, 1999; Su and Littlefield, 2001; Yao, 1999).

This study refines the research focus in this way mainly because in contemporary China and also some other developing nations in Asia, the gravest and most common type of corruption observed is bribe-taking by public officials and civil servants (Guo, 2008). The Chinese Anti-commercial Bribery legislation, which has a focus on both the briber and the bribed, also indicates that bribery by firms is often targeted at the corruption of officials (Tian, 2008). Other than government officials, public agencies and party officials have also been recognised as significant protagonists in the bribery activities in transitional China (Guo, 2008).

The extant empirical research on business ethics (especially in terms of corruption and bribery) can generally be characterised along two dimensions. First is the level of analysis (Chen, Yasar and Rejesus, 2008). This comprises two main elements — the macro-level, based on the comparison of cross-national data with country-level indices of corruption and broad sociocultural and institutional indicators (e.g. Baughn, Bodie, Buchanan and Bixby, 2010; Getz and Volkema, 2001; Khatri, Tsang and Begley, 2006; Treisman, 2000); and the micro-level which focuses on individual-level or firm-level determinants and factors of corruption (e.g. Svensson, 2003; Swamy, Knack, Lee and Azfar, 2001). The other main dimension relates to the supply or demand aspects of bribery-related behaviour. This investigates the nature of the parties who offer or take bribes (Baughn et al., 2010). The supply side focuses on the bribe giver and their incentives to pay bribes (Martin, Cullen, Johnson and Parboteeah, 2007), while the demand-side focus looks at factors that are largely associated with bribe recipients and their bribe collecting behaviour (Shleifer and Vishny, 1993).

Although this study has defined bribery in China from a demand side perspective (government agencies or their officials who actively seek bribes), due to the availability of firm-level data, this study will focus more on the propensity of firms to supply bribes to those public agencies and officials. Hence this study addresses a paucity of corruption focused work investigating the occurrence of bribery and

corruption from the perspective of firms' willingness to bribe (Calderón, Álvarez-Arce and Mayoral, 2009). The use of firm-level data, with individual firms as the units of analysis, is also a response to the limited amount of micro-level corruption research (Fisman and Svensson, 2007; Lu, 2000).

China's 'open door policy' and its consequent market-based reforms have created substantial challenges for Chinese firms who are now competing in a new business environment. Confronting such challenges, many see themselves as being compelled to take initiatives, either actively or passively, in terms of paying bribes to sustain their competitive advantages. As such, this research seeks to provide theoretical and empirical advances through a focus on the supply side of firm bribery decisions and activities.

6.2.2 Bribery through Guanxi-based Network

The role of bribery as either an active strategy or a passive response to the challenges posed by changing economic and legal environment could be realised through the frame of a concept indigenous to China — 'guanxi'. Guanxi can be equivalently described as the "tight, close-knit networks" (Yeung and Tung, 1996, p. 54), the "long-term cooperation among business partners" (Su, Sirgy and Littlefield, 2003, p. 303) and the "coalitional relationship based on the resource exchanges" (Su, Mitchell

and Sirgy, 2007, p. 303) in Chinese society. The practice of guanxi has had a profound influence on businesses in China (Luo and Chen, 1996; Park and Luo, 2001; Xin and Pearce, 1996). The nature of guanxi is characterised by its extensive application and ingrained root in Chinese society. It is believed "entering China's markets amounts to entering a huge web of guanxi" (Su and Littlefield, 2001, p. 199) and "in China, guanxi is everything" (Fox, 1987, p. 12).

Additionally, guanxi derives from the long-established Confucian heritage which draws upon the underlying moral principles of hierarchy, interdependence, and reciprocity (Hwang, 1987). Although guanxi traditionally implies a kind of informal and interpersonal practice (Shafer et al., 2007), it has been widely applied to both individual and organisational levels recently (Tsang, 1998). Hence, guanxi-based networks are also viewed as existent between individuals and organisations. In accordance with the definition of bribery, this study will still pay attention to the B2G (business to government) guanxi，namely the relationships and connections between organisations and government agencies and public officials (Braendle, Gasser and Noll, 2005).

The emergence of guanxi-based networks has been catalysed by the economic reforms and the open door policy in place since the late 1970s (Seligman, 1999; Su and Littlefield, 2001). Apart from the role of national and public orientation towards

opening to the world, Chinese firms' increasing tendency towards openness, especially in terms of inter-firm networks and relationships, may also be leading to the rapid growing of the guanxi web.

Entering guanxi-based networks is still seen as an imperative for doing business in modern China. It is an effective way of conveying interpersonal trust that holds Chinese society together (Braendle et al., 2005; Lovett et al., 1999). Guanxi could also be regarded as a form of social investment whereby Chinese businesses establish and keep good relationships with their key stakeholders, including customers and suppliers (Braendle et al., 2005; Dunfee and Warren, 2001).

On the other hand, it has been frequently argued that guanxi, to some extent, contemporaneously occurs with various forms of illicit payments and bribery in today's China (Chan, 2008; Millington, Eberhardt and Wilkinson, 2005; Steidlmeier, 1999; Su et al., 2003). Empirical evidence has suggested a negative relationship between the application of guanxi and the standards of business ethics and social responsibilities of firms operating in China (Ang and Leong, 2000). Although participation in guanxi does not imply any illegal orientation (Dunfee and Warren, 2001), the abuse of some guanxi-based networks is regarded as a social dynamic that promotes business ethics deterioration (Ang and Leong, 2000; Braendle et al., 2005; Dunfee and Warren, 2001; Su et al., 2003).

6.2.3 China's 'Open Door Policy' and Its Impacts on Local Firms

The 'open door policy', and consequent reforms, were first elaborated by the paramount leadership of China — namely Deng Xiaoping and his co-leaders — in 1978. Significant initiatives were involved, including the promotion of a market-driven economy with concomitant lessening of central control by government over everyday businesses. In terms of micro-economic reforms, parallel initiatives included the increased privatisation of government owned businesses, the encouragement of international trade and the attraction of foreign investment (Dunfee and Warren, 2001; Sands, 1990). These far-reaching reforms significantly contributed to China's notable economic growth and global economic integration over subsequent decades (Hung, 2008; Whitcomb et al., 1998).

From the micro-economic perspective, China's opening door to the global market has brought about substantial opportunities in its domestic business environment for individual firms (Dunfee and Warren, 2001). China's business networks developed from a very rudimentary base, to emerge as the foundation of a modern, technologically driven economy. A key element of these nascent networks has been an increasing 'openness' in terms of information fluidity and knowledge transfer between firms and other economic agents (universities, government, research labs, foreign partners, etc.). These information flows have been facilitated by the growth of the Internet and telecommunication channels within China and elsewhere (Dunfee and

Warren, 2001). Firms adopting an open strategy typically exhibit enhanced engagement in inter-organisational networking and collaboration (Economist Intelligence Unit, 2009; Zhang, 2009).

Other evidence has also supported an interpretation of a highly networked economy, including evidence of enhanced porosity of organisational boundaries (Liu and White, 2001); increased science and technology exchanges (Liu and White, 2001; Motohashi and Yun, 2007); and stronger and more dynamic regional networks and clusters (Lai, Chiu and Leu, 2005; Sonobe, Hu and Otsuka, 2002; Zhou and Xin, 2003).

Despite those opportunities, the reforms have inevitably brought about many challenges. With China's openness to the global competitive market, Chinese businesses have tended to face greater competitive pressures both internally and globally. Further, the decline of the communist welfare system has shifted many economic responsibilities from government to the local businesses (Dunfee and Warren, 2001). This is especially the case for formerly state-owned enterprises that were urgently required to find new sources of competitive advantages in a freer and more globalised market (Dunfee and Warren, 2001).

While the transmission of complementary expertise and knowledge across firm boundaries can create relational benefits, the benefits of an open network arrangement

might also lead to a lessening in terms of the rarity of the firm's resource and capability portfolio. This in turn might diminish the level and uniqueness of these resources and capabilities, and according to the research-based view, potentially impair a firm's competitive potential (Barney, 1991). As such, greater openness may indirectly lead to greater pressure on managerial decision makers to create sustainable competitive arrangements. Under such circumstances, it might be anticipated that they would seek relational advantages through bribery as a new means of accessing and obtaining relational rents not available to their competitors.

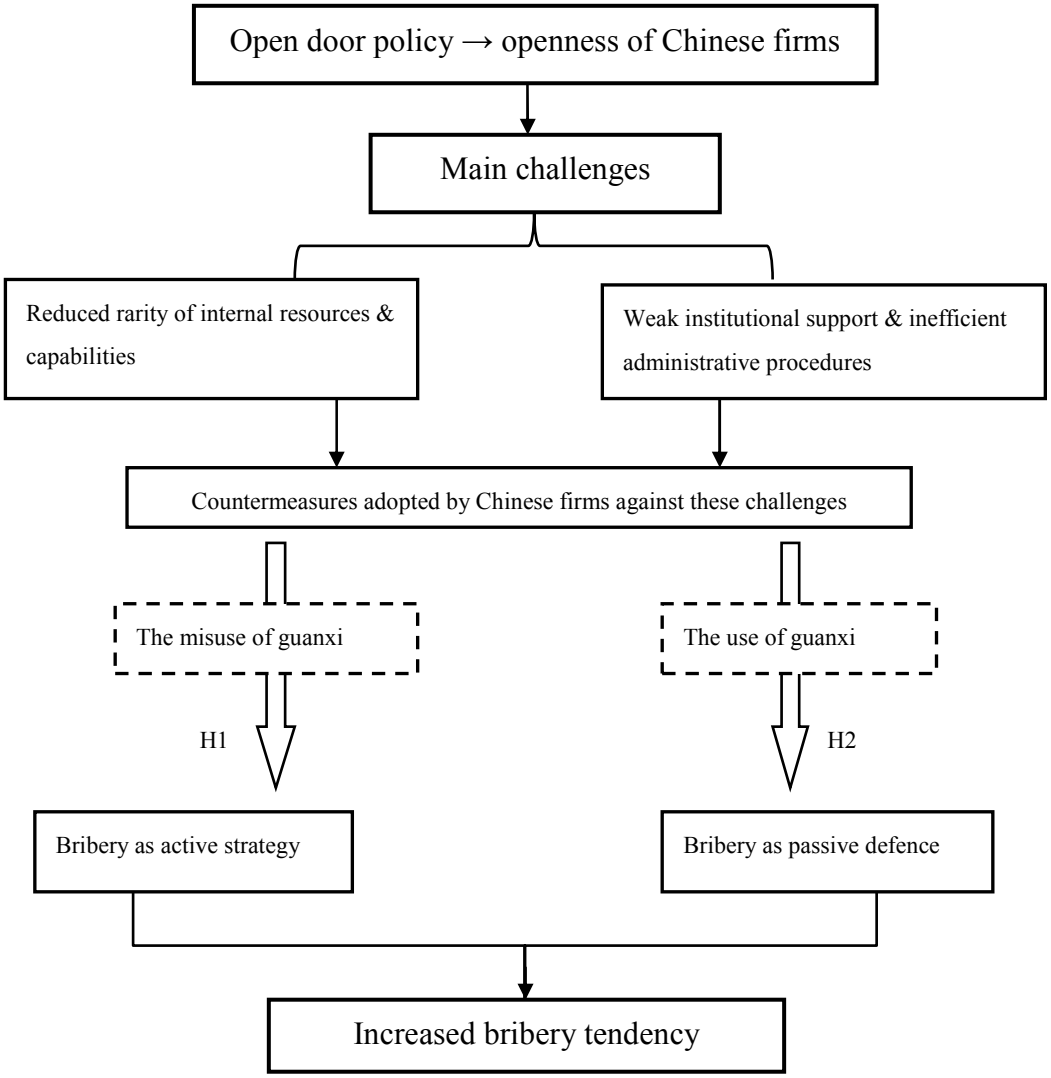
Economic growth generally, and greater competition and economic networking in particular, have also resulted in the emergence of potential conflicts between the formal rule of law and informal interpersonal relationships based on traditional guanxi networks (Dunfee and Warren, 2001; Pye, 1995). Given the relatively nascent and weak commercial and contractual legal system in reform-era China (Braendle et al., 2005; Dunfee and Warren, 2001), personal relationships and social exchanges still act as a partial substitute for formal commercial law in many situations (Wright et al., 2003; Xin and Pearce, 1996). It has been widely argued that the deep-rooted traditions of guanxi continue to play a role as unwritten rules to guide behaviour of Chinese people and organisations (Braendle et al., 2005; Li and Wu, 2007). It has been noted that "Chinese [people] cannot live without guanxi", even in the context of a free market economy (Su and Littlefield, 2001, p. 202).

Moreover, the relative inefficiency of public sectors in China, characterised by cumbersome administrative procedures and time-consuming application processing, has also emerged as a problematic dimension of transitional China (Dunfee and Warren, 2001; Xin and Pearce, 1996). Quite aside from the motives relating to firms' active pursuit of new competitive advantage by means of bribery, firms might also passively utilise corruption as a defensive measure against red tape and long waiting time in public services (Bardhan, 1997). Such expediting of bureaucratic procedures could ensure a firm's quick response to its changing external environment (Bardhan, 1997; Mauro, 1995).

6.2.4 Conceptual Framework

Based on the relevant literature reviewed above, I develop a conceptual framework upon which this study proceeds (as shown in Figure 6.1). This framework suggests that the challenges associated with China's open door policy (and consequently individual firms' openness tendency) predisposed firms to employ bribery-related activities, either as an active measure to sustain their resource-stock rarity, or as a passive defence against various bureaucratic inefficiencies.

FIGURE 6.1
Conceptual Framework



6.3 HYPOTHESES

As previously discussed, guanxi is viewed as a double-edged sword (Warren, Dunfee, and Li, 2004). While acting as a catalyst for business trust, many studies have raised concerns regarding the negative ethical consequences that guanxi might cause (Dunfee and Warren, 2001; Xin and Pearce, 1996). Among the diverse forms of

guanxi, B2G guanxi has been particularly condemned as the main means of bribery (Braendle et al., 2005). The problematic dimension of B2G guanxi could be mainly reflected by two approaches — the misuse of gift giving and the inappropriate use of intermediaries, respectively referred to as 'song li' and 'la guanxi' in the Chinese vernacular (Braendle et al., 2005; Dunfee and Warren, 2001).

Gift-giving, a most common custom in China, is generally used to convey underlying positive Confucian virtues, including caring, respect, friendship, trust, and especially reciprocity between different parties (Steidlmeier, 1999). However, in order to attain illegitimate favours or advantages, some forms of gift-giving are occasionally misused and the traditionally understood good intentions of these behaviours are distorted (Steidlmeier, 1999). In reform China where the economic and institutional systems are still in transition (Millington et al., 2005), the role of 'song li' (giving gifts with illegitimate intentions) clearly emerged. At its extreme, such behaviour may tend to undermine open competition and the forces of free market in some areas of the society and economy (Xin and Pearce, 1996). Examples may include gifts given to politicians and bureaucrats in return for illicit benefits in terms of information, resources, privileges or permits (Millington et al., 2005; Tian, 2008).

The abuse of intermediated relationships is another potential and elaborate channel to misuse guanxi. An explanation relates to the meanings through which guanxi is

established. The first part of the word, guan, equates to 'transferable' — "if A has guan with B and B with C, then B can introduce A to C, or vice versa. Otherwise contact is impossible." (Ambler, 1994, p. 74) The second part of the word, xi, translates as ties and connections (Tsang, 1998; Yang, 1989). Thus the literal explanation of guanxi suggests that it creates transferable ties and connections — useful in developing relationships within a network of individuals, firms and government agencies (Tung and Worm, 1997).

Increased involvement in organisational-level connections in terms of inter-firm relationships, such as collaborations and involvement with business associations, will significantly increase opportunities to access essential intermediaries and achieve relational benefits. These intermediaries play a boundary-spanning role in linking unrelated parties from different guanxi-based networks and developing a more integrated and comprehensive guanxi web (Dunfee and Warren, 2001; Su and Littlefield, 2001).

In that sense, as Chinese firms become more open towards each other, it is often the intermediary, an essential agent in cultivating guanxi connections, that may inadvertently (or perhaps deliberately) cause the deterioration of ethical behaviour within inter-firm networks. Generally, public officials or government agencies in charge of bureaucratic and regulatory decisions cannot be directly accessed, therefore

guanxi with multiple levels of intermediaries, can be used as a substitute for, and cloak of, direct transactional contacts between firms and state or party personnel (Dunfee and Warren, 2001). In other words, intermediary connections within and among guanxi networks are prone to be manipulated as illegitimate channels. In this sense, the heavy reliance on so-called 'la guanxi' (the use of the entering and linking of different guanxi networks through intermediaries) may aggravate the extent of corruption and bribery occurrences.

In summary, the tendency towards openness by Chinese firms promotes the proliferation of guanxi-based networks. The misuse of gift-giving and intermediaries, both of which are essential elements of guanxi, potentially exacerbate the negative side effects of guanxi. These compounding effects result in greater propensity towards firm-level bribery, as well as exacerbating the quantum of the bribery payments in the Chinese context. The overall proposition can be summarised via the following hypotheses:

H1a: The tendency towards openness of firms in China is positively related to the propensity towards firm-level bribery.

H1b: There is a positive relationship between a firm's tendency towards openness and the amount of the bribes they pay (after controlling for firm size).

Given the argument regarding the potential unethical consequences of guanxi, which may lead to the potential intensification of bribery, it is also worth assessing some of the positive sides of guanxi and their impacts on firms' bribery propensity.

Organisational-level ethical choices are often influenced by their exogenous institutional environment (Whitcomb et al., 1998; Martin et al., 2007). The actions of firms offering bribes are highly constrained and predetermined by power imbalances (Martin et al., 2007). Firms usually attempt to justify their corrupt payments by attributing their actions to the ineffectiveness of bureaucratic processes and a weak rule of law in the transitional context (Dunfee and Warren, 2001; Xin and Pearce, 1996). In this sense, guanxi may be employed as a substitute for formal institutional support (Xin and Pearce, 1996). Guanxi is also an important strategic tool to obtain rare resources and information otherwise inaccessible for firms due to the relative lack of transparency in their background institutional system (Braendle et al., 2005; Xin and Pearce, 1996).

Moreover, B2G guanxi implies the existence of some potential for the establishment and sustenance of effective relational connections with government and party personnel that might create commercially-beneficial outcomes which might otherwise not be available (Dunfee and Warren, 2001; Xin and Pearce, 1996). Based on those benefits, guanxi-based networks possessed by firms can be viewed as a type of

complex, intangible asset that can drive sustained competitive advantages (Garten, 1998; Tsang, 1998).

The inherent institutional weaknesses and the lack of transparency of laws and regulations in the transitional phase of China may create the impetus for guanxi-based networks which finally become significant channels to enact corrupt practices and bribery behaviours.

Another significant motive driving the bribery of government officials is the inefficiency of Chinese public service. Studies show that firms are often hindered by bureaucratic delays (Ali and Isse, 2003; Mauro, 1995). In order to bypass unwieldy and capricious bureaucratic processes, firms' managers sometimes resort to bribing officials to ensure certain actions occur, and occur quickly. This problematic set of circumstances is often prevalent in developing countries (e.g. Bardhan, 1997; Méon and Sekkat, 2005; Shleifer and Vishny, 1993).

Once firms and their decision makers see the potential commercial positives available from bribery, it may become more attractive for the firm and may be routinised as a type of repeated organisational behaviour (Martin et al., 2007). Incidental bribery might in turn evolve into a form of strategic investment in the long term (Luo, 2004; Quah, 2003). Firms not following such practices may in turn see themselves at a

disadvantage in the Chinese market.

In a word, the barriers rather than the institutional supports resulted from government institutions or officials impel the supply-side of bribery of firms in the context of openness.

H2: Firms will be less prone to provide bribes if more governmental and institutional support is provided to their business operations.

6.4 METHODS

6.4.1 Sample

The data for this study is drawn from the World Bank Investment Climate Survey 2003. The World Bank has conducted a series of firm-level surveys in various developing and transitional economies. A set of these are the Investment Climate Surveys (ICS) which were conducted in random samples of more than 26,000 firms in 53 developing countries (The World Bank, 2005).

The ICS collected a wide range of qualitative and quantitative firm-level information on the investment climate in various countries, including infrastructure, finance, regulation, labour, taxation, governance and corruption, and firm productivity and performance (Smith and Hallward-Driemeier, 2005). The ICS surveys were first

launched in 2001, with about 20 new surveys conducted each year since then (The World Bank, 2005). It was conducted in 2002 in China's five largest cities (Beijing, Guangzhou, Shanghai, Chengdu, and Tianjin), among 1,500 respondent firms (Smith and Hallward-Driemeier, 2005).

This study is on the basis of a sample of 2,400 Chinese firms in 18 cities involved in a follow-up survey conducted in 2003 (The World Bank, 2006). This dataset is used in this study because it involves a wider industrial and geographical coverage (these two survey data cannot be incorporated due to the differences in their survey questions). The survey sampled within 14 manufacturing and service sectors and within 15 provinces (including municipalities and autonomous region). These cities are distributed across five major economic regions of China: namely the North-eastern (e.g. Changchun, Benxi, Haerbin, Dalian), the Eastern (e.g. Hangzhou, Wenzhou), the Southern (e.g. Shenzhen, Jiangmen, Nanning), the Western (e.g. Chongqing, Lanzhou, Kunming, Xi'an, Guiyang) and the Middle China regions (e.g. Changsha, Wuhan, Nanchang, Zhengzhou).

6.4.2 Measures

6.4.2.1 Dependent Variables

Measures of the two dependent variables (DVs) of this study are constructed by

responses to a question relating to the payments of 'gifts and bribes required' in 2002. Specifically, these were in relation to payments to seven main government agencies that are closely related to a firm's daily operations, namely Tax Inspectorate, Labour and Social Security, Fire and Building Safety, Sanitation/Epidemiology, Police, Environment, and the Technical Supervision Bureau. The respective payment amounts are added to arrive at the total value of bribe payments required dealing with these government agencies.

The first dependent variable DV1 (*BriberyPropensity*) is generated based on whether this total amount of bribes reported by a firm is non-zero (indicating some bribe payments) or zero (no bribe payments). The second dependent variable DV2 (*BriberyIntensity*) is calculated by dividing the net value of a firm's assets in 2002 by the total amount of bribes reported in that year. By doing this, the size effect (in terms of firm assets) has been controlled in the measurement of bribe payments.

I am also mindful of the limitations of these measures. Firms may well under-report bribery behaviour, as both the payment and receipt of bribery are illegal in China. Nonetheless, bribery was reported by a significant proportion of respondent firms, and I thus suggest that these values do provide valid insights into these nefarious arrangements.

6.4.2.2 Independent Variables

With regard to Hypothesis H1a and H1b, I use the measure Inter-firm Networking (*Networking*) to account for a firm's tendency towards openness. *Networking* is measured by responses in the survey relating to whether or not the firm had engaged in any contractual or long-standing relationship with other firms in the year 2002. This is a dummy variable taking the value of 1 when the business indicated that it had used inter-firm networking and 0 otherwise.

I use two measures for hypothesis H2, which seeks to assess the perceived extent of assistance gained by firms in terms of the governmental and institutional support in their normal operations. The measure *GovernmentAid* is constructed by the survey question "Among the government officials that your firm regularly interacts with, which is the share that is oriented towards helping rather than hindering firms?" The response is expressed as a percentage ranging from 0 to 100%. The other measure *LawTransparency* is drawn from responses to the question relating to whether the business is satisfied with the availability/accessibility of information on relevant laws and regulations. This is semantically scaled from 1 to 5 (with 1 for not satisfied, 2 for somewhat unsatisfied, 3 for moderately satisfied, 4 for largely satisfied and 5 for very satisfied).

6.4.2.3 Control Variables

In addition to these independent variables, this study controls for the effects of firm age and employee size. Firm Age (*Age*) is calculated by the difference between the survey year 2003 and the year the firm was established. Employee Size (*Size*) is expressed as a logarithm of the numbers of total employees.

This study also controls for the exogenous factors relating to openness in a firm's operational environment. The customer aspect (*Customer*) is determined according to the survey question about the extent of major market dominance for the firm's main product: (a) the city the firm is located within; (b) the firm's province; (c) within China; and (d) China and overseas. The initial survey responses have been recoded to provide an ordinal measure of market dominance with values of 0 (low dominance) to 4 (high dominance). The supplier aspect (*Supplier*) is measured by the percentage of supplies outside the same province where the main plant of the firm is located. The competitor aspect is measured by both the number of competitors (*Competitor1*) within the firm's main business line in its major market (a scale from 1-5 with value 1 for 1-3, 2 for 4-6, 3 for 7-15, 4 for 16-100 and 5 for more than 100 competitors), and among all these competitors the percentages of competitors from overseas (*Competitor2*).

The existence of a potential endogeneity problem was considered (because the

measure of a firm's openness might be partly determined by these control variables representing the openness to customers, suppliers and competitors). This concern has been rejected by assessing the results of a Durbin-Wu-Hausman test on these variables. I found from the test that the coefficient of the first stage residuals was not significantly different from zero ensuring the consistency of model estimates.

6.5 STATISTICAL MODELS & RESULTS

6.5.1 Statistical Models

Due to the skewness of the responses reported by firms in my sample (in that the majority of the respondents reported no payment of bribes), it is noted that the traditional Ordinary Least Squares (OLS) based estimates might be unsuitable for this analysis. Moreover, given the potential (indeed expected) under-reporting of bribery, great care needs to be taken in modelling the bribery propensities of firms.

To partially mitigate these issues, a Heckman two-stage method was employed to correct selection bias (Heckman, 1979). Heckman's method was deemed suitable for my investigation of H1a and H1b also because it can differentiate the effects of independent variables on the two bribery decisions — whether or not to pay bribes (i.e. *DV1 propensity towards paying bribes*) and how much to pay (i.e. *DV2 the amount of payment*). In the first stage (the selection equation), a probit model was

conducted to analyse the propensity of firms to pay bribes. An *Inverse Mills Ratio* (λi) was calculated through which the non-random sample selection was treated as an omitted-variable source of bias (Heckman, 1979).

Using STATA's Heckman two-step method, a new variable LAMBDA was created and added into the second stage (regression stage) in the corrected OLS regression (where I examined the amount of bribe payment). The significance level of LAMBDA was then used to assess whether there was a selection bias in the initial model. Moreover, the inclusion of this new regressor in the second-stage regression model could be seen as a partially effective way to correct for selection bias (Martínez-Campillo and Fernández-Gago, 2011). The similar statistical approach has also been employed in the studies of Kim and Jang (2010) and Martínez-Campillo and Fernández-Gago (2011).

The Heckman method anticipates that there should be at least one variable (which is termed as an instrumental variable) that flags as significant in the selection equation but not in the regression equation (Puhani, 2000). In my study, both firm age and size are instrumental variables. After eliminating observations with missing values in both stages of the model, the actual sample size was reduced to 1,356 Chinese firms.

6.5.2 Results

Descriptive statistics and bivariate correlations are presented in Table 6.1. Table 6.2 displays the findings with regards to previously-stated Hypotheses. The overall significance of the Heckman procedure is indicated by the significance level of chi-square ($p < .05$). The slight significance of the coefficient for LAMBDA ($p < .10$) indicates the existence of some selection bias in the initial model before correction.

TABLE 6.1
Means, Standard Deviations and Correlations

Variable	Mean	S.D.	1	2	3	4	5	6	7	8	9	10
1. *BriberyPropensity*	.22	.42										
2. *BriberyIntensity*	.01	.14	.11**									
3. *Age*	16.45	13.97	.03	-.01								
4. *Size*	2.21	.59	.13**	-.02	.31**							
5. *Customer*	2.73	.92	.09**	.00	-.04*	.32**						
6. *Supplier*	.52	.36	.03	.04	-.07**	.17**	.22**					
7. *Competitor1*	3.06	1.40	-.07**	.01	-.03	-.16**	.01	-.09*				
8. *Competitor2*	.08	.20	.01	.02	-.08**	.14**	.32**	.16**	-.01			
9. *Networking*	.19	.39	.08**	.03	-.04*	.11**	.09**	.05*	-.10**	.01		
10. *GovernmentAid*	.36	.32	-.03	.02	-.03	.09**	.06**	-.00	-.03	-.01	.04*	
11. *LawTransparency*	3.04	.81	-.04*	.02	-.06**	-.03	.03	-.00	-.02	-.02	.04*	.16**

** Correlation is significant at the 0.01 level

* Correlation is significant at the 0.05 level

TABLE 6.2
Results of Heckman Two-stage Method Analysis

Independent Variables & Control Variables ↓	**Dependent Variable (DVs)**
Second-stage Corrected OLS Regression	**DV2 Bribery Intensity**
CVs:	
(Constant)	-0.355 *
Customer scale (*Customer*)	0.029
Supplier scale (*Supplier*)	0.048
Competitor number (*Competitor1*)	-0.030 *
Competitor overseas (*Competitor2*)	0.192 *
IVs:	
Networking (*Networking*)	0.100 $^{+}$
Government Assistance (*GovernmentAid*)	0.030
Law Transparency (*LawTransparency*)	0.001
First-stage Probit Model	**DV1 Bribery Propensity**
CVs:	
(Constant)	-1.218 ***
Firm Age (*Age*)	0.001
Employee Size (*Size*)	0.314 ***
Customer scale (*Customer*)	0.082 $^{+}$
Supplier scale (*Supplier*)	0.017
Competitor number (*Competitor1*)	-0.052 $^{+}$
Competitor overseas (*Competitor2*)	-0.102
IVs:	
Networking (*Networking*)	0.297 **
Government Assistance (*GovernmentAid*)	-0.307 *
Law Transparency (*LawTransparency*)	-0.096 *
LAMBDA	0.250 $^{+}$
Number of observations	1356
censored obs	1055
uncensored obs	301
Wald chi2 (7)	15.21
p-value	0.033

$^{+}$ p < .10

* p < .05

** p < .01

*** p < .001

The first-stage probit model examines H1a and H2. The second-stage regression model examines H1b. With regard to the hypothesis H1a which investigates the relationship between the propensity to pay bribes and a firm's tendency towards openness, the measure *Networking* is found to positively and significantly co-vary with the dependent variable ($p < .01$). Therefore, H1a is fully supported. H1b regarding whether the magnitude of bribe payment will positively vary with the tendency towards openness is also supported at significance level of 0.10 in the second-stage regression model.

H2 argues that firms will be less inclined to provide bribes when provided with more institutional and governmental assistance, rather than hindrance from these agencies. This hypothesis is also supported in my sample, as the coefficient for the variables *GovernmentAid* and *LawTransparency* show negative and significant relationship with the dependent variable ($p < .05$ for both) in the first-stage probit model emanating from the Heckman procedure.

Of the control variables, employee size (*Size*) seems to have positive effects on the propensity to pay bribes while firm age (*Age*) fails to significantly anticipate the likelihood of firm-level bribery in my sample. This is also shown by the results that the scale of customers (*Customer*) only positively leads to the propensity of bribery payouts, while the scale of suppliers (*Supplier*) does not affect either the propensity to

bribe or the amount of bribes. The two measures of openness to competitors have different effects. The number of competitors (*Competitor1*) negatively relates to both the propensity and payment for bribery. On the other hand a greater number of global competitors (*Competitor2*) seems to increase the quantum of the bribery payment. The differentiated effects of these exogenous factors in a firm's operational and strategic environment may be an area for future research.

6.6 DISCUSSION & CONCLUSION

This paper is concerned with the potentially negative impacts that are emerging during China's transitional phase from a centrally planned economic system to a market-driven and highly networked open economy. Openness and bribery are both important issues in the contemporary Chinese business context. This study attempts to provide new insight into corruption and its underlying causes in the context of openness in transitional China.

Clearly, the positive effects of openness on firms, in terms of enhanced engagement in inter-organisational networking and collaboration, exist. There has been a wide range of research on the significance of networking in advancing strategic capabilities (e.g. Chaston, 2000; Monsted, 1994; Stuart, 1998), enhancing knowledge bases (Shaw, 1998), mitigating resource and capability absences (Ahuja, 2000; Powell et al., 1996),

and achieving synergies relating to complementary skills and resources (Hagedoorn and Duysters, 2002).

However, it is found, on the basis of this study's analysis, that inter-firm networking and openness do co-vary positively and significantly with bribe paying in China. In a more open environment**,** with more business connections, firms have more opportunities to share resources and access information that may not be available otherwise. The opportunity for sharing knowledge creates not only positive effects, but also the potential for moral hazard in managerial behaviour.

A possible explanation for the positive relationship between openness and bribery may relate to resource based view considerations, discussed previously. The enhanced fluidity of information flows, and the more effective dissemination of information in the market, may reduce firms' capacity to protect their resource stock uniqueness, and hence undermine their competitive position.

Under such circumstances, firms may tend to purposefully seek business opportunities and competitive advantages that are able to be facilitated by the payment of bribes. This finding is in line with Martin et al (2007). Moreover, in a context where corruption is relatively widespread, the suspicion that competitors might benefit from these illegitimate ways may create a fear of losing competitive positioning. In this

sense, more active bribery behaviours are encouraged as a new strategic tool in the context of openness, thus heightening the potential moral hazard involved

Moreover, the openness towards global competitive markets may also lead to the emergence of an overemphasis on market-oriented values in the pursuit of profit, conflicting with the espoused positive virtues of guanxi norms (Dunfee and Warren, 2001; Whitcomb et al., 1998). As such, increased openness may well elicit inappropriate use of guanxi-based networks as facilitators for bribery and corruption.

Theories of comparative advantage would indicate that in the long term, the openness of firms and national economies will bring about various opportunities which should outweigh the potential threats with regard to reducing the rarity of a firm's core resources. From the supply side, it should be fully realised that the use of bribery and other corrupt practices as forms of "pragmatic and utilitarian" strategies (Pedigo and Marshall, 2009, p. 69) may be a shortcut to achieve organisational goals in the short term, but a hazard to the virtuous business relationship cycle of a firm, and may indeed jeopardise its long-term survival. Regardless of its forms, the harmfulness of bribery to the confidence in legal systems, corporate governance and economic development is well established (Braendle et al., 2005; Dunfee and Warren, 2001; Shleifer and Vishny, 1993). The discussion above suggests that firms, as the main suppliers of bribes, should be integrated as 'crucial allies' against corruption, if

bribery reduction is to be achieved (Calderón et al., 2009).

The findings also suggest that bribery and corruption are indeed encouraged by greater bureaucratic barriers and obstacles faced by firms. This finding is consistent with other studies which have also identified overregulation (Friedman, Johnson, Kaufmann and Zoido-Lobaton, 2000) and bureaucratic delays (Mauro, 1995) as important drivers of corruption. Corruption is believed to reflect institutional loopholes inherent within traditional economic systems (Guo, 2008). The passive form of bribery paying may develop as a defensive approach to avoiding red tapes or long waiting times for regulatory approvals. The rapid organisational response to environment changes is more likely to be facilitated this way. These obstacles to the organisational development might also cause a vicious cycle that some government officials might purposively retain the applications which could be processed quickly otherwise to ask for some bribes from businesses.

Therefore, other than the recent measures taken by Chinese government against bribery through improving transparency and integrity of its legislation, as well as increasing penalties for bribe-taking and bribe-giving (Calderón et al., 2009; Tian, 2008), this study shows that another priority of anti-bribery efforts should be to enhance the effectiveness of governmental functions and the efficiency in China's public sector.

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CHAPTER VII

Openness and Appropriation:
Empirical Evidence from Australian Businesses

Paper accepted with revisions by the Journal of *Technovation* (second revision submitted)

STATEMENT OF AUTHORSHIP

OPENNESS AND APPROPRIATION: EMPIRICAL EVIDENCE FROM AUSTRALIAN BUSINESSES

Journal paper (accepted with revisions)

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For this paper (chapter), Fang Huang developed the theoretical framework and hypotheses, performed data analysis and interpretation, wrote the manuscript and acted as the corresponding author. Dr John Rice and Professor Peter Galvin assisted in theory development, provided supervision and critical evaluation.

The majority of the work and the primary authorship have been undertaken by Fang Huang.

Fang Huang (Candidate)

I hereby certify that the statement of contribution is accurate.

Signed [redacted] Date 29/8/2011

Dr John Rice

I hereby certify that the statement of contribution is accurate and I give permission for the inclusion of the paper in the thesis.

Signed [redacted] Date 20/8/2011

Prof. Peter Galvin

I hereby certify that the statement of contribution is accurate and I give permission for the inclusion of the paper in the thesis.

Signed [redacted] Date 17/8/2011

THE RELATIONSHIP OF THIS CHAPTER TO THE DOCTORAL RESEARCH

This chapter continues to place emphasis on the potential threats pertaining to open innovation strategies. Based on the findings of the prior chapter regarding the reduced resources/capabilities heterogeneity (hence reduced competitive competencies) in the context of openness (which is one of the underlying causes of bribery), this chapter further relates these disadvantages to the 'paradox of open innovation' (indicated by the second research question) with which open innovators seek to balance the risks resulting from unwilling knowledge spillovers and the benefits brought by voluntary knowledge sharing and information flows. This study is conducted through the analysis of appropriation mechanisms employed by open innovators which largely reflect their real intention to facilitate or block knowledge sharing when they are faced with this paradox. In this sense, the principle research problem concerning whether firms can really benefit from an open innovation strategy is thoroughly explored.

ABSTRACT

The adoption of open innovation approaches creates a dilemma for firms. On the one hand, openness facilitates the flow of knowledge between firms, preferably on a relatively fluid basis unconstrained by royalties and other appropriation constraints. On the other hand, openness may lead to unintended and involuntary knowledge spillovers or leakages, limiting firms' abilities to commercialise their knowledge and requiring them to exert more control over the knowledge transfer processes and their own intellectual property rights. This dilemma creates a need to consider the relationship between openness and firms' appropriability regimes. In order to explore this 'paradox of openness', this paper investigates the appropriability regimes adopted by 'open innovators' through empirical analysis of innovation-related data from 4,322 Australian businesses. Findings of this study provide new insights regarding the appropriability regimes adopted in an open environment. It is found that the relationship between the two indicators of openness (the breadth of external knowledge sources and the scope of inter-organisational collaboration) and the scope of appropriability regimes employed by a firm exhibits a non-linear, inverse-U form. Results also indicate that open innovators actually increase controls on their intellectual property through informal appropriability regimes rather than loosening these mechanisms to promote knowledge spillovers as open innovation theories suggest.

7.1 INTRODUCTION

At a time of increasingly complex technologies, higher level of uncertainty surrounding research and development (R&D), increasingly costly R&D projects and shorter innovation cycles, it is often suggested that the inspiration and development of innovations within the boundary of a single firm is sub-optimal (Arora, Fosfuri and Gambardella, 2001; Chesbrough, 2003a; Miotti and Sachwald, 2003).

The theoretical and empirical moves toward an externally-oriented view of innovation are most currently encapsulated in the work concerning 'open innovation' (Chesbrough, 2003a, 2006a). By definition, open innovation entails "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively" (Chesbrough, 2006a, p. 1). Open innovation may entail the dissemination of knowledge embedded in physical products (i.e. components, intermediate products) or in more intangible form (i.e. patents, know-how) or both (i.e. procedural solutions integrating physical and intangible knowledge forms).

Chesbrough's definition essentially implies that there are two dimensions of open innovation activities: *inbound* open innovation and *outbound* open innovation (Chesbrough and Crowther, 2006). In respect to the new product development event, inbound open innovation refers to *ex-ante* processes of actively in-sourcing and

absorbing knowledge from the external environment to supplement a firm's internal R&D, while outbound open innovation represents *ex-post* and purposeful search activities to facilitate external commercialisation paths for creative ideas generated in-house (Chesbrough, 2003a; Lichtenthaler, 2009a; Spithoven, Clarysse and Knockaert, 2010). Hence, firms may open up their innovation processes relying on these two complementary approaches — the outside-in approach through knowledge sourcing channels, and the inside-out approach through knowledge commercialisation mechanisms (Christensen, Olesen and Kjær, 2005; Lichtenthaler, 2009a; West and Gallagher, 2006b).

Inbound open innovation is based on the systematic exploration of inward flows of knowledge and technology (Lichtenthaler, 2009a; West and Gallagher, 2006b). There are two primary elements to facilitate these knowledge inflows — external sources from which the exogenous knowledge emerges, including from customers, suppliers, competitors, government agencies and research institutes (Katila and Ahuja, 2002; Laursen and Salter, 2006); and channels through which knowledge can be inwardly transferred, such as technology in-licensing, inter-firm collaboration, and joint development (Christensen et al., 2005; Grönlund, Sjödin and Frishammar, 2010; Spithoven et al., 2010).

Outbound open innovation, on the other hand, is enabled by facilitating the outflow of

knowledge and technology (Chesbrough and Crowther, 2006). This is mainly realised by means of external commercialisation approaches through which knowledge and technologies are transferred to the external environment (Lichtenthaler, 2009a; Lichtenthaler and Ernst, 2006; Spithoven et al., 2010; West and Gallagher, 2006b). Outbound open innovation thus depends on this process of actively and systematically promoting internally generated intellectual property (IP) to the outside world (Gassmann, 2006; Lichtenthaler, 2010). This outward dimension of innovation reflects an entrepreneurial approach to the management of intellectual property, which has hitherto been regarded primarily as a means of knowledge protection for inbound open innovation (West and Gallagher, 2006b). In this sense, the economic profits of open innovation can be optimised through the selling of IP or licensing out technology developed through in-house R&D (Dahlander and Gann, 2010; Schmidt, 2006).

Despite evidence that both directional dimensions are widely employed, most current research on open innovation continues to focus primarily on inbound-oriented activities (Lichtenthaler, 2009a; Lichtenthaler and Ernst, 2007). This is largely because in practice, inbound activities are more prevalent and occur earlier in the innovation process (Chesbrough and Crowther, 2006). The inbound perspective of a firm's open innovation strategy is also the focus of this study.

This research seeks to shed some light on an unresolved paradox in the theoretical assumptions of inbound open innovation, namely the relationship between the access to external knowledge through inbound mechanisms and the use of appropriability regimes of open innovators. Henceforth this paper uses the term 'appropriability regimes' to refer collectively to those formal and informal arrangements that firms may use to extract returns from their intellectual and tangible resources. This follows the development and use of this term by Teece (1986), Todorova and Durisin (2007) and others.

Open innovation suggests that the generation of innovative outputs is facilitated by increased fluidity of knowledge and information flows between firms (Chesbrough, 2003a; van de Vrande, de Jong, Vanhaverbeke and de Rochemont, 2009). Such flows are enhanced when they are generally unconstrained by excessive appropriation of knowledge royalties (West, 2006; West and Gallagher, 2006b). The use of shared appropriability regimes has also been recognised as a means to encourage and facilitate the sharing of various forms of knowledge and concomitant rents (Almeida and Kogut, 1999; Lavie and Rosenkopf, 2006; West and Gallagher, 2006b). A common conclusion of these studies is that shared benefits are maximised through a reduction of transactional costs and royalty-based constraints between firms (Lazzarotti and Manzini, 2009; Spencer, 2003).

However, these assumptions imply a paradox of openness with regard to the appropriability regimes affected by open innovation practices (West, 2006). On the one hand, open innovation encourages firms to reduce the appropriability regimes constraints, and disseminate knowledge to increase their use by others rather than leave them in house (Chesbrough, 2003a). Firms are likely to gain numerous indirect benefits from their innovations in this way (Dahlander and Gann, 2010). On the other hand, in the context of openness, the necessity to disclose knowledge might lead to unintended and involuntary knowledge spillovers or leakages, requiring firms to exert more control over potential IP rights. In that sense, there might be a creative tension between the knowledge disclosure (including spillover) effects, and the protections and returns facilitated by different elements of appropriability regimes.

This paradox leads us to consider the complex impacts of inbound open innovation arrangements upon the appropriability regimes employed by firms. As suggested by Laursen and Salter (2005) and West (2006), most extant research that does address open innovation fails to articulate the ambiguous theoretical underpinnings regarding the appropriation approaches taken by 'open innovators'. Therefore, this paper seeks to address this largely neglected area within the open innovation literature — how does openness actually affect a firm's management of appropriability regimes to garner benefits from its innovations? This study attempts to address this research question by quantitatively examining inbound open innovation in terms of external

knowledge sources and knowledge access channels, and their effects on the decisions of appropriation regimes in terms of both formal and informal IP rights instruments.

7.2 LITERATURE REVIEW

7.2.1 Defining Open Innovators

Although the term 'open innovation' is relatively recent, it does not represent a new organisational phenomenon (Christensen et al., 2005; Spithoven et al., 2010). Chesbrough and Crowther's (2006) study found that many open innovation concepts have been in practical use for some time. The growing trends and approaches towards better understanding the rationale for, and processes of, the inbound flow of knowledge to organisations have been recognised in extensive literature (Chesbrough, 2006). These antecedent theories highlight two main streams underpinning inbound open innovation.

The first stream relates to the inward knowledge flows to firms (Chesbrough, 2003a, 2006a). Highlighting the advantages of these flows for open innovation, some "innovative firms now spend little on R&D and yet they are able to successfully innovate by drawing in knowledge and expertise from a wide range of external sources" (Laursen and Salter, 2006, p. 132). This central premise is empirically consistent with much of the 'sources of innovation' literature (e.g. McAdam and

McClelland, 2002; Salter and Gann, 2003; von Hippel, 1988). To access these sources, Chesbrough (2003a) specifically suggests that the boundaries of the firm must become more porous, facilitating the formation of various ties across their boundaries (Vanhaverbeke, 2006). These ties involve linkages with a wide range of crucial parties such as customers, suppliers, universities, research centres and other actors to establish value networks for firms in the context of open innovation (Vanhaverbeke and Cloodt, 2006).

The use of external knowledge sources helps firms to identify and maintain potentially valuable innovations during the early stages of technology development, while also shaping the roles of partners in creating and capturing value at the final stage of commercialising innovation outputs (Chesbrough and Rosenbloom, 2002). The scope of external sources of knowledge is the most commonly used measure of the degree of openness for firms. Lazzarotti and Manzini (2009) operationalised it with 'partner variety' in their research, i.e. a typology of the variety of partners with which the company collaborates. Laursen and Salter's (2006) study also assessed the number of external sources of innovation. They operationalised this measure as 'external search breadth', ensuring its inclusion in later studies as a key measure of openness. The findings of these studies imply that those firms involved with a larger number of external partners tend to be relatively more 'open' than others (Dahlander and Gann, 2010).

The second body of literature examined here relates to the various means by which firms access and acquire knowledge. These means include purchase of knowledge and technology through the marketplace or acquisition of them through active and deliberate R&D cooperation with other firms (Arora and Gambardella, 1990; Cassiman and Veugelers, 2006; Dahlander and Gann, 2010; Veugelers and Cassiman, 1999). Common among these studies is the jointly transactional and collaborative nature of open innovation practices (Christensen et al., 2005; Igartua, Garrigós and Hervas-Oliver, 2010).

This study thus will adopt measures of these two forms 'inter-organisational collaboration' and 'technology purchase' within my models. In the relevant literature, technology purchase is typically a form of transactional arrangements undertaken to acquire external knowledge and technology, including through the purchase of patents, trademarks or licenses (Sen and Rubenstein, 1989). Such arrangements facilitate the 'buy' option for firms facing 'make or buy' decisions relating to the alternative options of conducting in-house R&D or commercially buying in technology (Kurokawa, 1997; Chesbrough, 2003a).

Moreover, firms often depend on more informal inter-organisational collaborations to avoid costs associated with IP contracting or licensing agreements. These interactions

are intended to be less formal than transactional technology purchases, and are regarded as an essential means by which inbound open innovation functions in gaining access to complementary information and know-how (Vanhaverbeke, 2006; Vanhaverbeke, Duysters and Noorderhaven, 2002).

Therefore, this study categorises 'open innovators' based on these two perspectives of an inbound open innovation — namely firms that are involved with broader *scope of external sources of knowledge* and engaged in more *inter-organisational collaborations* and *technology purchase activities* to obtain knowledge from outside are comparatively more 'open' than others. These three constructs will also be employed as the main variables jointly measuring the 'degree of openness' for the focal firms in my models. That is to say, firms with a higher degree of openness can be considered comparatively open innovators.

7.2.2 Inbound Open Innovation and Appropriability Regimes

This study seeks to assess how openness impacts the appropriability regimes that firms follow. Appropriability regimes seek to protect and facilitate the commercial exploitation of knowledge. Certain attributes of industrial knowledge, including its intangible nature, its cumulativeness and its indivisibility, make managing its diffusion and exploitation a singularly challenging task (Antonelli, 2003; Teece,

1998). In discussing knowledge management, the principal tasks are often presented as exploration, exploitation and retention (Argote, McEvily, Reagans, 2003; Grant, 1996). Open innovation integrates these tasks in terms of the exploration, exploitation and development of inbound and outbound knowledge (Lichtenthaler, 2009a; Schmidt, 2006).

In the context of inbound open innovation, firms involve themselves in different exploration activities outside their boundaries to overcome knowledge deficiencies, and to assist them in accelerating their innovation efforts (Chesbrough, 2003a, 2006a; Grant and Baden-Fuller, 2004; Laursen and Salter, 2006). To counter the perception (or reality) of opportunism, the exploration process often also entails making some knowledge and resources available to other firms.

Promoting an organisation's knowledge within external networks leads to some managerial tensions. By necessity effective promotion includes the protection of an organisation's core knowledge because firms' competitive advantage lies in an organisation's "ability to create, transfer, assemble, integrate and exploit knowledge assets" (Teece, 1998, p. 75). While knowledge resources are likely to be an integral contributor to a firm's competitive advantage due to the difficulty in replicating such resources (Barney, 1991; Foss, 2007), firms must often actively protect such knowledge through various appropriability regimes.

There are numerous IP protection mechanisms that facilitate the appropriation of firms' intellectual assets (Leiponen and Byma, 2009). These are usually divided into two groups — formal mechanisms that legally preclude the non-agreed use of knowledge by competitors (such as patents, copyrights, trademarks and other forms of property right protection), and informal methods that protect technology from unanticipated outflows (including enhanced lead time from competitors, firm secrecy and complexity of design) (Cohen, Nelson and Walsh, 2000; Schmidt, 2006). Although some empirical studies have looked peripherally at the use of patenting, copyright and trade secrecy by open innovators (Schmidt, 2006; West, 2006), open innovation research has not paid enough attention to this issue thus far.

7. 3 HYPOTHESES DEVELOPMENT

7.3.1 The Degree of Openness and the Use of IP Appropriability Regimes

Traditionally, the choice of IP appropriability regimes has been contingent upon firm level factors such as size as well as upon the nature of the external partners with which the firm engages (Jensen and Webster 2006; Leiponen and Byma, 2009; Willoughby, 2010). Firms may engage through the use of vertical linkages with suppliers and buyers, horizontal interaction with competitors and partners, or networking with universities and research institutes (George, Zahra, Wheatley and

Khan, 2001). In line with my previous discussion, I operationalise this by assessing firms' degrees of openness towards the external environment (in terms of both the breadth of external knowledge sources employed, and the scope of collaborative and transactional partners involved through inter-organisational collaborations and technology transactions).

As firms purposefully expand search strategies outside their boundaries, the scope of external sources they contact with increases. Firms may, on an ad-hoc basis, set different requirements regarding the degree of knowledge disclosure to these sources. In a study within mobile telephony handset manufacturing, Galvin and Rice (2008) found that firms differentiated their sharing strategies between firm partners, and between knowledge types, on a contingent basis.

Opportunism is a constant threat, for all parties, within open innovation arrangements (Hoecht and Trott, 2006; Kale, Singh and Perlmutter, 2000). Managers are often well informed about these risks, and tailor their information strategies accordingly (Saxenian, 1994). Firms may utilise formal IP controls to safeguard themselves from their competitors' opportunism (Agarwal, Ganco and Ziedonis, 2009), or may utilise secrecy, speed to market, limits on employee mobility or other arrangements (Almeida and Kogut, 1999; Schmidt, 2006; Song, Almeida and Wu, 2003). Nonetheless, firms often purposely reveal important information to competitors in

order to jointly drive investment and market growth, or to promote lead-user adoption (Ettlie and Reza, 1992; Hoang and Rothaermel, 2005).

In this paper, I propose and test the proposition that as firms increase the openness of their external knowledge exploration activities, they will increase the scope of their appropriation regimes, namely the number of different protection methods they employ, to deal with the different demands of knowledge spillovers to these sources. As firms build openness with respect to external parties, they are likely to seek some form of IP protection. This may take on a variety of forms including relying upon informal approaches such as trade secrets, through to formal approaches such as patents and copyright. The variety and selection of appropriation arrangements adopted by firms has been shown to be highly contingent, often strategic, and made in reference to a variety of internal, market and relationship-specific factors (Blind, Edler, Frietsch and Schmoch, 2006; Lichtenthaler, 2009b; Willoughby, 2010). For example, cooperating with universities firms tend to use patenting more likely as an IP appropriability regime, whereas with "horizontal collaborative innovation arrangements", firms are "statistically significantly more likely ... to emphasize speed [to market]" (Leiponon and Byma, 2009, p. 1478). As the degree of openness increases, so too does the scope of appropriability regimes.

While the scope of opportunities for appropriation will tend to increase as firms

become more open, I would suggest that this increase faces declining marginal utility. In order to minimise the collective risks and costs of too many appropriability regimes arrangements, firms attempt to optimise these relative to their product portfolio and innovation situation (Arundel, 2001). Firms thus start to invest in certain appropriability regimes over others to enhance their efficiency. For example, patenting is often viewed as an inferior IP protection mechanism for small firms or firms that patent infrequently due to the costs of establishing, monitoring and potentially enforcing the patent (because of the need to either internally develop the capabilities to navigate the complex regulations or utilise expensive specialist legal firms) (Olander, Hurmelinna-Laukkanen and Mähönan, 2009). Firms that do make these investments in patenting management, (via the employment of patent attorneys and associated support staff, for example) may well integrate patenting into the R&D process to the point that patenting becomes something of a default option for some firms (Blind et al., 2006). In much the same way, there are capabilities associated with ensuring an IP protection strategy based on (informal) secrecy actually works. There are clear administrative requirements in respect of law such as "explicitly defining the trade secret and ... providing unambiguous and appropriate notice to employees, visitors and research partners, etc" (Willoughby, 2010, p. 16). Again, once a firm develops these capabilities, secrecy becomes a more viable option for different IP both in respect of cost and efficiency in limiting IP spillovers.

As the degree of openness increases, it thus becomes inevitable that firms will use some IP appropriability regimes more often than others. It is through this process of capability building in respect of selecting appropriability regimes and positive reinforcement that firms will move away from using a wide array of IP appropriability regimes and instead start to focus upon a more limited set of choices. I suggest that path dependencies, value and competency accumulation, and declining marginal utilities ensure that firms are likely to make choices that over time to reinforce the effectiveness of some appropriability regimes over others.

Overall, I suggest that as the external search activities increase, so too will the utilisation of different appropriability regimes due to an increase in the variety of partners that they come into contact with and their different impacts on knowledge spillovers. I then anticipate that the growth in the variety of appropriation strategies will tend to tail-off, and potentially decline at some point, due to firms minimising the collective risks of multiple appropriability regimes by investing in a limited set of options and developing a set of capabilities in respect of these options that improve their IP management efficiency (but which simultaneously become self-reinforcing and thus option limiting). Hence, I propose the first hypothesis:

Hypothesis 1: The degree of openness (operationalised by the breadth of external knowledge sources employed and the scope of collaborative and transactional partners involved) is curvilinearly (taking an inverted U-shape) related to the scope

of IP appropriability regimes.

7.3.2 The Adoption of Formal and Informal Protection Arrangements by Open Innovators

The discussion in the introductory section of this paper illustrates a paradox that open innovators might face: on the one hand, openness facilitates the flow of knowledge between firms, preferably on a relatively fluid basis unconstrained by royalties and other appropriation constraints. On the other hand, openness may lead to unintended and involuntary knowledge spillovers or leakages, requiring firms to exert more control over the knowledge transfer processes and their own intellectual property rights. Through this hypothesis, I intend to further explore this paradox.

IP appropriability regimes can be categorised into two main types — formal and informal. They tend to affect outward knowledge spillovers in different ways (Schmidt, 2006). It is shown above that various choices made by managers regarding IP protection arrangements and appropriability regimes adoption are contingent on a variety of factors. Among those factors, one important driver may be the intended extent of knowledge exposure by firms. While the use of formal protection instruments such as patents, licenses and copyright is often seen as highly restrictive, these arrangements may actually be seen as active forms of disclosure of proprietary knowledge to other parties, including competitors (Gallini, 2002; Schmidt, 2006;

Willoughby, 2010). Such disclosure of protected knowledge represents a kind of voluntary knowledge spillover, with the aim of transferring complementary knowledge between external parties, including potential competitors (West and Gallagher, 2006b). In that sense, these formal protection methods are used for the purpose of knowledge brokering and knowledge sharing rather than only knowledge protection (Chesbrough, 2003a; Dahlander and Gann, 2010). The disclosure effect of formal IP protection mechanisms tends to counterbalance, and may even outweigh, their constrictive effects (Schmidt, 2006). Therefore, in an open innovation model, the effective use of formal appropriability regimes can be seen as a proactive and positive measure to encourage the knowledge disclosure by open innovators (Chesbrough, 2003a).

Informal knowledge protection (for example, secrecy) may at first appear to be a less restrictive form of IP protection. However, on the contrary, such arrangements have the direct, specific and intended effect of limiting knowledge flows between firms (Willoughby, 2010). While the formal appropriation instruments, discussed above, have counterbalancing impacts, informal methods do not have any knowledge disclosure element (Willoughby, 2010), and hence would effectively limit outward knowledge flows (Schmidt, 2005).

Firms tending to utilise secrecy and other forms of informal IP protection may be

seeking strategic advantages within their market based upon first mover positioning (Schmidt, 2006) or differentiation of their products in such a way that replication by competitors is challenging (Barney, 1991). On that basis, the use of informal protection methods may indeed indicate a genuine aversion to any knowledge spillovers and networking (Arundel, 2001). Hence I propose the second hypothesis:

Hypothesis 2: The degree of openness is positively related to the use of formal IP appropriability regimes, and negatively related to the use of informal IP appropriability regimes.

7.4 METHODS

7.4.1 Sample

The data for analysis was drawn from the *2003 Innovation in Australian Business Survey (IABS)* available from the Australian Bureau of Statistics (ABS). I chose this database as it provides comprehensive details of firm-level innovation activities that are not available from other surveys in the Australian context. Furthermore, the survey questions and frameworks are largely consistent with the Oslo Manual on Innovation (OECD, 1997), therefore maintaining partial comparability with several international surveys (e.g. the Eurostat Community Innovation Survey (CIS)). This facilitates the potential for comparison between different innovation contexts in future research.

The scope of the IABS was all business units in Australia who had registered with Australian Taxation Office and had more than 4 employees, with the exception of government enterprises or businesses in several specific industries (e.g. Agriculture, Forestry and Fishing; Education; Health and Community Services; Personal and Other Services). The survey was conducted based on a random sample of businesses within this survey scope. The sample released in the 2003 IABS Expanded CURF was 4,520 respondent businesses, approximately 73% of the businesses that contributed to the survey (The Australian Bureau of Statistics, 2003).

The sample for this study was refined to ensure comparability and completeness of data for respondent businesses. Through a process of careful screening, 4,322 Australian businesses were identified which reported on all data items of the survey (i.e. no missing values of all the variables for these observations), and had non-zero total financial expenditures during the period of survey.

7.4.2 Measures

Dependent Variables

For the first hypothesis, the scope of IP appropriability regimes (*IP_Scope*) employed by the focal business is measured by the sum of responses to eight related questions

drawn from the survey. This construct combines both formal and informal methods of intellectual property protection, namely 'patents', 'registration of design', 'copyright or trademark', 'other formal methods', and 'secrecy (including electronic protection methods)', 'complexity of product design', 'making frequent and rapid changes to the good or service', and 'other informal methods'. Every business was asked whether it had utilised each appropriability regime component during the calendar year 2003, answering with a binary variable, 1 for yes and 0 for no. These responses were subsequently aggregated to construct the overall scope of the appropriability regimes within the focal business. Accordingly, this ordinal measure ranges from 0 to 8.

For the second hypothesis, the six main formal and informal protection mechanisms stated above will be respectively employed as dependent variables, namely formal methods — patents (*Patent*), registration of design (*Registration*), copyright or trademark (*Copyright*); and informal methods — secrecy (*Secrecy*), complexity of product design (*Complexity*), and making frequent and rapid changes to the good or service (*Speed*). All of them are dummy variables and are coded with the value of 1 if the business had adopted this specific method and 0 otherwise.

Independent Variables

The three variables (IVs) that measure the *degree of openness* will be constructed as follows.

The breadth of external sources (*Sources*) is measured by the 11 key knowledge sources the IABS listed that might contribute to the development of innovations by firms, namely customers, suppliers, consultants, competitors, universities, government agencies, private research institutions, commercial laboratories, professional conferences, websites and journals, and other sources of ideas or information. These in turn fall into three main categories — market sources, institutional sources and other sources. Each business was asked to indicate the sources it had used. By combining the respective binary responses to the use of these eleven sources, an ordinal scale of measurement was developed, taking the value of 0 with no external sources used and 11 with all of these potential sources used.

Inter-organisational Collaboration (*Collaboration*) is measured by summing the binary responses to six survey questions regarding whether the business had actively engaged in any types of collaboration (to develop new products or services or new processes during the calendar year 2003). These activities included joint marketing or distribution, joint manufacturing, joint research and development, other joint ventures, licensing agreements, or other forms of collaboration. Each question is a binary variable taking the value of 1 when the business indicated that it had used this type of collaboration and 0 otherwise. Therefore, the aggregate ordinal measure for collaboration ranges from 0 to 6.

Technology Purchase (*Techbuyin*) is measured by the proportion of the estimated value of machinery, equipment, licenses, patents and other intellectual property externally acquired to develop new goods or services (or new processes) to total expenditure of the business, this is a continuous variable ranging from 0 to 1.

I have noted that the construct of the dependent variable — the scope of IP appropriability regimes — may involve some licensing agreements which are also presented in the measures of independent variables such as inter-organisational collaboration and technology purchase. I believe that this will not affect the validity of my statistical analysis because although similarly termed, they are sourced from two distinct questions in the survey. For the licensing-in arrangements involved in the independent variable measures, they mainly refer to purchasing licenses of those externally developed technology, essentially an approach to acquiring exogenous knowledge (Dahlander and Gann, 2010); while for the licensing arrangements in the dependent variable measure, they relate to the licensing of the organisation's internal innovation output, mainly an effective means of appropriation and knowledge protection (Arora, 1997).

Control Variables

Other than external search efforts, I control for the role of internal R&D in terms of

two proxy measures — 'R&D expenditure' and 'investment in internal human capital'. As per my previous discussion, I suggest that there is a complementary and interactive relationship between endogenous R&D and external acquisition of exogenous knowledge and technology (Cassiman and Veugelers, 2006; Vanhaverbeke et al., 2002).

R&D Expenditure (*R&D*) has been calculated based on the estimated expenditure on research & development activities of new or changed goods/services (or processes) controlled by the total expenditure of the focal business. These actual expenditure values were gathered by the ABS, and thus provide a continuous measure of the relative importance of financial investment in internal research and development. The investment in human capital of the focal business (*Staffing*) is constructed by combining three main survey questions with regard to whether the business had employed new skilled staff, whether the business had employed new graduates, and whether it had employed academic or research staff.

Additionally, I take into account another two common control variables with regard to a business's basic attributes — firm size and industry type. Firm size (*Size*) is measured by the number of employees of the focal business. The responses to this survey question were released by the ABS only as a categorical variable (on a 1-3 scale: 1 for 5-19 persons, 2 for 20-99 persons, 3 for 100 or more persons). An industry

dummy (*Industry*) is included as well with the value of 1 if the business was in the manufacturing industry and 0 otherwise, after recoding the original responses of 12 different industries. As the ABS only provided the aggregate category of manufacturing industry along with other 11 non-manufacturing industries based on ANZSIC industry division category values, I could only control for the difference in firms' propensities towards various types of appropriability regime between manufacturing and non-manufacturing sectors. Although this issue also leads to research attention in related studies (e.g. Cohen et al., 2000), a more fine-grained measure concerning sub-categories of manufacturing industries cannot be provided here. I note this as a limitation of this study.

7.4.3 Descriptive Results

Descriptive results of variables are displayed in Table 7.1. The respective correlation coefficients between them suggest that none of them are sufficiently strong to indicate any multicollinearity based on the sample of this study.

Given the identified limitation of this study that the differentiated effects of industries on appropriation mechanisms cannot be fully explored due to the unavailability of the data, I attempt to partially address it by distinguishing the scopes of appropriability regimes employed between firms in the two general types of industry —

manufacturing and services. My sample consists of 1,827 manufacturing businesses and 2,495 services businesses. When I disaggregate these two broad industrial groups, I note that the use of appropriability regimes for manufacturing firms (0.785) and services firms (0.600) differs significantly ($p < .001$ indicated by a t-test). I think this is also consistent with the inherent nature of the innovation outputs of these two industries, as new services are relatively more intangible and different to appropriate than new products, services firms are generally less likely to use such a large variety of appropriability regimes as manufacturing firms.

Table 7.1
Means, Standard Deviations and Correlations

Variable	Mean	S.D.	1	2	3	4	5	6	7
1. IP_Scope	0.678	1.076							
2. Sources	2.384	2.096	.32**						
3. Collaboration	0.335	0.925	.33**	.28**					
4. Techbuyin	0.009	0.048	.09**	.09**	.11**				
5. R&D	0.012	0.069	.13**	.07**	.09**	.08**			
6. Staffing	0.494	0.927	.35**	.40**	.26**	.09**	.09**		
7. Size	1.739	0.793	.28**	.18**	.14**	-.01	-.03*	.35**	
8. Industry	0.423	0.494	.09**	-.02	.01	.05**	.03*	-.07**	-.08**

n=4322

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

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

7.4.4 Statistical Models and Modelling Results

For Hypothesis 1, as the dependent variable *IP_Scope* is a non-negative count variable with over-dispersion (i.e. the variance of this variable is much larger than its mean as shown in Table 7.1), a Negative Binominal Regression model is used for this analysis (this has been shown to be superior to Poisson and OLS regression models for data of this type) (Hausman, Hall and Griliches, 1984). A hierarchical arrangement will be adopted in this study, meaning only control variables will be included in the basic model, with the three measures of the degree of openness *Sources*, *Collaboration* and *Techbuyin* and their squared terms entered in a stepwise arrangement to examine their inverted U-shape effects. For Hypothesis 2, as all six dependent variables are binary variables, a Binary Logistic Regression arrangement is employed for each model. The modelling results regarding the testing of Hypothesis 1 are presented in Table 7.2.

The models in Table 7.2 aim to test how the variance in the degree of openness (measured by the breadth of external sources, the scope of inter-organisational collaboration and the extent of technology buy-in activities) explains (or co-varies with) the scope of the overall appropriation mechanisms employed by the focal firms. All these models show a high significance of the overall model (indicated by the significance level of Chi-square).

TABLE 7.2
Results of Negative Binominal Regression for Scope of Appropriability Regimes

Control Variables & Independent Variables ↓	**DV — Scope of IP Appropriability Regimes** (*IP_Scope*)		
(Constant)	-1.621 ***	-1.913 ***	-2.133 ***
Firm Size (*Size*)	0.421 ***	0.391 ***	0.389 ***
Industry Dummy (*Industry*)	0.383 ***	0.369 ***	0.371 ***
R&D Expenditure (*R&D*)	2.225 ***	1.667 ***	1.528 ***
Human Capital (*Staffing*)	0.299 ***	0.153 ***	0.158 ***
The Degree of Openness			
Scope of External Sources (*Sources*)		0.122 ***	0.298 ***
Inter-organisational Collaboration (*Collaboration*)		0.201 ***	0.429 ***
Technology Purchase (*Techbuyin*)		0.949 *	1.841 *
The Degree of Openness Squared			
Scope of External Sources Squared ($Sources^2$)			-0.025 ***
Inter-organisational Collaboration Squared ($Collaboration^2$)			-0.055 ***
Technology Purchase Squared ($Techbuyin^2$)			-1.974
LR Chi-square	642.52 ***	935.53 ***	1012.59 ***
Log likelihood	- 4568.275	- 4421.769	- 4383.240
Pseudo R^2	0.0657	0.0957	0.1035

n=4322
$^+$ p < .10
* p < .05
** p < .01
*** p < .001

The modelling results provide strong support for my first hypothesis because: first the coefficient of all three measures of the degree of openness namely *Sources*, *Collaboration* and *Techbuyin* are positive and highly significant (p < .001 for *Sources* and *Collaboration*, and p < .05 for *Techbuyin*), indicating that external sources and

inter-organisational collaborations and technology purchase activities are all important explanatory factors in determining the scope of appropriability regimes employed by firms, and there is an increase in the model fit (indicated by a significant change in the Pseudo R^2) when these terms are introduced to the basic model. Secondly, the $Sources^2$ and $Collaboration^2$ are both negative and highly significant ($p < .001$), with a concomitant significant improvement in the explanatory power of the model with the introduction of these squared terms (indicated by the Pseudo R^2). However, the $Techbuyin^2$ is not significant ($p > .10$), indicating this measure of the degree of openness tends to only have a linear effect on the scope of appropriability regimes employed by firms.

Taken together, these imply that in the process of opening up their innovation networks, firms are likely to collaborate with more diverse external partners and utilise a greater variety of external sources, and they accordingly tend to rely on an increasing number of appropriability regimes. Nevertheless, firms are likely to narrow the scope of protection methods employed if they progress towards greater openness (and are involved with a larger variety of external partners and knowledge sources).

However, it is also shown by my modelling results that firms won't reduce the scope of IP protection mechanisms if the extent of technology purchase activities continues to increase. Therefore, based on the sample of my study, my hypothesis asserting that

the degree of openness is curvilinear (taking an inverted U-shape) in its relationship to the scope of a firm's appropriability regimes is supported for two of the three forms of openness.

I think that the reason technology purchase does not present a declining marginal effect as per the other two measures of openness might be related to the specific characteristics associated with technology buy-in activities. Whereas the inter-organisational collaborations and knowledge sources available to firms can be encapsulated into a limited number of categories (such as the 6 types of collaborations and the 11 sources of knowledge as previously stated), the types of technology acquired from the outside might be tremendously diverse. This is why I adopted a percentage rather than a categorical variable to construct this measure. In other words, the heterogeneity regarding the objects of technology buy-in might be much higher than the other two measures of openness. Consequently, when dealing with the increase in the variety of technology purchased, it may be less likely for firms to narrow their selection of certain appropriability regimes as the protection of the underlying IP may have been already designated by the seller or it may be purchased in a form that is best suited to a particular appropriability regime. Path dependencies to narrow the scope of appropriation mechanisms might be also inapplicable due to the large variety of buy-in technology.

Table 7.3 illustrates the results regarding Hypothesis 2 which proposes that the degree of openness will be positively related to the formal use of appropriability regimes and negatively related to the informal appropriability regimes. All these six models show a high significance of the overall model (indicated by the significance level of Chi-square), and moderate level of model fit (indicated by the Nagelkerke R^2). However, the results of these six models are almost contrary to my hypothesis. As the degree of openness is still constructed by three variables *Sources*, *Collaboration*, and *Techbuyin*, the insignificance of external sources for the method of patent, and the insignificant effect of technology purchase for all three formal methods (i.e. patent, registration, copyright) demonstrate that the degree of openness is not significantly associated with the use of formal appropriability regimes. On the other hand, all these three measures are significantly and positively related to all informal protection methods (i.e. secrecy, complexity of product design, and rapid and frequent changes to the product). This suggests that firms tend to increase the use of informal appropriability regimes, instead of reducing them as the open innovation literature would suggest.

With regards to the control variables, it is shown by my models that firm size is positively related to the use of both formal and informal knowledge protection mechanisms. Belonging to the manufacturing sector increases the likely use of all formal methods of knowledge protection, but only increases the use of one informal

method (i.e. complexity of product design). With regard to the role of internal R&D, it is shown that the investment in internal human capital is positively related to all six protection mechanisms while R&D expenditure also positively affects them all except one formal instrument — registration.

TABLE 7.3
Results of Binary Logistic Regression for Specific IP Appropriability Regimes

IVs & CVs ↓	**DVs — Specific IP Appropriability Regimes**					
Independent Variables — The Degree of Openness	**Formal**			**Informal**		
	Patent	***Registration***	***Copyright***	***Secrecy***	***Complexity***	***Speed***
External Sources (*Sources*)	0.043	0.092 *	0.121***	0.182 ***	0.153 ***	0.125 **
Collaboration (*Collaboration*)	0.251 ***	0.211 ***	0.259 ***	0.310 ***	0.239 ***	0.332 ***
Technology Purchase (*Techbuyin*)	-0.363	1.574	0.574	1.469 *	1.609 *	2.705 **
Control Variables						
Firm Size (*Size*)	0.966 ***	0.649 ***	0.639 ***	0.341 ***	0.239 **	0.181 +
Industry Dummy (*Industry*)	1.381 ***	1.043 ***	0.339 ***	0.012	1.198 ***	0.267
R&D Expenditure (*R&D*)	2.332 ***	0.510	1.669 **	1.377 **	2.391 ***	2.458 ***
Human Capital (*Staffing*)	0.241 ***	0.263 ***	0.170 ***	0.265 ***	0.281 ***	0.317 ***
Constant	-5.770 ***	-5.453 ***	-3.662 ***	-2.645 ***	-4.274 ***	-4.554 ***
Chi-square	367.517 ***	195.075 ***	404.769 ***	527.783 ***	321.957 ***	180.188 ***
-2 Log likelihood	1801.378	1424.786	3303.150	4131.159	2199.581	1291.294
Nagelkerke R Square	0.207	0.141	0.155	0.174	0.162	0.142

+ p < .10

* p < .05

** p < .01

*** p < .001

From the above statistical results regarding the second hypothesis, an issue remains unclear — why the effect of collaboration on all formal appropriation mechanisms are significantly positive while the other two measures exhibit somewhat or completely insignificant effects? One possible explanation may be attributed to the way I constructed the variable of *Collaboration*. With an aggregate variable that covers different types of collaboration, it might be hard to investigate what actually happens within the broad category of collaborations as well as what is each type's individual effect on IP protection. Therefore, I further disentangle the variable *Collaboration* into these six specific variables in Table 7.4.

It is shown in this detailed set of models that although this variable is significantly positive for all appropriation mechanisms in the models of Table 7.3, actually there are some slight differences in the effects of specific sub-types of collaborations between formal and informal instruments. It is found while generally joint marketing or distribution, and licensing agreement are equally important for both formal and informal mechanisms (both of them are significantly positive for two sub-types of both formal and informal mechanisms), joint R&D which is usually conducted with horizontal partners and research institutes, are comparatively more related to the informal IP protection (significant for two sub-types of informal protection but just one sub-type of formal protection mechanisms). This finding strengthens out prior conclusion that open innovators tend to increase the use of informal appropriability

regimes, instead of reducing them as open innovation literature suggests.

TABLE 7.4
Results of Binary Logistic Regression for Specific IP Appropriability Regimes (After disaggregating the variable Collaboration)

IVs & CVs ↓	DVs — Specific IP Appropriability Regimes					
Independent Variables — The Degree of Openness	**Formal**			**Informal**		
	Patent	***Registration***	***Copyright***	***Secrecy***	***Complexity***	***Speed***
Collaboration (*Collaboration*)						
Joint marketing or distribution	0.112	0.591 *	0.657 ***	0.402 *	0.655 **	0.266
Joint manufacturing	-0.028	-0.183	0.014	-0.083	0.044	-0.006
Joint R&D	0.856 ***	0.059	0.112	0.652 ***	0.600 **	0.413
Other joint venture	0.188	0.056	0.052	0.138	-0.130	0.354
Licensing agreement	0.057	0.470 $^{+}$	0.435 *	0.399 *	0.156	0.640 *
Other form of collaboration	0.372	-0.032	0.023	0.320	-0.201	0.058
Technology Purchase (*Techbuyin*)	-0.385	1.696	0.656	1.482 *	1.653 *	2.710 **
External Sources (*Sources*)	0.041	0.088 *	0.119 ***	0.180 ***	0.151 ***	0.119 **
Control Variables						
Firm Size (*Size*)	0.952 ***	0.657 ***	0.648 ***	0.336 ***	0.238 **	0.169
Industry Dummy (*Industry*)	1.363 ***	1.069 ***	0.350 ***	0.013	1.172 ***	0.289 $^{+}$
R&D Expenditure (*R&D*)	2.244 ***	0.556	1.694 **	1.322 **	2.355 ***	2.418 ***
Human Capital (*Staffing*)	0.247 ***	0.255 ***	0.166 ***	0.266 ***	0.280 ***	0.316 ***
Constant	-5.730 ***	-5.481 ***	-3.684 ***	-2.634 ***	-4.258 ***	-4.535 ***
Chi-square	375.232 ***	199.542 ***	412.993 ***	534.450 ***	332.443 ***	183.196 ***
-2 Log likelihood	1793.663	1420.320	3294.926	4124.492	2189.095	1288.286
Nagelkerke R^2	0.211	0.144	0.158	0.176	0.167	0.144

$^{+}$ $p < .10$

* $p < .05$

** $p < .01$

*** $p < .001$

7.5 DISCUSSION & CONCLUSION

There are some crucial issues associated with the open innovation paradigm which have received growing research attention recently. However, the extant research on these topics is still at the preliminary stage, with several essential matters unresolved. Among them, for example, what is the impact of the degree of openness on the appropriability regimes firms will employ? Which types of appropriation regime components will open innovators tend to adopt? I attempt to address these issues by conducting an empirical study on 4,322 Australian businesses. I examine the role of openness in explaining the variance among the adoption of various appropriability regime components.

This study produces some interesting findings. First, the results of this study reveal a complex relationship between the degree of openness (in terms of the breadth of external knowledge sources and the scope of inter-organisational collaborations that a firm is involved with) and the variety of appropriability regimes employed. It is shown that firms employ increasingly complex and multifaceted appropriability regime arrangements when operating in an open innovation mode, with the propensity to the scope of regimes flattening (and probably declining) as the degree of openness increases. I attribute this declining marginal effect to firms minimising the collective risks of multiple appropriability regimes by investing in a more limited set of options and developing a set of capabilities in respect of these options that become

self-reinforcing over time.

The modelling results based upon Hypothesis 2 provide some challenges for the adoption of open innovation, which shows that open innovators tend to adopt more informal appropriation and IP protection mechanisms, potentially blocking necessary knowledge spillovers to external partners. This tends to hinder knowledge exchange which is supposed to be facilitated based on reciprocity as suggested by open innovation assumptions.

This finding provides new insights regarding the form and complexity of appropriability regimes adopted in an open environment. It is also consistent with some doubts about the theoretical foundations of the open innovation paradigm. Specifically, recent research has questioned the feasibility of gaining returns through open flows and shared knowledge (Helfat, 2006; Trott and Hartmann, 2009).

Actually corralling the royalty rights to innovation-based products or processes is at the heart of traditional understandings of IP appropriation. This classical view of appropriability underscores the importance of limiting a firms' spillovers of important knowledge to the external environment to capture values from innovations (Leiponen and Byma, 2009; Trott and Hartmann, 2009). This provides a clear, property-rights based logic to the investments necessary for effective R&D (Levin et al., 1987).

Open innovation literature suggests that, in contrast to the closed innovation model within which knowledge flows are largely avoided, firms operating an open innovation strategy attempt to purposively produce spillovers, enabling the disclosure of knowledge and technology, in order to secure profits from openness (Chesbrough, 2003a; Schmidt, 2006).

However, in practice, the garnering these mooted benefits within the open innovation environment is extremely challenging (Trott and Hartmann, 2009; West and Gallagher, 2006b). This has been influenced by higher rates of the mobility of skilled workers which in turn facilitates the flow of their tacitly held knowledge (Dahlander and Gann, 2010; Gassmann, 2006); and increasing globalisation that advances the transfer of technology and knowledge embodied in products within boundaryless markets (Schmidt, 2006; West, 2006). Enhanced unintended knowledge flows, along with increased voluntary knowledge disclosure, tend to increase knowledge outflows, including sensitive knowledge and valuable technologies of the firm (Trott and Hartmann, 2009).

In that sense, the potential to benefit from knowledge sharing and transferring might be replaced by the threat arising from the unintended leakage of core resources and knowledge. The sources of competitive advantages of open innovators are thus

questionable (Helfat, 2006). According to the resource based view, when making the knowledge boundaries of the firm more permeable, the risks of open innovation might reduce the differentiation of a firm's core resources and further weaken its competitive position (Lichtenthaler, 2009a). Dahlander and Gann (2010) clearly note this as a potential downside of open innovation. With the fear that the benefits from open innovation may not successfully outweigh the negative effects associated with weaker competitive heterogeneity, firms may tend to resort to more elaborate appropriability regimes as an effective source of competitive differentiation (Grant, 1996; Teece, Pisano and Shuen, 1997; Zhao, 2006).

I believe these considerations might provide some explanations for the results of the second hypothesis. It is shown that firms adopting open innovation strategies actually increase the control on their intellectual property through informal appropriability regimes rather than loosen these mechanisms to promote knowledge spillovers as open innovation theories suggest.

This might raise significant concerns regarding the practical application of open innovation. As Schmidt (2006) has suggested, the open innovation strategy might become only a 'marketing stunt' if firms claim they are open while not increasing any knowledge outflows to other firms. The necessity for firms to both 'give and take' within the open relationship leads to some degree of knowledge sharing. Without this

'give and take' foundation, fewer and fewer firms would continue to supply free knowledge, leading to a vicious cycle where reciprocity, which is the core of open innovation, will decline over time.

The open innovation phenomenon can thus be seen as informed by game theory model. The derivation of private returns from freely exchanged knowledge could be considered opportunistic, and yet such private returns are an essential element of business profitability which must be accrued through the success from a firm's products in the competition (which is, at least in part, at the expense of other firms' success in the same marketplace). This suggests a classical *prisoner's dilemma* problem for firms (Bicchieri, 1993; Zhang and Rajagopalan, 2002), where the performance outcomes emanating from cooperation and opportunism compete. It is expected that the integration of open innovation theories with related bodies of literature could build a more sound theoretical foundation for this emerging paradigm.

Therefore, the applicability of this new paradigm in practice requires further research. I believe that firms are likely to benefit from openness, although great care must be taken in adopting the open innovation strategy. Firms need to learn how to deal with the trade-off between knowledge sharing and knowledge protection. This key challenge could be partially resolved by the effective management of open innovation approaches, the careful control of relationships with partners and the suitable choice

of appropriability regimes (Trott and Hartmann, 2009).

There are limitations of this study. Other than my limited capacity to control for industry-specific effects (discussed earlier), another major limitation relates to the unavailability of longitudinal data. As innovation is a continuous and path dependent process, prior innovative activities and investment might be highly influential to the current performance (Boer et al., 2001). I may also be able to anticipate when the declining marginal effect of the degree of openness would start by the use of a longitudinal dataset.

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CHAPTER VIII

Consolidation and Conclusion

8.1 KEY FINDINGS

This doctoral research focuses on special issues relating to the generalisability and the benefits (/costs and threats) of open innovation paradigm, in particular with respect to inbound open innovation. The key findings inform the two research questions put forward in the first chapter and correspond to the two gaps found in the extant literature as introduced in the second chapter.

In response to the first research question, the investigation of the generalisability of this paradigm shows a good application of open innovation in some contexts. For instance, open innovation strategies in terms of knowledge acquiring approaches and knowledge sourcing practices are generally useful for process innovation as well as product innovation (in Chapter 3). It is also found that firms in European regional clusters tend to more easily benefit from open innovation strategies by means of the increased firm-university linkages and the enhanced inter-firm explicit and tacit knowledge flows (in Chapter 4). Geographical proximity is thus proved to be a facilitator of innovation effectiveness through which the benefits of openness (such as reduced transaction costs and increased trust and reciprocity) are optimised and the philosophies of open innovation (such as ‘connect and develop’ and ‘take and give’) are largely realised.

On the other hand, a declining marginal effect of the openness towards external knowledge sources is demonstrated (in Chapter 3). It is also shown from the projects in this research that while there is a growing trend towards the adoption of open innovation strategies, it is not suitable for some types of firms, such as for Chinese businesses and particularly for smaller businesses which face certain barriers to benefiting from the key external sources of openness, such as inter-firm networks, university linkages and research institute relations (in Chapter 5). This finding is consistent with my previous study (Huang and Rice, 2009) which also reported Australian manufacturing SMEs' difficulties in capturing open innovation value. In addition, it is revealed from results of most projects that generally firms in the manufacturing industries are more likely to garner benefits available from openness than their counterparts in other industries (in Chapter 3, Chapter 4 and Chapter 5).

This empirical evidence indicates that open innovation is not applicable to all types of organisations and this finding is congruent with Lazzarotti and Manzini (2009) who argued that in some cases total openness might be not the most suitable option, but rather different degrees and different ways of open innovation, even sometimes closed innovation should be employed according to the firm's current innovation state. Given results shown in this research that some open innovation approaches (such as R&D outsourcing in Chapter 3) and some external knowledge sources (such as universities in Chapter 5 and research institutes in Chapter 4 and Chapter 5) are actually not so

useful to facilitate open innovation effectiveness as others, the decisions regarding whether and how to adopt the open innovation strategy should be contingent on specific situations of focal firms.

In response to the second research question, the findings of the series of projects also show that the benefits of openness should be achieved and are likely to outweigh its potential costs and threats only under certain circumstances. The significance of interaction effects between external knowledge sources and absorptive capacity is observed supporting the idea that effective knowledge absorption capabilities are of vital importance in the facilitation of innovation effectiveness (in Chapter 5). This finding implies that the access and acquisition of external know-how is not sufficient and public knowledge might have little value to those firms who lack the required level of absorptive capacity (Lane, Koka and Pathak, 2006).

This viewpoint is in line with other empirical studies in the field of open innovation asserting the importance of building absorptive capacity for focal firms (e.g. Lichtenthaler and Lichtenthaler, 2009; West and Gallagher, 2006a). However, on account of the declining marginal effect of absorptive capacity observed by this research (in Chapter 3), in particular for process innovations, an over-investment in such capacity might detract from innovation outputs rather than contribute to it. In this sense, how to achieve an appropriate level of the investment in absorptive capacity

becomes a real challenge and stands as an area for future research. Moreover, firms should also place emphasis on the role of their internal R&D in leveraging external research benefits as the complementarity between internal and external innovations have been reported by projects in this research (e.g. Chapter 3 and Chapter 4).

Based on the above analysis, certain organisational attributes such as the level of absorptive capacity and the role of internal R&D are needed as a *prerequisite* for leveraging knowledge externally acquired so that the benefits of an open innovation strategy can be optimised.

The second *prerequisite* lies in the degree of firms' genuine intention to open up their innovation processes and facilitate knowledge outflows to the external environment. As found in the last project (Chapter 7) that firms actually increase control over their intellectual property through informal appropriation regimes to tighten knowledge spillovers, rather than loosen these mechanisms to promote knowledge spillovers as open innovation theories suggest. This behaviour results from the concern that the knowledge flows facilitated by open innovation approaches are as likely to enhance the innovation performance of receiving firms (some of whom may be direct or indirect competitors) as they are to enhance the performance of the focal firms. The potential loss of resource and capability heterogeneity might lead to the reduced level of competitive advantages as explained by projects in this research (e.g. Chapter 6 and

Chapter 7). The enhanced control on knowledge outflows might make it hard for firms who are really giving out free knowledge to capture value from openness. Without this 'give and take' foundation, fewer and fewer firms would continue to supply free knowledge, leading to a vicious cycle that might gradually undermine the core of open innovation.

In that sense, how to reach an appropriate extent of knowledge spillovers (and an appropriate degree of knowledge appropriation accordingly) and how to manage the balance between knowledge sharing and knowledge protection might, to a large extent, determine whether a firm can succeed in the adoption of an open innovation strategy. Firms are more likely to benefit from openness when the returns from knowledge disclosure can outweigh the risks and threats associated with openly revealing knowledge and the costs relating to knowledge protection (Schmidt, 2006).

In summary, the results of this doctoral research suggest that it is only when both those prerequisites (namely certain organisational attributes such as the suitable level of absorptive capacity and an effective R&D role within firms, and the appropriate degree of knowledge protection/disclosure by firms) are met that the benefits of open innovation could surpass its potential costs and threats, and whereby open innovators are likely to really garner economic returns from the open strategy. On the other hand, firms are likely to fail in the open innovation implementation if the open strategy is

incompatible with the firm's innovation systems and capabilities.

8.2 SIGNIFICANCE/CONTRIBUTION OF THE THESIS

8.2.1 Contributions to Knowledge

This doctoral research attempts to enrich our understanding of open innovation and contribute to the current research by providing both theoretical insights and empirical evidence into this emerging paradigm.

First, this thesis project seeks to address the gaps in the extant research on open innovation by a systematic assessment of the generalisability and broader applicability of this paradigm through a set of various research projects with large sized samples. By doing this, the variations of open innovation application across different contexts are comprehensively explored.

Second, this research empirically examines both the positive and negative sides of open innovation and puts forward significant potential risks and threats associated with the open strategy, for instance, the competitive disadvantages and the paradox of open innovation. Therefore, the effectiveness of this paradigm is critically inspected.

Third, the research establishes a comprehensive conceptual framework (illustrated in Figure 1.1, Chapter 1, p. 7) with regard to the components of open innovation thus providing theoretically grounded constructs to assess an open innovation strategy and

multiple relationships it embraces. Each project (Chapter 3-Chapter 7) involved in this research (except chapter 6) is developed on the basis of this framework. Therefore, the validity of this framework is empirically tested with various data sources involved in each project constituting this thesis.

Finally, this research points out research opportunities in the field of open innovation, such as outbound open innovation; the relationship between knowledge management and open innovation; and measurement issues of open innovation constructs especially some ambiguously measured concepts such as absorptive capacity and the degree of openness (which are further discussed in Section 8.4.3).

8.2.2 Contributions to Practice

Managerial implications can also be drawn from the findings of this research which could contribute to the better practices of organisations. It is suggested that while there is a growing trend towards the adoption of an open innovation model, it is not a panacea. Open innovation strategy should be employed by managers with great caution. First, managers need to control the degree of openness based on the firm's own innovation situation because complete openness or over-openness towards external sources might generate some adverse effects on firms. They would also realise that openness is actually not beneficial for firms who are not really ready (in terms of the possession of adequate internal research expertise and capabilities to absorb and utilise exogenous knowledge). It means under some circumstances partial openness or closed innovation might be also suitable as long as they fit the organisation's current innovation state and its business models.

Second, it might be beneficial for managers to always ensure the two essential prerequisites (as stated earlier) are met to optimise open innovation performance, that is to say, when they conduct relevant initiatives, they need to pay close attention to the extent of absorptive capacity input and the balance between knowledge sharing and knowledge protection. They could also place emphasis on the role of their internal R&D in leveraging external research benefits given the complementarity between internal and external innovations.

Finally, the implication of open innovation also provides some insights into general open strategies. Managerial decision makers could be able to make best use of advantages brought about by the firm's openness towards external environment and seek to actively respond to the greater pressure an open strategy might present. Facing the potential threat of losing resource-stock rarity because of the enhanced knowledge sharing between firms, firms might adopt some passive means such as purposely limiting knowledge outflows through tight IP regimes (see Chapter 7), or resorting to bribery for obtaining advantages in terms of temporary information, resources and privileges over competitors (particularly in countries where the institutional system is not very complete) (see Chapter 6). It would be realised by managers that these passive responses to openness which might create short-term profits in some cases, will actually impair a firm's ability to sustain value of open strategies and thus place

the firms at a competitive disadvantage in the long run. That is because in light of the current knowledge landscape where both voluntary and involuntary knowledge spillovers are facilitated, retaining all useful information in house might make firms lose substantial valuable opportunities to update their internal knowledge bases and commercialise internally developed products/services. Similarly, bribery might be some kind of shortcut to temporarily achieving resource rarity, but it will place the firm in a vicious cycle with the inability to compete with others in a free market in the long term.

8.3 LIMITATIONS

The limitations of this research largely lie in the cross-sectional nature of the data it employs. As innovation is a continuous process (Boer et al., 2001), prior investment in open innovation activities might have some lagged effects which cannot be observed by firms' contemporaneous innovation performance. In a similar vein, the 'path-dependent' nature of some open innovation constructs such as absorptive capacity (Cohen and Levinthal, 1990) may not be accurately detected by the snapshot of innovation activities in a given year. Moreover, although this research predicted a curvilinear relationship between the extent of absorptive capacity (also knowledge sourcing) and innovation performance in Chapter 3, I cannot anticipate when the declining marginal effect will start, or until which point the costs associated openness

will exceed the benefits gained (whereby the over-openness occurs). Additionally, the relationship between openness and the scope of appropriation mechanisms in Chapter 7 would be more clearly explored if the practices of open innovators during different phases could be exhibited. All of these concerns raise the need of using some longitudinal data sources through which open innovation practices over a long period of time could be more fully investigated.

Another issue associated with the data is the measurement of some variables, particularly the use of dichotomous dependent variables in Chapter 3 and Chapter 4 given the lack of relevant continuous variables in the secondary datasets employed. It is recognised that the binary dependent variable is a flawed indicator of innovation performance, but it is a direct measure of innovation output, therefore comparatively better than those proxy measures which also have been widely used in the contemporary innovation literature (such as R&D expenditure and patenting frequency). In order to partially overcome this limitation, in the project of Chapter 5 where there is more available data regarding the innovation performance, I used the proportion of a firm's sales relating to innovations to its overall sales as the dependent variable. This is a relatively stronger variable which is also consistent with Laursen and Salter's (2006) study. Similar measures are expected to be more frequently used in my future studies.

It might be another limitation that all of the results of this thesis are drawn depending on the secondary data obtained from other authorities. Although the advantages and necessity of employing secondary datasets such as addressing research questions and ensuring quality and quantity of the data have been clarified earlier in the first chapter, it might be also worth attempting some primary data collection methods and qualitative research approaches (e.g. interviews and case studies) as a complement to the employment of these quantitative data in future studies. The mixed research methods are likely to provide more comprehensive empirical evidence to further inform the research questions highlighted in this thesis.

8.4 AREAS FOR FUTURE RESEARCH

Other than the key research areas and the associated important issues emphasised in this thesis, the research also sheds light on several opportunities for future studies which are outlined as follows.

8.4.1 Outbound Open Innovation

As displayed in the fundamental conceptual framework for the thesis in Section 1.3.1, outbound open innovation is the other essential approach to openness which exists apart from the focus of this research, namely the inbound open innovation. Actually inbound and outbound open innovations are generally intertwined and concurrent, as

each inbound activity by an organisation is essentially generated by a reciprocal outbound activity from some other organisations (Chesbrough and Crowther, 2006). Thus it is important to investigate both these perspectives to deepen our understanding of the behaviours and strategies of firms engaged in open innovation practices in future studies.

Outbound-oriented innovation encompasses both selling and revealing processes (Dahlander and Gann, 2010). Selling refers to how firms commercialise innovation output by means of selling of IP, spin-off of new firms and licensing out technology developed via in-house R&D (Dahlander and Gann, 2010; Schmidt, 2006). Revealing relates to how firms deliberately reveal some resources and information to the external environment in exchange for useful feedback knowledge with limited transaction costs (West, 2006; West and Gallagher, 2006b). Both these processes require further extensive empirical examination. Such investigation of innovation approaches and processes beyond the boundary of inbound open innovation is likely to build a more complete understanding of this emerging paradigm.

8.4.2 Knowledge Management and Open Innovation

Knowledge spillovers, which are considered inherent to the process of knowledge generation (Grossman and Helpman, 1990), have received growing research attention

particularly in terms of the knowledge flows between firms and from local academic to firms (Breschi and Lissoni, 2001). Knowledge flows play a crucial role in facilitating innovations through formal and informal networks outside a firm's boundary (Simard and West, 2006).

The increasing importance of knowledge flows and spillovers can also be observed in the open innovation context. Future research opportunities in this vein could be explored from two aspects. First, there is a change in the role of knowledge spillovers in facilitating innovation effectiveness with the trend towards openness. Knowledge spillovers were traditionally regarded as inadvertent outbound flows or unintended by-product of innovation with the closed innovation model. In contrast to the closed innovation within which firms try to avoid such spillovers, open innovation believes firms should purposively produce spillovers and enable the disclosure of internal developed knowledge and technology, in order to secure profits from outside (Schmidt, 2006). These spillovers are becoming valuable opportunities for developing new business models and innovation commercialisation channels rather than just the costs of doing innovation as before (Chesbrough, 2006b).

Second, in discussing knowledge management, the principal tasks are often presented as exploration, exploitation and retention (Argote, McEvily and Reagans, 2003; Grant, 1996). Open innovation integrates these tasks in terms of the exploration, exploitation

and development of inbound and outbound knowledge (Lichtenthaler, 2009a; Schmidt, 2006). Inbound open innovation is based on the systematic exploration of inward flows of knowledge and technology (Lichtenthaler, 2009a; West and Gallagher, 2006b) while outbound open innovation is enabled by the commercial exploitation of the outflow of knowledge and technology (Chesbrough and Crowther, 2006). As knowledge resources are likely to be an integral contributor to a firm's competitive advantage due to the difficulty in replicating them, the role of knowledge management tasks in promoting open innovation performance deserves further attention. Extending from this discussion, open innovation is also of great relevance to some other domains suggested by this research, such as intellectual property management (in Chapter 7) and business ethics (in Chapter 6). In that sense, open innovation practices are expected to be better interpreted with a variety of multi-paradigm theories.

8.4.3 Measurement Issues of Open Innovation Constructs

The open innovation phenomenon involves some abstract and inexplicit concepts which are difficult to operationalise, such as absorptive capacity, the degree of openness, and open innovation performance. In this research, a proxy (R&D human resources) is adopted for absorptive capacity in the samples of Chinese firms (in Chapter 5). This proxy is further extended to 'human resources in the whole

organisation', which I believe is a better measure in the specific context of process innovation (in Chapter 3). This implies that there are no universally applicable measures of open innovation strategy in different research contexts, even for those well established concepts like absorptive capacity.

This research also attempts to rigorously measure the degree of openness (in Chapter 7), a challenge which hasn't been fully explored elsewhere. It is grounded on the inbound knowledge perspective involving the scope of external knowledge sourcing and the adoption of open approaches (e.g. inter-organisational collaborations and technology purchase activities). This measure, however, takes account of neither the depth of external search nor the outbound open innovation perspective due to the limited information provided on these dimensions by the dataset used.

Similarly, given the unavailability of the relevant innovation regarding the performance of new processes, the performance of product innovation (either dichotomous or continuous) is still adopted as the measure of general innovation performance in some projects (e.g. Chapter 4 and Chapter 5). The challenge relating to the accurate measurement of some ambiguous open innovation concepts is a perplexing, but ultimately fundamentally interesting, issue for future research.

8.5 CONCLUDING REMARKS

To conclude, this doctoral thesis unveils the mysteries of open innovation, a recently emerging paradigm which is espoused as a more advantageous way to conduct innovation. A series of quantitative projects contained in this project jointly reveals some important findings relating to the applicability and effectiveness of an open innovation strategy. The research shows close geographical proximity is a facilitator of open innovation, and identifies the investment in absorptive capacity, the role of internal R&D, and the degree of knowledge protection/disclosure as essential prerequisites of a firm's ability to seize open innovation benefits.

This doctoral research makes a valuable contribution to the field of open innovation. From the theoretical perspective, this thesis attempts to contribute to the research on open innovation by addressing the significant gaps in the existing literature, establishing a comprehensive conceptual framework for this new paradigm, extending knowledge and theoretical foundations, and leading other researchers to concern some important issues which require further examination. From the practical perspective, it will contribute to the managerial practice by providing useful suggestions on whether to adopt the open strategy and how to implement it successfully.

Recommendations are put forward based on the main findings of this doctoral research. In order to maximise the potential benefits provided by the open innovation

strategy, managers need to control the degree of openness according to firms' own innovation situation, they should also make sure adequate internal research expertise and capabilities to absorb and utilise exogenous knowledge are in place in the organisations. If successfully managed, the open innovation strategy is likely to improve a firm's innovation performance and sustain its competitive advantage in the new innovation landscape.

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