Ambidextrous and disruptive innovation: how latecomers strive to become the leaders

Jung Bum Kim

The Bartlett School of Construction and Project Management

University College London (UCL)

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Declaration

‘I, Jung Bum Kim, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.'

Signature:_________________________ Date:_________________________

Abstract

Innovation in the context of NICs were vigously researched in the late 1990s with the interest in how few successful latecomer countries had achieved rapid economic growth during that period. The most well-established model in catching-up innovation is the three stage linear innovation process model by Kim (1997), known as ‘acquisition – assmiliation – improvement’. Another important research were carried out by Hobday (2005) and Hobday, Bessant and Rush (2004) to translate the successful cases of latecomers in NICs into technological innovation research. Although these research have provided a powerful theoretical framework, it has been 20 years since the models were introduced. The dynamic business and technological environment and more competitive global market conditions call into question its applicapability to the modern world. This research gap calls for a new analysis of NIC innovation models with a new perspective that recognises and enhances the dimension of dynamic capabilities and disruption employed in the process of catching up with innovation.

This thesis presents the research results drawn from three case studies in the semi-conductor (IT), automotive steel and construction industries in Korea. It shows that latecomers develop the dynamic capability of transforming their structure to an ambidextrous organisation to cope with both radical and incremental innovations and deal with the rapidly changing dynamic business environment. By using the research data taken from the case studies, this thesis proposes a newly developed model, ‘transformational innovation capabilities', which considers that latecomers progress beyond catching-up with innovation by following four phases: capability building, disruptive catching up, transitional and leading phases. After following these phases, they develop ‘transformational innovation capabilities’ which determine the form of ambidexterity, a firm's disruption strategy and exploitation of dynamic capabilities under the given contingency. The transformational innovation capabilities allow latecomers to strive to become the technological leaders.

The thesis contributes to the NIC literature, dynamic capability and disruptive innovation by emphasising the growth, evolution and revolution of catching-up firms. The findings provide a number of insights into how catching-up firms can be managed in order to reduce the technological gap and set an R&D and organisational strategy that competes against incumbents.

Impact Statement

This thesis has academic impacts to three areas in innovation and management field. First, it suggests a new theoretical framework that will increase our understanding of NIC-based, latecomers' innovation models. As argued in the thesis, latecomers catching up innovation has not achieved any considerable theoretical development since Kim (1997), Hobday (2005) and Hobday, Bessant and Rush (2004). Although the previous models provided a valid and powerful theoretical lens, its focus and locus did not seem appropriate for recent environments where the velocity of technological change and the uncertainty of market conditions are higher than in 1990s, or even the early 2000s. Under these dynamic conditions, the simple approach of 'from imitation to innovation' lacked explanatory power. This thesis argues that the dynamic capabilities view of the firm is a more appropriate approach as the catching-up innovation process has become more complex and complicated. Second, the literature about ambidexterity and ambidextrous organisations do not discuss possible structures and forms that successfully address both radical and incremental innovations. This research found that there can be many different forms of ambidexterity as a result of the firm's innovation strategy and contingencies from the dynamic environment. Three ambidextrous structures were discovered and suggested in this thesis. Third, although Christensen (1997) and his colleagues viewed a disruptor as an opportunistic entrepreneur who focuses on the under-valued segment of a market, this thesis argues that latecomers naturally serve the low-end market due to their lack of technologies, and their strategy of low cost, price and quality. successful latecomers are disruptors who successfully gain a foothold in the market and compete against incumbents – advanced firms. The research found that once the latecomer successfully serves the segment, it seeks higher profit margins. In order to move up to the mainstream and high-end markets, where profit margins are much higher, innovation becomes the key activity for the latecomer, as this will enable it to raise the quality of its products up to the level that customers demand. Thus, successful latecomers are disruptors who successfully gain a foothold in the market and compete against incumbents – advanced firms. This new method of approach and perspective widens up the applicability of disruptive innovation theory.

The research also has practical impacts and implications. The findings of this dissertation are a call for managers involved in technological innovation to set a new managerial strategy and rethink their approach to innovation. Depending on the degree of dynamic capabilities, recent paradigms of open innovation or collaborative R&D might not be useful enough to achieve the transition. By assessing the velocity and dynamic factors in the transitional innovation capabilities (TIC) model in this thesis, managers would be possible to reform their organisational structure to achieve the most appropriate mode of innovations.

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Chapter 1

Introduction

1.1 Background

Innovation is often depicted as the process by which firms survive in competitive environments, yet the term is poorly understood. A general belief about innovation is that new, positive and beneficial change can be achieved by just promoting it. Indeed, in the past innovation seemed a straightforward operation. For example, when the military's demand for high technologies and the supply from science laboratories were being met, and the time when market demand drove the path of scientific outputs, innovation mainly referred to obvious technological developments that increased the production or process systems of firms. However, its political, practical and even societal role, as well as its importance, has increased over the past few decades, corresponding to the rapid and dynamic shifts of the competitive environment. Recently, practical managers have started recognising innovation as a vital activity that can achieve the firm's sustainable competitive advantage. The main concern is that how the firm should arrange the most appropriate organisational settings including firm-level capability, structure, culture and operational systems to deliver innovations successfully.

Great efforts have also been made in the academic world to establish and develop innovation models and theories. The theoretical foundation of innovation underlies

Schumpeter, who introduced the original idea of innovation (1939) and recognised it as an endogenous process that produces a new combination of resources. He explained innovation activity in terms of it being an economic and entrepreneurial behaviour that enables economic agents to obtain a temporal surplus or entrepreneurial profit by introducing a new combination of existing resources into the market. Beyond Schumpeter's theory, the idea of innovation has been rigorously developed with other aspects to enable a greater understanding of the creation and diffusion of innovation in the modern environment. Amongst the literature in innovation studies, Rothwell's fifth generation of innovation was remarkable in that it highlighted how innovation models change with practical developments made in industry and technology (Rothwell, 1994). More recently, Chesbrough (2003) contributed to open up the sixth generation of innovation, which is also referred to as 'open innovation'. The open innovation paradigm has had an impact that has been embraced by many fields in management studies. As a result of this interest, a number of research outputs have discussed open innovation in the last decade (West et al., 2014).

Whilst the field of mainstream innovation has been making sophisticated progress and reaching a new generation beyond open innovation, research into innovation in the newly industrialised countries has interestingly not generated significant research outcomes since the late 1990s to the early 2000s; and they are still staying with the old concepts. Most studies of innovation have implicitly departed from the view of the developed economies and industries with mature firms or Multinational Corporations (MNCs). Firms in advanced economies already possess a wide range of Research and

Development (R&D) capabilities and a market to deliver a new product/process from innovative activities. These models – which are oriented towards developed countries – are not strictly appropriate for newly industrialised countries (NICs), as firms here will face totally different conditions in order to achieve successful technological knowledge development through innovative activities.

Important findings from Lee, Bae and Choi (1988), Kim (1997), Hobday (2005) and Hobday, Rush and Bessant (2004) have suggested, and indeed confirmed, that catching-up firms in NICs show different innovation processes and paths from the developed countries. The core idea of their arguments is that catching-up innovation occurs by acquiring developed technologies from advanced firms. Accordingly, the firm's success in catching up depends on its ability to assimilate the imported knowledge and generate its own capability to design and produce its own products.

Although these models have captured the fundamental, reversed type of linear innovation processes and provided theoretical development in NIC context, they were introduced almost 20 years ago. The business environment has become more dynamic, rapid and competitive since then. Technologies have become more complex and challenging to be transferred and assimilated as a one-off package box, as the technological flow from developed to developing countries might no longer be as torrential as it was before the 21st century. Few successful latecomers now operate in the global market and put their products in direct competition with advanced firms from developed economies. Thus, the question of how latecomers maintain the competitive advantage and facilitate the innovation capability to occupy the leading position after they have successfully caught up remains unanswered.

The title of this thesis portrays the theme and purpose of this research. The theme is to identify how latecomers can technologically catch up with advanced incumbents and compete against them. The purpose is to propose a theoretical development that contributes to innovation research in the context of the newly industrialised countries. This research, therefore, starts by questioning how catching-up firms can accomplish rapid technological developments. From the review of existing literature and secondary research, it identifies under-researched areas in mainstream innovation models and NICs-based theories and conducts a conceptual framework with a set of definitions and propositions. This framework and the propositions are later examined against empirical data. A qualitative research method is employed by case study of three major conglomerates in the semi-conductor (Computer), steel & automobile and construction industries in the Republic of Korea – which will be referred to as Korea from now on. The findings from these three case studies, and other secondary materials, are then analysed to examine the conceptual framework and also support the development of it into a theory.

The theory contributes to the existing innovation field by radically reassessing the dynamics of the catching-up innovation process in the context of NICs. Furthermore, it also contributes to the theory of disruptive innovation and ambidexterity as a dynamic capability view of the firm by providing a deeper understanding of the latecomer's actual market position, organisational structure and its application in practice.

1.2 Research scope, aim and question

The scope of the research is on newly industrialised countries and technological latecomers. The setting of the research is Korea and Korean firms. Amongst the developing countries, there are the well-known four tigers (Korea, Singapore, Hong Kong and Taiwan), which have been studied and are considered to be the most successful cases, both in terms of their industrial and technological achievements. However, there has been a tendency for the literature, which has generally dealt with the rapid industrialisation of East Asia (e.g. The World Bank, 1993) to place emphasis on neo-classical explanations that stress economic policies, foreign direct investments, export-orientation and governmental interventions. Furthermore, the most influential literature implicitly advocates these explanations by linking common factors that contributed to industrialisation, rather than by focusing specifically on innovation processes and organisational performance.

In order to clarify the unique features of NIC's innovation activities, it is important to specify the terminology of the developed, developing and newly industrialised (or less developed) countries, which have been both widely used and abused in many subjects in social science. Originally, the classification of countries was achieved using political economic measurements, such as per capita incomes – GNP or GDP.

However, this neo-classical economic view makes it difficult to not only measure the output of R&D and other technological developments, but also the growth that occurs as a result of technologically catching up and the resulting increase in national production.

Therefore, this research restricts the classification of countries by the use of a narrow perspective. By following the contextual innovation perspective, rather than using economic measurements, developing countries are defined as technologically catching-up countries that have less systemised and integrated innovation capabilities. NICs can be classified as countries that are successfully, or still in the process of, improving their national innovation capabilities after initial systemisation. Thus, NIC and developing countries are used interchangeably in this thesis.

NICs have characteristics that are different to developed countries. Ernst (2002) listed four basic features of developing countries that are not well presented in NIC concepts and theories. Developing countries tend to have highly heterogeneous economic structures which constrain agglomeration economies; low learning efficiency due to weak and unstable economic institutions; a limited knowledge base that forces them to use external and foreign sources of knowledge; and a highly vulnerable economic and financial structure and system that constrains capital for the development of the domestic knowledge base (Ernst, 2002:p.500). In order to understand the innovation dynamics of NICs, it is important to approach them with multi-level, multi-disciplines and a broad insight into the different perspectives of the technology, economics, strategic management and organisation (Kim, 1997).

One of the cases that most clearly represents this remarkable growth and technological development is South Korea. After the Korean War in the 1950s, Korea achieved phenomenal economic growth and industrialisation within just three decades as a result of the speed of its technological development, which rapidly caught up with other successful countries. In addition, Korea is now a leading country in some areas of technology, such as IT (Computer), and the steel and automobile industries. Indeed, its success story might be unique. Most developing countries have tried to industrialise their economies, but the majority of them have either achieved little progress or failed to possess the technological capabilities that are required to catch-up. This fact has implications and poses many questions about the kind of path and organisational setting that can be taken towards innovation, the models that firms in developing countries should consider, and how they should follow them.

The existing innovation models for NICs, which extend the developed countries-based models of the linear and bottom-up process, have dealt with innovation processes, as well as learning activities with external sources of knowledge. Although these models suggest there are explanations for acquiring the resource capabilities of innovation and technological learning in NICs, they do not consider the dynamics of their capability building, handling the strategic ambidexterity and R&D management, nor the rapid penetration into existing markets by encroaching low-end markets.

In fact, key literature on NIC-based innovation, and research into it, was conducted during the last decade when latecomers were either still catching up or reaching towards the innovation frontier. Accordingly, the focus of catching-up innovation was on reducing the technological gap. Recently, due to globalisation and the competitive market environment, the game of catching-up innovation has changed and is now about how latecomers can strive to become leaders. This research gap calls for a new analysis of NICs that would change the stagnant innovation model for a new generation.

Therefore, the research aim is to set up a new theoretical model that pushes the frontier of the NIC-based theory of innovation. The transformational innovation capability model considers four stage dimensions that a successful latecomer, who lately became a leader, might follow: *Capability-building phase, Catching-up phase, Transitional phase* and *Leading phase*. Each of these dimensions were reviewed and revised against the empirical data in order to formulate it as a theory.

To shed light on this neglected area in the research gap, a generic research question has guided this study: *how do technological latecomers strive to become leaders?* This broad, but concise, research question was used to construct the research setting, as well as the context and the targets of the study. The context of the research is only focused on NICs. Among the many NICs who have shown rapid industrialisation and technological catching up in the global market, it is South Korea and the firms based there who are the targets, as they have become leaders in certain industries.

1.3 Research design and process

After adopting Sandberg and Alvesson (2010) and Yin's (2009) case study design, the research started by recognising and questioning the under-researched area within the existing literature. The research question used to investigate that area also indicated its aim, target and scope. The research, thus, approached NIC innovation models by using an abductive research design that departs from the questions that arose from the literature review. In order to find the answers, a radical revision of theoretical frameworks in catching up guided to adapt the perspectives of the dynamic capability and ambidexterity as a means to understand both the rapid catching up of NICs and the technological overtaking that takes place after they have successfully caught up. The concepts of the dynamic capability and ambidexterity are defined in the next section in key terms and discussed in Chapter 3.

For the first step, the models by Kim (1997) and Lee et al. (1988) are adopted as the fundamental theoretical base. Hobday (2005) and Hobday, Rush and Bessant (2004) were also key in providing a nourishing insight into firm-level innovation in the context of NICs. After rigorous revision, the research then reassessed the models from a modern perspective of the firm's dynamic capability (March 1991; Teece et al., 1997; Teece 2007; Helfat and Peteraf, 2003; Eisenhardt and Martin, 2000), ambidexterity in organisation (O'Reilly and Tushman, 2008) and disruptive innovation (Christensen, 1997, Christensen and Raynor, 2003, Christensen, Raynor and McDonald, 2015). By critically dissolving them into the NIC context, the research developed a conceptual model that consisted of theoretical propositions.

The empirical data was collected to evaluate the conceptual model and its propositions. Multiple case studies – three in all – were conducted by adopting Yin's (2009) guidelines on the case study method. The strategy for the selection of cases was inspired by Flyvbjerg (2006), who stated that cases are selected to obtain information about various circumstances from multiple cases that are different in one dimension. In this research, the cases are from different industries that have distinct industrial characteristics and different degrees of technological velocity. Furthermore, one case is a project-based firm where innovation occurs from the project level and flows upwards to the firm level.

Firm level innovation activities involve various factors at different scales such as macro-factors (e.g. organisational structure, characteristic, strategy, systems, and finance) and micro-factors (human resource, leadership, behaviour, and social network). There are studies researching innovation at multiple or meso-level to find innovation factors and develop an in-depth model. Among these different factors and scales, however, the case study in this thesis was principally designed to examine the building of strategic/managerial level of capabilities. It is believed that this selection of unit of analysis helps to directly answer the primary research questions of 'how latecomers strive to become leaders' and the secondary research questions and propositions developed from the literature, 'how latecomers successfully perform catching up and transition'. By answering these two research questions, the thesis suggests a top level/strategic direction in a model. This method of designing the analysis unit of case studies is defined and advised by Yin (2009). As he noted, "Selection of the appropriate unit of analysis results from your accurately specifying the primary research questions … each case study and unit of analysis either should be similar to those previously studied by others or should deviate in, clear, operationally defined ways. In this manner, the previous literature therefore also can become a guide for defining the case and unit of analysis" (Yin, 2009: p. 25). However, it is fully recognised that other level approaches investigating different firm factors might raise contrasting findings. For instance, this study has not considered the input of human resource to construct ambidextrous form or the financial capital movements between teams or projects. Furthermore, the research method was not intended to provide statistical insights because primarily it is a qualitative study, but also it is designed to capture the strategic level of the dynamics in innovation. Hobday (2007) argued a similar concern as noting "recent innovation surveys in some developing countries tend to hide important nuances of technological change inside and across firms and do not adequately capture the dynamics of change. They also tend to overemphasise conventional indicators (e.g. R&D expenditures and patenting statistics)" (Hobday, 2007: p. 13). Thus, this research lies within the boundaries of managerial and strategic levels. The research methods are also bound to qualitative and narrative modes.

The main case study method was interviewing. 45 semi-structured interviews were carried out with senior managers and senior staff in R&D departments. The interview questions used to investigate the firms' R&D activities were kept as open and simple as possible, so as to support this thesis' theory-laden and abductive mode of study. A secondary material database, such as annual reports, published materials on the official company websites and media interviews, also proved an important source of data that was used to understand the firms' context and their historical developments. The empirical data in the existing literature was also a rich source that was used to frame the context of the case studies.

From the case studies' findings and further analysis, the conceptual model was then revised and tailored in order to reconstruct it as a model. This method of theory development was inspired by Van de Ven (2007) and Van de Ven and Johnson (2006).

The detailed research methodology and methods, as well as the interview protocol, are discussed in chapter 4 in this thesis.

1.4 Key terms

It is important to clarify the key basic terms that are used in this thesis, as such terms are occasionally used in different ways with distinct meanings across literature and in practice. Other terms that are not covered in this chapter are discussed in-depth in the relevant chapters in the later part of the thesis.

1) Innovation

The original definition of innovation from Schumpeter (1939) was from an economic perspective: an endogenous process that produces a new combination of resources. This implies that economic agents are able to obtain a temporal surplus or entrepreneurial profit by introducing a new combination of resources onto the market. Freeman's (1982) definition provides a basic grounding to innovation in management and organisational studies. In his view, innovation is the invention of a new idea or formula for a new process or product, as well as the commercial use of an invention. The definitions have been developed and evolved over time, according to the different aspects of each innovation model generation. It is out of the scope of this thesis to discuss all of the definitions from various perspectives (e.g. Duncan, 1972; Utterback, 1974; Rogers, 1983), but in the most recent paradigm of open innovation, Chesbrough (2006) defined innovation as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively" (p. 1). This definition was extended in response to the interest in non-pecuniary knowledge flows and the practical aspect of being engaged in open innovation (see Chesbrough and Bogers, 2014).

However, Hobday (2005) argued that these definitions were based on developed countries and fail to capture the fact that incremental innovations can lead to benefits in productivity, product quality, organisational change, economic growth and catch up. Furthermore, as innovation from latecomers tends to occur from behind the innovation frontier, the definition of innovation should take this into account. Thus, in his definition, innovation is “a product, process or service new to the firm, not only new to the world or marketplace” (Hobday, 2005: p. 122). Although this definition considers the substantial modulation of a business model or system by innovation and places less emphasis on commercialisation, which may not be seen directly in NICs, it does place less attention on the continuous learning and capability development of a business, and its R&D as a strategic systematic organisation.

Van de Ven (1986) defines innovation in a broader sense and context. In his words, innovation is “a new idea, which may be a recombination of old ideas, a scheme that challenges the present order, a formula, or a unique approach which is perceived as new by individuals involved … as long as the idea is perceived as new to the people involved, it is an “innovation”, even though it may appear to others to be an “imitation” of something that exists elsewhere.” (p. 591-592). Similarly, Bell (2009) defines innovation into a wider taxonomy of new-to-the-firm and new-to-the-economy and new-to-the-world knowledge creation.

Inspired by Van de Ven and Bell’s definitions, this thesis defines innovation as an idea that creates the development of new capability which brings a substantial modification not only to a firm’s product portfolio and process, but also to the strategic incremental and radical system of the firm.

2) Radical/incremental innovation – Product and process innovation

Utterback and Abernathy (1975) divide the innovation process into two types: product innovation and process innovation. They define a production process as "the system of process equipment, work force, task specifications, material inputs, work and information flows etc that are employed to produce a product or service" (p. 641). Starting from this definition, they argue that productivity improves by incremental changes of the production factors and systems as a process that continues to develop. Thus, incremental innovation can be defined as countless minor improvements of the products and systems that build a product, its production process and the system itself into a highly specialised mass volume production in order to achieve economies of scale (Utterback and Abernathy, 1975).

A product innovation is defined as "a new technology or combination of technologies introduced commercially to meet a user or a market need" (Utterback and Abernathy, 1975: p. 642). In other words, a radical innovation can be defined as a development of major new products that require a new combination of the firm's resources, capabilities, corporate goals, firm structure etc.

3) Firm capabilities.

There has been a wide range of views about firm-level capabilities. As Collis (1994) quoted, "there are almost as many definitions of organisational capabilities as there are authors on the subject" (Collis, 1994: p. 145). The definitions of organisational capabilities broadly can be classified into three categories. The first is the notion that refers organisational capabilities to an ability to perform the basic functional activities of the firm, more efficiently than competitors. For example, Amit and Schoemaker (1993) view capabilities are "developed in functional areas" (Amit and Schoemaker, 1993: p. 35), and Grant (1991) defined as "capabilities can be identified and appraised using a standard functional classification of the firm's activities" (Grant, 1991: p.120). The second is the notion that identifies capabilities in the theme of dynamic improvement to the firm's activities. For example, Teece, Pisano and Shuen (1997) defined capabilities as "the ability of an organisation to learn, adapt, change and renew over time (Teece et al., 1997: p. 20). Similarly, Hayes and Pisano noted that capabilities enable a firm "to switch gears – from, for example, rapid product development to low cost – relatively quickly and with minimal resources" (Hayes and Pisano, 1994: p.78). The third category of capabilities is closely related to dynamic improvements, but emphasises the importance of strategy that enables a firm to recognise the value of other resources to develop novel strategies before competitors. For example, Barney (1992) argued that capabilities "enable an organisation to conceive, choose and implement strategies" (Barney, 1992: p.44), and Henderson and Cockburn (1994) further defined as "the organisational abilities to deploy the firm's resources and to develop new ones" (Henderson and Cockburn, 1994: p.3).

Although each of those categories has a number of different perspectives which were grounded into other theories of the firm, such as the resource-based view, knowledge-based view and dynamic capabilities view, they all concern the ability of firms to perform an activity (whether it is static, dynamic or creative) more efficiently than competitors. Recent theories of the firm emphasise the significance of knowledge and the use of it as a fundamental element of the capabilities a firm (Dodgson, Gann and Salter, 2006).

This thesis defines firm capability in simple terms, but in line with the dynamic capabilities view: it is a firm's unique ability to combine, integrate and apply its heterogeneous resources and competencies (Barney, 1991; Teece et al., 1997). The definitions of firm's capabilities related to specific activities of firms can be defined in line with this definition of capabilities. Innovation capabilities are defined as a firm's ability to combine or develop any necessary resources and assets, such as capital, tacit and implicit knowledge, and capacity in order to achieve innovation. The definition of a firm's capacity, here, refers to as what Oxford Dictionary defined, as "the ability or power to do or understand something" (Oxford dictionary, 2018). Thus, production capacity, for example, is the firm's ability to produce a product or service through its production process or system. R&D capabilities can be also defined as a firm's unique ability to form an appropriate R&D structure and combine and use necessary resources, such as capital, tacit and implicit knowledge, and facilities. Similarly, the definition of technological capabilities is "the ability to make effective use of technological knowledge" (Westphal et al., 1984). Technological capabilities consist of three capabilities: production, investment and innovation. Production capabilities refer to the ability to facilitate, operate and maintain production.

Investment capabilities refer to the ability to invest in new facilities for new production capacity. Innovation capabilities are the abilities to create and exploit technological possibilities (Kim, 1997). It is fully acknowledged that much mainstream innovation research places emphasis on commercialisation in the definition of innovation capabilities. However, this thesis passively considers commercialisation because of its inappropriateness within the NIC context. This is fully discussed later in Chapter 2.

4) Dynamic capabilities

Grounded from the dynamic perspective in the resource-based view (e.g. Teece et al., 1997; Eisenhardt and Martin, 2000) and March (1991)'s mode of exploration and exploitation, dynamic capabilities refer to the strategic innovation process of integrating and reconfiguring a firm's internal and external resources, competences and routines to adapt to rapidly evolving and changing environments. In order to survive in the existing market condition and compete in challenging environments, O'Reilly and Tushman (2008) insist that firms are required to possess not only the operational capabilities and competencies, but also the ability to recombine and reconfigure assets and organisational structures to adapt to emerging markets and technologies. This concept is fully developed and discussed in Chapter 3.

5) *Disruptive innovation*

The following definitions are provided by Christensen (1997) who introduced the idea of disruptive innovation. He defined "disruptive technologies bring to a market a very different value proposition than had been available previously. Generally, disruptive technologies underperform established products in mainstream markets. But they have other features that a few fringe (and generally new) customers value. Products based on disruptive technologies are typically cheaper, simpler, smaller, and, frequently, more convenient to use" (Christensen, 1997: p. 11). He also defined disruption as "a process whereby a smaller company with fewer resources is able to successfully challenge established incumbent businesses" (Christensen et al., 2015: p. 3). Disruptive innovations are "initially considered inferior by most of an incumbent's customers. Typically, customers are not willing to switch to the new offering merely because it is less expensive. Instead, they wait until its quality rises enough to satisfy them. Once that's happened, they adopt the new product and happily accept its lower price" (Christensen et al., 2015: p.4-5).

However, Christensen's definitions have been challenged by others for a lack of consistency and coherence of its application. But, in this thesis, disruptive innovation is defined as a creation of products and services that regardless of whether it completely opens up a new market or not; it challenges the present market order, business form or approach, and that is power enough to restructure and revamp the market. This new definition is discussed in Chapter 3.

1.5 Structure of thesis

The thesis continues in Chapter 2 by reviewing the key literature in the innovation field. A comprehensive but broad overview of innovation and its sub-areas and disciplines are discussed. Understanding the broad theoretical underpinnings is important, since the innovation field has been developed and broadened by various theoretical lenses and their relevant contexts. This knowledge of each branch of innovation helps to develop an understanding of the theoretical foundation a firm-level innovation model is based on. It also helps to understand how the concepts have construed its context in the innovation process as theoretical models. Innovation models can be divided into two contexts: developed and developing countries. As will be discussed in the chapter, innovation models and concepts of each context are significantly different because the innovations of firms in developing countries are different from those of developed countries. A critical assessment of those innovation models is presented and is important as it discusses the theoretical gaps, neglected and under-researched spots in the existing literature, which provides a foundation for a new innovation model that this thesis will suggest.

In Chapter 3, a new conceptual NIC innovation model is introduced. This model consists of a set of theoretical assumptions with recent theories of dynamic capabilities and disruptive innovation. The dynamic capabilities of the firm and its ambidexterity provide a useful insight into how latecomers structure their R&D to cope with two critical issues of their innovation: catching up the technological gap and following the constantly advancing innovation frontier. Disruptive innovation provides an explanation of the latecomers' position in the market and the way they generate competitive advantages by moving up from low-end to mainstream.

Chapter 4 describes in detail the research philosophy and methodology that was used for this research. The chapter describes the philosophical stance of the author and the methodology that was used to develop a theory by adopting abductive reasoning and the theory-laden approach. The research method used in this research is qualitative multiple case studies. Data was gathered by interviews, the annual reports of each case company, other officially published documents and previous research that studied the same firm as the case study. Data was coded by sets of codes that were developed from the literature review. These set of codes were then categorised into four dimensions from the conceptual framework.

Chapter 5 presents the case studies. These were written for all three firms: a semi-conductor, a steel/automobile firm and construction company. A brief overview of the cases will be presented to help the overall understanding of the industry, as well as the context and history of the firm. Quotes from interviewees will overlap with the analysis in order to make it easier to understand and interpret the information. The interviewees preferred to remain anonymous, therefore the company's name, interviewees' names and specific job titles have been excluded. However, a rough description of their job titles was included with agreement from interviewees. Although each company has its own structure and levels of management, Korean firms have a certain common hierarchy of management. Directors or general managers are normally considered to be at a senior, high-middle level, having worked for the firm for at least 10 years. Team managers or assistant managers are middle-low level and have worked for the firm for at least 5 to 7 years. Other staff can be considered to be general staff. For the sake of simplicity, managers from the middle to high levels are labelled as senior managers; team managers or assistant managers are called managers; and other staff are labelled as staff. For example, a director of a new product development team in an R&D centre is stated as being a senior manager in an R&D centre.

Chapter 6 presents the analysis of the case study findings. After an analysis of each case, a cross-case analysis provides important findings into the relationship between the degree of dynamic capabilities, the dimensions of innovation and the degree of environmental change in the industry. The case study findings reveal that the focus of catching-up innovation should be on the accumulation of the firm’s capability of undertaking radical product innovation while still being able to nurture existing products and the market, rather than the successful acquisition of already commercialised technologies, as the existing literature argues. From these reflections on the findings, this chapter finishes with an analysis of linking the findings to the existing literature and model.

Chapter 7 provides a further discussion of the case studies, presenting a new final revised model of NIC innovation, the transformational capability building model.

This thesis finishes with the conclusion of the thesis. The research is summarised, and theoretical and practical contributions are clarified. The limitations of this research are also clarified and a number of recommendations for future research are suggested.

Chapter 2

Innovation and a review of the literature

For nearly a century, innovation research has proliferated and been studied from different perspectives in various disciplines. Innovation studies started to emerge as a separate management field of social science research in the 1960s and 1970s, which was independent from economics and the other science fields. The most remarkable step forward in this shift was the birth of the Science Policy Research Unit (also well-known as SPRU) at the University of Sussex, England, in 1966. As its name portrays, the institution inspired and led to many important pieces of research into innovation as a science policy that focused on the role of technological innovation in economic growth and social developments. As one of the consequences of this progress towards heterogeneity, many studies during the last few decades have a cross-disciplinary orientation that recognises no single discipline can deal with all of the aspects and ingredients of innovation. Thus, innovation has increasingly been linked, or sometimes merged, with various areas within management studies recently, such as organisational strategy, project management, knowledge management, marketing, product management and the national level studies of industrial policy.

2.1 Review of key theoretical concepts in innovation

It is impossible to review all of the disciplines and perspectives in the modern innovation field. Hence, it is possible to understand a broad picture of innovation by examining the dominant thoughts in each paradigm shift in the long history of innovation research within the context of national-level and firm-level studies. Until the 1950s, innovation was mostly written about in the language of economics. The modern innovation theory's central idea departs from the systems of innovation – or innovation systems that highlights the importance of the systemic interactions between the various actors at the micro-level and the role of the state in coordinating this interactive process. In the following part of the chapter, various subject areas and levels of studies of innovation are reviewed in order to provide historical insights into the development of innovation theory.

The national systems level of innovation

The early classical economists were well aware of the critical role that technology has in economic progress. They considered and explained technological progress within the notion of capital, economic growth in the twentieth century and in the two post World War periods. This traditional economic view of innovation was altered by the emergence of the concept of the systems of innovation. The National Systems of Innovation (NSI) concept provided policymakers with a strong national-level framework for the role of the state and an innovation policy that was able to create institutional conditions for a knowledge-driven economy. The strongest contributors in the NSI view were the institutional economists (Freeman, 1987, Lundvall, 1992) and the evolutionary scholars (Nelson and Winter, 1982, Metcalfe, 1995). Their definitions of NSI are different but they also share a common idea. All of these definitions state that NSI is a systemic approach of the role of the state-level setup in running the system of coordination that considers the importance of institutions and interactions at a micro-level.

Freeman (1987)	"The network of institutions in the public and private sectors whose activities and interactions initiate, import, modify, and diffuse new technologies." (p.1)
Lundvall (1992)	"All parts and aspects of the economic structure and the institutional setup affecting learning as well as searching and exploring." (p.12)
Nelson (1993)	"A set of institutions whose interactions determine the innovative performance of national firms." (p.4)

Table 1. The definitions of NSI

However, as these definitions hint at, the main focus of the NSI was slightly different. Freeman (1987) emphasises four main elements of the NSI by studying Japan. His argument is that the Japanese case specifically explains how the NSI can help latecomers to economically catch up through technological innovation. First, he stressed how the role of corporate R&D was one of the critical elements in the (Japanese) NSI. Corporate R&Ds were used to assimilate external knowledge that was acquired from advanced economies abroad, which was used to create their own internal technologies that were then adjusted for Japanese interests. Second, he focused on the role of the capabilities of human resources and organisations in implementing large technological systems. Third, he pointed to the role of Japanese policymakers in making strategic choices for particular industries that brought about strong economic growth. Fourth, he looked at the conglomerate structure in Japanese industry where only a few gigantic firms dominate the markets. Under this structure, firms were able to internalise externalities that were embedded in their supply chains. It also helped with the implementation of externally acquired technologies into the organisation and production system.

Lundvall (1992) has a somewhat similar view to Freeman's in which the NSI needs a nation state level of settings for their interaction. However, he clearly put more emphasis on the distinction between learning, search and exploration. Learning is associated with routine activities which provide the experience and knowledge that lead to new and innovative ideas. This is in line with Arrow's (1971) idea of learning-by-doing. On the other hand, search and exploration is a distinct activity of R&D. His second concern was the distinction that exists between incremental and radical innovations. In his view, the nature of innovation is cumulative and incremental through the constant process of learning and searching. The third was feedback, not only between different actors, but also non-market actors, such as user-producer interaction. The exchange of information between users and producers leads to producers adapting new information to improve their products and innovation.

Nelson's view shares many commonalities with Freeman and Lundvall, but it is based on empirical studies. He added the role of universities and modes of university-industry interaction in different industries as the source of NSI (Nelson, 1993). As with an evolutionary perspective, the emphasis was on the particular ways that the university system coordinates with the commercial R&D system.

These NSI concepts were most influential during the late 1980s and early 1990s when they agreed with the interests of the policymakers by helping them to explain the competitiveness of national economic growth. One of the reasons that the policymakers needed this was to understand the knowledge or technological gap that existed between the United States and European nations, which popularised comparative country studies in the 1950s. European and US scholars, such as Gerschenkron and Abramovitz, pioneered this kind of nation-level comparative study to explain the catching up of latecomers. Using the example of Germany's attempt to catch up with Britain, Gerschenkron (1962) argued that once a country has succeeded in an innovation-driven attempt to catch up and achieved economic growth, others might find it difficult to follow the same path as the conditions would have changed considerably. Thus, new institutional instruments that have no counterpart in an established industrial economy are crucial for latecomer countries. Several studies were made that used the context of East Asian countries where new latecomers clearly indicated the institutional changes that were involved in catching up (e.g. K.R. Lee[1], 1996, 2007, 2014). Furthermore, Abramovitz (1986) suggested the idea of technological congruence and social capability for latecomers. The notion of technological congruence refers to the degree in which the leading and following nations' characteristics are congruent in areas such as market size and factor supply. Social capability refers to the capabilities that the catching-up countries have to acquire to be successful, such as improving the education system, industrial infrastructure etc. These two ideas are generally used in the context of many developing countries and their success and failure. It later provided a strong framework for catching-up economies, such as Taiwan, Korea and other Asian latecomers.

The NSI concept was an important and remarkable new approach to studying innovation in a new analytical perspective that moved away from the neo-classical view of allocation to innovation. By focusing on the process of interactive learning between the agents, it generated a new critical analysis on innovation in terms of the role of the economic structure and institutions. NSI still provides a powerful framework in the macro-level of studies, such as the national-level, geographical

[1] During and after his study at SPRU, his works mostly focused on the NSI in the context of Korea. Notable research included the institutional setting for university-industry interactions in latecomers and the sectoral innovation systems.

(cluster) level and industrial-level of studies. The next step is to understand what is in the micro-level studies of innovation.

Firm level innovation

Firm-level innovation research has a broad range of perspectives, depending on the context. Hence, selected literature, concepts and disciplines are categorised and introduced in this thesis in order to understand a comprehensive insightful overview of the key relevant areas in mainstream research. The first stream is innovation in organisational learning and knowledge management. The second is linked with organisational strategy. The third is related to product and process management. The last is innovation in project management. This categorisation is helpful in tracking back the antecedents of each sub-area of thoughts. Although the lengthy history of each study has bred many streams of research within its own area, they also inspire each other, and scholars cross-reference each other's work. In other words, they are not absolute and independent. Indeed, they are deeply related to each other. Therefore, the most critical issue in understanding innovation depends on how the heterogeneity and multi-disciplines are understood within the given context. Therefore, the core concepts of some literature are mentioned in more than one category.

Innovation in organisational learning and knowledge management

Organisational learning itself has a wide range of perspectives, thoughts, concepts and models. For instance, economic views have been used to examine the importance of learning in the creation of new industries and technologies (Rosenberg, 1976), economics of productivity (Arrow, 1971; Adler, 1990) and industrial structures (Dosi, 1988). Learning has also been considered a feature in firm-level theory, such as learning and knowledge creation as a routine (Nelson and Winter, 1982; Nonaka 1994, Nonaka and Takeuchi, 1995), and learning and knowledge in the context of a firm's capacity (Cohen and Levinthal, 1989, 1990).

Intuitively, these various notions, and other representative literature in organisational learning, suggest there is no holistic agreement within the disciplines as to what learning really is. One of the useful definitions of learning is "the ways firms build, supplement and organize knowledge and routines around their activities and within their cultures, and adapt and develop organizational efficiency by improving the use of the broad skills of their workforces" (Dodgson, 1993: p. 377). Starting from this definition, it is possible to draw some of the key roles of learning in the context of innovation.

1) Innovation is a process of learning by which firms accumulate technological knowledge.

This is related to the knowledge-based view of the firm and firm competencies. For Pavitt (1991), innovation is the uniqueness of a firm's knowledge base and this learning generates firm specific, cumulative and differentiated capabilities. Similarly, Prahalad and Hamel (1990) argue that a firm's competitive advantage stems from the way it nurtures its core competencies through the collective learning of the organisation. Teece et al. (1990, 1997) extend this idea into dynamic capabilities that put emphasis on learning in a dynamic, rapidly changing environment.

2) Learning through innovation activities can increase the firm's economies of scale (productivity).

For economists, learning explains how production unit costs reduce over time and achieve economies of scale through mass-production. Arrow (1971) argues that productivity is achieved by 'learning-by-doing'. For example, the labour per unit of production can be reduced by learning that accumulates knowledge of production equipment. Cohen and Levinthal (1989) argue that R&D not only generates technological knowledge, but also "it develops the firm's ability to identify, assimilate and exploit knowledge from the environment … [that is] absorptive capacity" (Cohen and Levinthal, 1989: p.569).

3) Learning is a routine and continuous process that is embedded in the organisation; and so is innovation.

Nelson and Winter (1982) introduced the concept of 'organisational memory'. At the core of the concept, knowledge consists of the firm's specific routines that are reproduced through practice and learning. By linking this idea with innovation, it can be argued that learning through innovation is also routine and embedded within a firm. This is what is called 'the search routine' that carries out innovation through the actions of search and selection. Accordingly, firms evolve over time and the resources to either develop a new routine or improve on an existing one, depend on how a particular routine fits into the firm's criteria.

This routinised learning is also related to Nonaka and Takeuchi's SECI model (socialization, externalisation, combination and internalisation). One of the features of this model is that once a firm successfully goes through the steps, the process continues at a new level because the final stage of internalisation is also the process of a continuous feedback loop (Nonaka and Takeuchi, 1995).

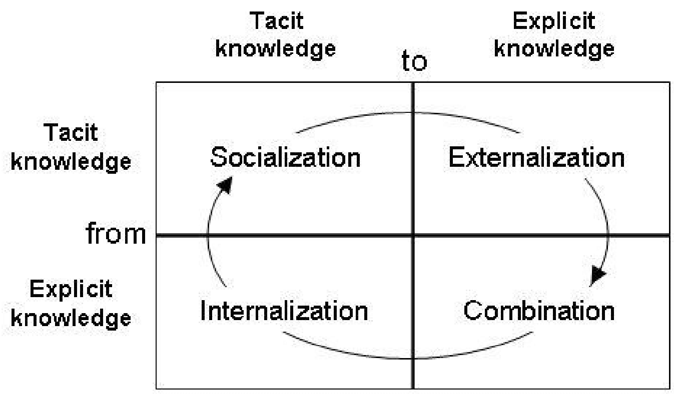

Figure 1. Nonaka and Takeuchi's (1995) SECI model

Innovation in organisational strategy

Another approach is to link innovation with organisational strategy. This perspective has acquired more attention recently with the dynamism of market competitions and economies that have been caused by environmental change and uncertainty. Most theories in strategic management from the 1980s-1990s departed from two main paradigms in the field: competitive advantage and the contingency theory.

The competitive advantage approach, widely developed by Porter (1980), emphasises the firm's ability to create defensible positions in the market against competitive forces. The main focus is on how the industry structure influences the competition and the strategies that are available to firms. Thus, the key issue for the firm is the environment of the industry in which it competes. The environment is determined by five industry level forces – entry barriers, threat of substitution, bargaining power of buyers, bargaining power of suppliers and rivalry among industry incumbents (Porter, 1980). By analysing each factor, a firm might gain a picture of a segment in the market or the market as a whole. The firm then sets up its strategy by defining the market position. This process implies that any firm might be able to enter and perform if it can identify a potential market and strategy and develop the necessary assets. Technological change can influence all five forces, so a firm needs to choose the right strategy. Later in his 1985 article, he reinterpreted the concept of competitive advantage in terms of technological innovation (Porter, 1985). Being fully aware of technological change is one of the main drivers of competition, he argues there are important links between technological change, competitive advantage and industry structure.

	Cost leadership	**Differentiation**	**Cost focus**	**Differentiation focus**
Product technological change	Product development to reduce product cost	Product development for quality, features etc	Product development for minimum design for the target segment	Product development to meet the need of a particular segment (Niche market)
Process technological change	Learning curve process Process development to enhance the economies of scale	Process development to support quality control, deliverability, response time	Process development to improve the value chain to lower the cost of serving the segment	Process development to improve the value chain to segment needs to raise buyer value

Table 2. Four market strategies and product/process technological change
Source: Porter (1980, 1985)

Porter (1980) suggested four generic market strategies for firms: a) overall cost leadership, b) product differentiation, c) cost focus and d) differentiation focus, and linked product and process technology with these generic strategies. The choice of product strategy has a direct influence on the choice of technological strategy, especially when a firm is choosing priorities in product and process development. For instance, a firm that follows cost leadership may choose lower material inputs for product development. On the other hand, if a firm prioritises differentiation, it may enhance the quality and feature of a product in product development (Porter, 1985).

Technological change is an important determinant of the overall industry structure in Porter's five forces; by shifting entry barriers by raising or lowering the economies of scale, shortening the pace of the introduction of new production or increasing investment in a new production paradigm. Buyer power shifts through technological change as differentiation and switching costs are a determinant of buyer power (e.g. the decline in the cost of personal computers in the 1980s-1990s had a major impact as it meant many could afford their own machines). Supplier power also shifts as technological change reduces dependence on a certain supplier as it allows a number of different substitute inputs for a firm's product (e.g. new materials or technologies in construction can introduce powerful new suppliers to a construction firm). Technological change can provide a wide range of substitutes by either creating entirely new products or improved products that outperform existing ones. Lastly, technological change widens industry boundaries. An example of this is the technological advance in transportation or logistics that has expanded the domestic market into a globalised one. Another example is the increase in interrelationships there are among industries. For instance, the industrial boundaries that exist between construction and information technology are becoming blurred as IT technologies are applied in the construction industry. On the other hand, technology can also narrow industry boundaries, such as when a segment becomes an industry. An example of this is the personal drone, which has become a full industry that is now independent of the professional heli-camera industry for military or professional recordings.

Based on his analysis of the five forces, Porter continued his argument that a firm had to decide between two technological strategies: technological leadership or followership. The innovation leadership strategy allows a firm to deliver a whole new kind of product to the market. The innovation followership strategy, on the other hand, allows a firm to follow leaders in the market through learning by imitating the experience of these leaders. It requires a strong level of market analysis and reverse engineering, as well as testing and evaluating existing products from incumbents (competitors) in the market (Porter, 1980, 1985). His latter point explains how latecomers achieve competitive advantages by adapting an innovation followership strategy.

Although Porter's framework has been used by many managers in practice and has inspired many scholars in strategic management, it has also faced much criticism. One of the notable weaknesses of his framework is that it overestimates the power of managers to identify, decide and implement innovation strategies, and underestimates the importance of uncertainty, complexity and rapid dynamic change in the environment. Christensen and Reynor (2003) had a similar concern that: "The problem with the core-competence/not-your-core-competence categorization is that what might seem to be a noncore activity today might become an absolutely critical competence to have mastered in a proprietary way in the future, and vice versa… core competence, as used by many managers, is a dangerously inward-looking notion. Competitiveness is far more about doing what customers value than doing what you think you're good at" (Christensen and Reynor, 2003: p.125 and p.162).

Contingency theory offers the potential to understand the issue of organisational structure for a given contingency better. It is important to note here that contingency theory considers various factors, such as size, strategy, uncertainty, technology, complexity etc. Woodward (1965) considers technology to be a contingency and identified a relationship between production technology, organisational structure and performance. Perrow (1970) developed a more detailed typology of technology and considered task analysability and variability. Lawrence and Lorsch (1967) emphasised the rate of environmental change, differentiation and integration within an organisation. Galbraith (1971) proposed a relationship between task uncertainty, control and communication structures. Mintzberg (1994) developed organisational structural templates to specific task forces. More recently, Tidd (1995, 1997) proposed that uncertainty and complexity were important contingencies in the organisation and management of innovation. He differentiated between uncertainty and complexity as uncertainty refers to "a function of the rate of change of technologies and product-markets, whereas complexity is a function of technological and organisational interdependencies" (Tidd, 2001: p.175). This matrix, figure 2, by Tidd (2001) shows a simple relationship between uncertainty and complexity. There are four domains, depending on the degree of uncertainty and complexity.

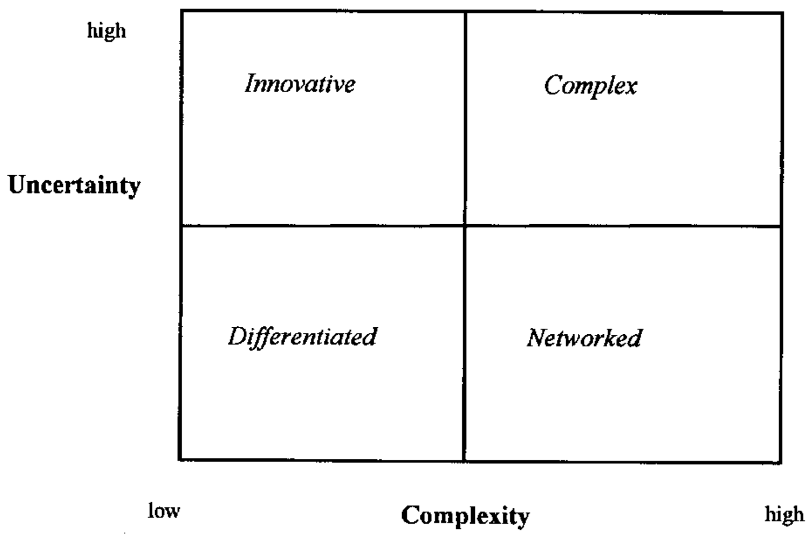

Figure 2. The matrix of uncertainty and complexity

Source: Tidd (2001)

In the ‘differentiated’ domain, product and service differentiation is the critical issue under low uncertainty and low complexity. A typical organisational structure is product or market multi-divisional. In the ‘innovative’ domain, technological competencies are critical under high uncertainty and low complexity. A typical structure is a functional structure. In the ‘networked’ domain, project management competencies are critical under low uncertainty and high complexity. A typical form is a professional structure. In the ‘complex’ domain, various competencies, including flexibility, adaption, learning and application, are the key issues under high uncertainty and high complexity. This contingency concept of uncertainty and complexity provides a very useful insight and explanation of the different forms of ambidexterity that are found from the case studies of this thesis.

The management of product and process innovations

Innovation can take two basic forms: product innovation that is a change in the product or service that a firm offers; and process innovation that is a change in the production process and system that the product or service has created and delivered. According to Utterback and Abernathy (1975), product and process management in the context of innovation are clearly distinguished. Recalling their definitions of the production process and product innovation introduced in Chapter 1, a model of process and product development consists of stages.

A process development has three stages: uncoordinated, segmental and systemic. The uncoordinated stage is the early phase in the life of a process of a product and the market in which they compete. The rates of product and process innovation are high due to the immaturity of the market. The segmental stage is when the market, product and process begin to mature. The market competition becomes intense and production systems become specialised and routinised for efficiency – economies of scale. The systemic stage is when a process becomes highly developed, integrated and settled. In this stage, almost no change occurs because any change might require a huge effort and be expensive. Thus, if the market and technology continue to evolve, firms might face evolutionary change, rather than revolutionary change (Utterback and Abernathy, 1975).

Similarly, product development has three stages: performance-maximising, sales-maximising and cost-minimising. Performance-maximising is the early phases of the product lifecycle where the rate of product change is rapid due to the uncoordinated state the market for a new product is in because it not yet matured or defined. Accordingly, firms face a high degree of uncertainty. Product innovation tends to be driven by need, feedback from the new market or opportunities. Sales-maximising firms face a higher degree of competition based on product differentiation. With the diffusion of product and technology, firms may adapt advanced technology for further product innovation. The cost-minimising stage is when the product becomes standardised, and technology and the market become mature. Competition focuses on price reduction, efficiency and economies of scale. This explains why advanced firms relocate their production system overseas to achieve lower costs of labour factor inputs.

Using a combination of product and process innovation dimensions, the Utterback and Abernathy model describes three main phases of innovation. The 'fluid phase' is where the rate of product innovation is high. The product and technology are not mature at this stage, thus major changes in the products and production processes occur. The 'transitional phase' is initiated by a dominant paradigm of a certain design or technology. There are some degrees of market competition by a few firms with differentiated products. The focus of product and process innovation is the standardisation and mass production of the dominant product. The last phase is the 'specific phase' where both product and process innovations decline due to the maturity of the market and the product. Thus, the focus here is normally on efficiency and cost reduction (Abernathy and Utterback, 1978).

The product life cycle model provides a powerful explanation of the evolutionary innovation process for permanent and conventional firms, which shifts towards high volume along with the product lifecycle. This model was to later deeply inspire the NIC innovation models.

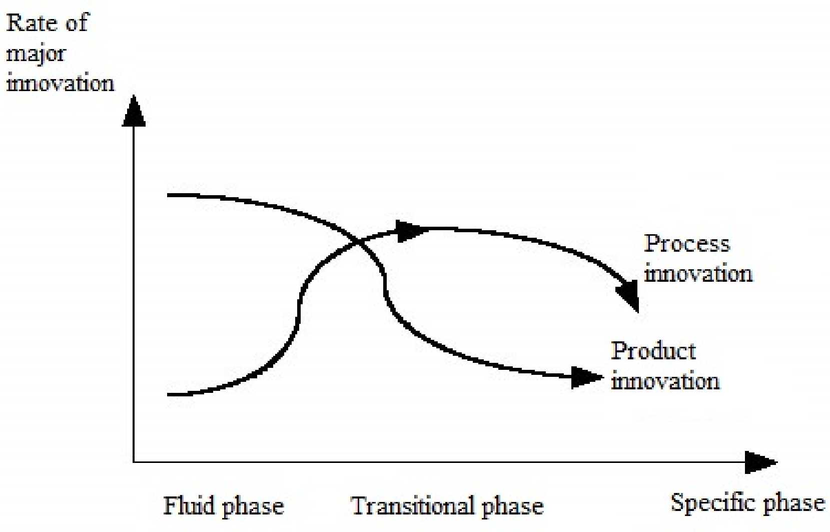

Figure 3. The product life-cycle model
Source: Utterback and Abernathy (1975, 1978)

Innovation in project management

The operations, processes and characteristics of project-based firms and project-based innovations are different to those of permanent organisations. In order to understand the difference, the definitions of project and project-based firms should be revised first. Simply, a project can be defined as “a combination of people and other resources brought together in a temporary organisation and process to achieve a specified goal" (Davies, 2017: p.2). Davies also defines a firm or organisation is 'project-based' when "most of its design, development, and productive activities are handled as projects for clients and are embedded in a permanent organisation which is expected to remain in business and find new work when each project is completed" (Davies, 2017: p.114). Some project-based firms create and develop new customised products and services as one-offs or in small batches for external customers, but also have high-volume operations as their core business and thus may undertake projects for their own in-house needs. In other words, in terms of operations project-based firms do most of their work in projects and put the main focus on the project dimensions rather than the functional dimensions (Lindkvist, 2004). As Galbraith (1969) and Mintzberg et al. (2003) suggested, organisational forms can vary from the pure functional form through the matrix form to the pure project-based form. In the functional form, a firm's activities are organised by functional specialised departments (e.g. R&D, marketing, human resource management). In the pure project-based form, "projects embody most, if not all, of the business functions normally carried out within departments of functional or matrix organisations … in other PBOs [project-based organisations], much or all of the project may be carried out within the boundaries of a single company" and "the project is the primary unit for production organisation, innovation and competition" (Hobday, 2000: p.874). Thus, the project is the primary core mechanism for co-ordinating and integrating all the main business functions of project-based firms (Hobday, 2000; Whitley, 2006), and the firms build up the knowledge, capabilities and resources through undertaking major projects (Hobday, 2000; Gann and Salter, 2000). Similarly, Davies and Brady (2000) and Brady and Davies (2004) defined a project organisation as a temporary organisation that combines and coordinates the specialised knowledge, skills, and resources required to complete the project goal on time, and within the cost, quality and other business constraints. In other words, the process of creating knowledge and capabilities of project-based firms are significantly different from other forms of organisations.

In general, firms usually develop routines in their business processes based on ongoing and repetitive tasks. Routines can increase the firm's operational or production efficiency [mass production], as well as stimulate innovation, providing there are chances for incremental innovation for existing products or production processes, or radical innovation for new market opportunities (Gann and Salter, 2000). Project-based firms tend to produce unique or highly customised products and services and perform non-routinised tasks with limited opportunities for standardisation, economies of scale or innovation (Davies and Brady, 2000; Gann and Salter, 2000). The focus and locus of innovation in project management are on the improvement of productive performance through innovation, which is significantly different to that of the other management disciplines.

A classical concept from Woodward (1958, 1965) suggests that there are two ways to improve productive performance. The first is to adopt and refine the most advanced innovations into a given system of production. The second is to progress the production volume systems from low to high, by adopting the appropriate technologies to pursue larger markets and achieve economies of scale (Wheelwright and Clark, 1992). Davies, Gann and Douglas (2009) clearly stated that this idea was based on the product of the mid-20th century, when the main focus was on achieving high volume, efficient mass production and economies of scale. Informed by Woodward and other research – such as Hayes and Wheelwright's (1984) and Abernathy and Utterback (1978) – Davies et al. (2009) suggested a product-process matrix of modern projects. As a firm makes progress towards the high-volume production of standardised products, the competitive advantage also shifts from production flexibility and customisation to production stability and standardisation (Davies et al., 2009).

Indeed, there has been a tendency towards deploying and improving on the project form of business for strategic and innovation purposes: to satisfy the customer's specific requirements and to respond to uncertain, changing environments. The purpose of the shift of firms from mass production to a more flexible project-based organisation is to produce "high cost, technology-intensive, customised, capital goods, systems, networks, control units, software packages, constructs and services" – the so-called complex products and system (CoPS) (Hobday, Rush and Tidd, 2000: p. 793-4). Although CoPS is a very important concept that has led to many research areas and issues, it is beyond the scope of this thesis to discuss all the innovation dynamics of CoPS (e.g. various issues of CoPS were discussed in the special issue of *Research Policy*, 2000).

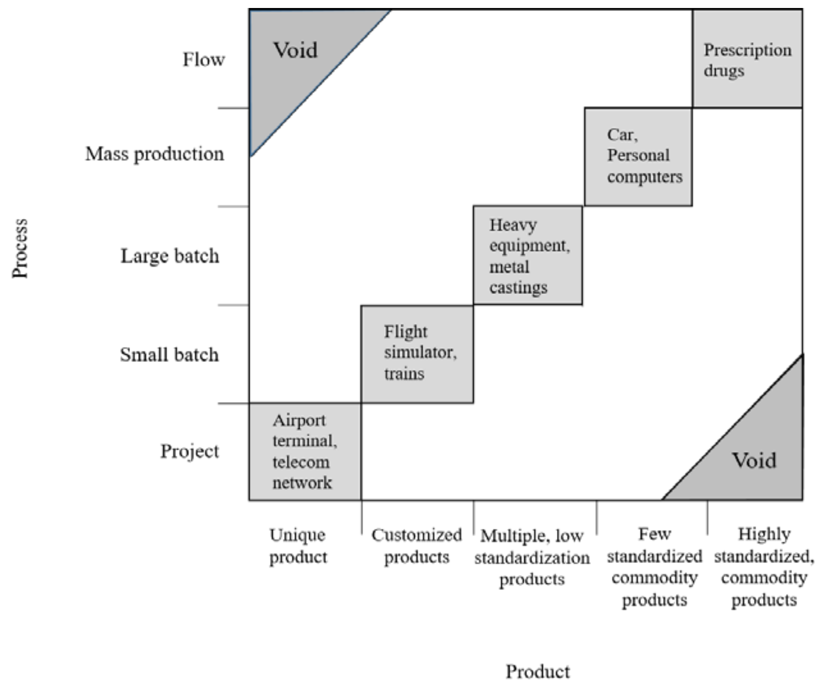

Figure 4. Product and process matrix
Source: Wheelwright and Clark (1992)

Still, the innovation issues raised by CoPS' characteristics are crucial in project management. There are three unique characteristics that distinguish it from mass-produced goods. First, CoPS consists of large numbers of customised sub-systems and components within a system. Second, CoPS tend to show unexpected and unpredictable emergent properties that arise during production. Third, CoPS are produced in highly customised projects or small batches that involve users or customers in the innovation process (Hobday et al., 2000). Because of these characteristics, the innovation of CoPS is different from conventional innovation. Generally, the mass production or standardisation of products and technologies follow the lifecycle of Utterback and Abernathy (1975). At the micro-component and sub-system level, commodity goods consist of smaller numbers of standardised components and technologies that can be substituted by advanced ones through incremental innovation in the product or process. However, the components and sub-systems of CoPS are highly customised and inter-connected. In other words, CoPS does not go along with the conventional product lifecycle and innovation cycle (Hobday et al., 2000; Davies et al., 2011). Instead, Davies (1997) suggests that CoPS can evolve in two innovation phases. The first is the early design phase when a new system's architecture develops before the commercialisation stage because architectural designs are strongly influenced by suppliers, users and regulators. The second is the new product generation phase (Davies, 1997, Davies and Hobday, 2005).

Coming back to the project management level, if organisational learning is indeed the key to innovation, it is important to understand the mechanism of project-based learning and the incorporation into new routines to the firm. There are two major issues that impair project-based innovation and learning: the unique and the temporary nature of projects (Prencipe and Tell, 2001). Regarding the former, each project is likely designed, tailored and productively processed as a specific well-defined product specification of one or a few identified customers (Hobday, 2000; Gann and Salter, 2000). This one-off characteristic means that project-based firms must confront the difficulty of achieving "learning by doing" or "learning from samples of one or fewer" (March et al., 1991). In addition, projects can have long life cycles, so there could be long time intervals until similar project activities can be retrieved and repeated (Prencipe and Tell, 2001). In regards to the latter, projects can be unique in which firms have too little time to develop ‘organisational memory’ (Nelson and Winter, 1982), or have “the constellation of people they entail”, which implies that new human conflicts and relationships are involved whenever a new project starts. These two issues challenge project-based firms to achieve ‘learning,’ as knowledge and learning acquired and developed during the project are disposed or disappear before they are transferred to the organisational level.

However, project-based firms do achieve innovations. Firms in many low-volume industries produce unique or highly customised products that achieve innovation and performance improvements by moving towards higher volume production stages. Therefore, firms should find a way to improve their performance through innovation in their products and process within the project production stage, where each customer order initiates a new project, and in which project management coordinates and controls the firm’s resources, knowledge and skills in order to meet the constraints of time, cost, quality, customer satisfaction and added value (Davies, Gann and Douglas, 2009).

Process innovation in project production is difficult to achieve because projects involve many non-routine processes and higher uncertainty from customisation than standardised production. Nevertheless, firms can achieve the competitive advantage of 'economies of repetition' by developing the project's capabilities at their core business (Davies and Brady, 2000; Brady and Davies, 2004).

Product innovation in project production is influenced by three dimensions: 1) technological uncertainty, 2) systems complexity (Shenhar and Dvir, 2007) and 3) product novelty. The first dimension, technological uncertainty, is determined by the amount of new technologies that are involved in the product. It is possible to categorise the types of projects according to the degree of technological uncertainty there is: low-tech, medium-tech, high-tech and super high-tech projects. Accordingly, the degree of product innovation is in direct proportion to the degree of technological uncertainty. For example, low-tech projects have almost no uncertainty as they are incorporated with existing technologies that have already been proven in the commercialisation of the production and the market. The second dimension, systems complexity, depends on the hierarchy of systems of a product that a project is responsible for. For example, assembly projects that produce an assembly product or a product with a single function have low complexity. On the other hand, a system of systems projects that produce a diverse collection of systems and sub-systems that function together as a final product have high complexity (e.g. city infrastructures or an airport). The third dimension, product novelty, depends on how new a product is to customers or the market. One type of these projects is breakthrough projects, which create new products and processes within a given production system through radical innovation. Due to the high uncertainty and risk involved, breakthrough projects require a new type of procedure and organisational approach to lead the project to success (Davies and Brady, 2000, Brady and Davies, 2004).

Davies and Brady (2016) suggest that the project's dynamic capabilities provide a way of dealing with complex and uncertain conditions in innovation. By linking the dynamic capabilities with project capabilities they first identified, Davies and Brady (2000) argue that firms should develop dynamic project capabilities that would enable them to deploy routinised or standardised projects for existing customers and launch new innovative projects to develop new technologies and markets. Brady and Davies (2004) explained that the project-based firm evolves towards a transition from exploratory to exploitation, which is represented by three distinct phases of organizational learning: 'within the project', 'project-to-project' and 'project-to-organization'. The goal is to create sustainable competitive advantage and transform exploratory learning into exploitative knowledge to sell it through repeatable solutions, generating value from economies of repetition. Routine projects are exploited and organised to achieve a set of predefined goals under given project constraints (time, cost and quality). Innovative projects focus on dealing with highly unpredictable conditions by shifting the organisational structure, design, routines and capabilities. One of the most important and interesting concepts here is that 'a vanguard project' is required to encourage the exploration of new opportunities, innovative problem solving and new project routines. Due to their high degrees of novelty and complexity, innovative projects cannot be planned in advance. A vanguard project plays the key role of experimental searching processes, real-time learning and exploring multiple solutions until the project producer finds the best solution among them (Davies and Brady, 2016).

With the findings from cases of construction firms, Gann and Salter (2000) provide a model, as in figure 5 below, that shows how project-based firms manage both project and business processes. Bearing in mind that in construction, firms' design and production processes are organised around projects and they operate in coalitions of different companies, suppliers and customers, knowledge associated with 'know-what' and 'know-why' tends to be codified while 'know-who' and 'know-how' tends to be uncodified, or tacit. Thus, they argue that the resources – knowledge, are embedded at both the project and the firm level. To be successful, firms need to integrate the experiences of projects into their continuous business routines, and the core firm resources need to be mobilised to support projects and feedback from projects (Gann and Salter, 2000).

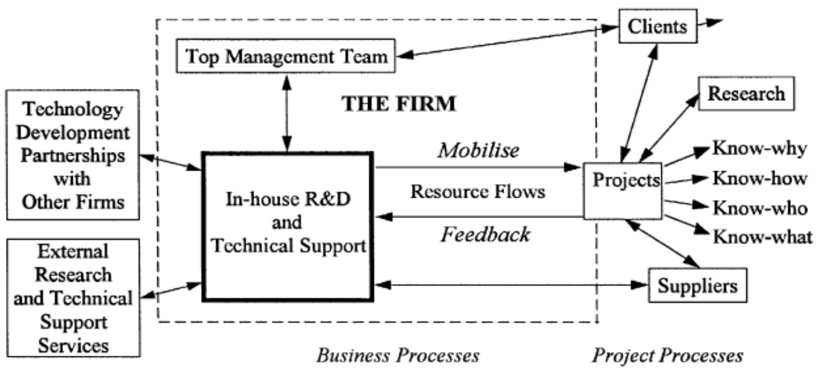

Figure 5. The project-based firm and technical resource flows

Source: Gann and Salter (2000)

As a summary, innovation in projects and project-based firms shows some degree of differences and difficulties when compared to permanent firms. However, the literature suggests that innovations in projects is similar to permanent firms as both organisations put the emphasis on the role of dynamic capabilities to facilitate learning to concrete knowledge acquired from projects and to transfer it to the organisation.

2.2 Innovation models in the context of developed countries

The mainstream innovation models have been researched in the context of developed countries and their history, dating back to the 1940s. Accordingly, several approaches have been made to analyse the innovation process and the issues in practice from different perspectives. Rothwell (1994) categorised and suggested five models in each generation in their order of historical development. Table 3 attempts to describe these generational models.

The fundamental logic behind the first-generation model was an economic approach that considered technological advances to be a component of economic growth. It suggested a substitute explanation for economic growth that neither changes in capital nor labour could explain (Marinova and Phillimore, 2003). From the Second World War in the 1940s to the middle of 1960s, the first-generation reflected the emergence of new technology-led industries, such as semi-conductors, pharmaceuticals and electronic devices. At the same time, existing industrial sectors, such as steel and textiles, also demanded new technologies in order to increase productivity and the quality of production. As technology and science were considered to be an injection of economic reinforcement during this period, large amounts of investment were made, along with government level and public support. Under these conditions, the process of industrial innovation was seen as a linear progression from scientific discovery, through technological development in firms, and finally to the market. Thus, this first generation used a “technology-push” process, as it was assumed that ‘more R&D inputs’ were needed for ‘more successful new products output’ (Rothwell, 1994).

The second-generation model, from the middle of the 1960s to the early 1970s, viewed technological development as a driving force for innovation, which resulted in a flow of new discoveries in basic science that led to new products and processes, and finally to the marketplace (Rothwell and Zegveld, 1982). During this period, manufacturing output and productivity were prosperous. Levels of industrial concentration and competition were also high due to the imbalance that existed between supply and demand, as newly introduced products were created by applying existing technologies. Under this competitive intensified condition, there was an emphasis on the importance of marketing as companies fought for their market share. This caused a shift in innovation progression towards ‘market-pull’ or ‘demand-pull’, which was a simple sequential model that made market demand the source of R&D’s direction (Rothwell, 1994).

Those two linear models failed to analyse the complex interactions that exist between science, technology and the process of commercialisation. Thus, because of the need for deeper understanding, the third-generation model introduced an interactive process, which included feedback and loops that allowed innovators to add additional research to tackle any problems that arose (Kline and Rosenberg, 2010).

Two major oil crises in the 1970s had a huge impact on the world economy and led to high rates of inflation and stagflation, as well as structural unemployment. In order to reduce the failure of technological innovation and waste under constrained resources, firms were forced to undertake the consolidation and rationalisation of their innovation process. During this period, a number of detailed pieces of empirical research on the innovation process that led to the innovation model was established as systematic studies and as a wide-ranging portfolio. Those empirical studies suggested that the previous technology-push and market-pull processes of innovation were both extreme and bi-polarised. It, therefore, recalled a more generalised model that contained interaction between the technological capabilities and market demands. This coupling model – the third-generation model – was a complex stage of the communication paths that linked the in-house functions to the wider scientific and technological community and the marketplace. One of the remarkable implications of this third-generation model was that the success of innovation could be explained in terms of multi-factors and multi-tasks (Rothwell, 1994).

The early 1980s was a period of economic recovery when firms started to become aware of the emphasis that was placed on strategic technological accumulation and so they focused on their core businesses and core technologies. Competition in the global market increased, so firms were forced to find a global strategy and forge strategic alliances with others. This period also saw the remarkable performance of Japanese firms in the world market, which was based on a combination of innovation and technological strategy. Two features of the Japanese innovation strategy were integration and a parallel development system of new products. Japanese firms integrated their suppliers in the supply chain to product development, while also integrating the various in-house departments involved in parallel, rather than a sequential series. Thus, the fourth-generation model was an integrated and collaborative innovation process that brought different elements and participants together by considering all of the activities as being parallel (Rothwell, 1994).

While many firms were committed to the strategies of the 1980s, the speed of development was considered to be an important factor for competitive advantage in the late 1980s and the early 1990s. As rates of technological change were high and the product lifecycle became shorter, firms had to be the first to introduce a new product or service to the market in order to gain the economic benefits and a greater market share. Doubling up the resource-inputs may have significantly reduced the development time by raising the speed of the technological innovation process. However, Gupta and Wilemon (1990) suggested that the U-shaped development and time, which showed an optimal range of development time and cost, meant the expected effect of obsessive resource inputs could be diminished and delayed the development time.

Firms took an integrated and parallel process in order to ensure the speed, efficiency and flexibility of product development, as well as collaborative research into the forms of joint R&D ventures or alliances there were at the time. This indicated that the fifth-generation of the innovation process had become more about network-based activities (Rothwell, 1994).

Recent innovation works have been inspired by Chesbrough, who opened up the new paradigm shift called open innovation. Network is the core idea of the fifth-generation model, and it elaborates on both the internal innovation process and the externalisation of innovation activities. It assumes that competitive advantage not only comes from inbound innovation activities (internal R&D), but also outbound innovation through formal/informal networks that a firm is embedded in. A network, in this context, refers to a web of various channels and nodes that enable individuals and firms to access external resources (Dodgson, Gann and Salter, 2008). This implies that access to external knowledge resources is also a source of competitive advantage. Many pieces of research have confirmed this open innovation paradigm and investigated the openness of the innovation process (e.g. Chesbrough, 2003, Chesbrough and Crowther, 2006, Chesbrough and Rosenbloom, 2002, Laursen and Salter, 2006, Laursen and Salter, 2014).

Generations	Time	Fundamental Perspectives	Process structure	Process characteristics
First generation	1950s – mid 1960s	Technology push theory	A simple linear process	Scientific and technological developments push a new product/process to market.
Second generation	mid 1960s – early 1970s	Market pull theory	A simple linear process	The market demands push the innovation process, and influence both the direction and technological developments.
Third generation	mid 1970s – mid 1980s	Coupling innovation process theory	A sequential interactive process	Integrating both 'technological push' and 'market pull' theories, emphasizing a series of independent stages, feedback to the previous stage.
Fourth generation	early 1980s – mid 1990s	Integrated and collaborative theory	Integrated and collaborative process	Emphasising the complex interrelationships and feedback loops among various elements operating within and between firms, considering all activities are in parallel by cross-functional teams
Fifth generation	mid 1990s – 2000s	Innovation network theory	Strategic and technological integration process	Focusing on collaboration within a wide network with competitors, suppliers, distributors, customers, etc. The separation of research and development. The speed of product development is imperative.

Table 3. Description of the generations of innovation process

Source: Rothwell, 1992; Dodgson, Gann and Salter, 2008; Chesbrough, 2003, Nobelius, 2004

So far, a brief review of innovation was presented along with selected literature. As mentioned above, innovation has been researched within a wide range of diverse disciplines in management. Each of the related disciplines and theoretical frameworks has helped to extend the knowledge of innovation. Although they cross-reference and borrow concepts and ideas from each other, they have all developed their own unique, prestigious research streams. Based on the theoretical concepts in each domain in innovation, the models for innovation and technological development have been continuously revised and established, according to the particular economic and business environments of each period. The developed countries models have evolved or shifted into new research paradigms from the simple linear process of innovation in the 1950s to a complex networking innovation process in recent years.

However, when applied in a developing countries context, these concepts, ideas and theories provide different implications, and some of them have a significant lack of explanatory power and applicability. Many scholars studying developing countries or latecomers point out that innovation and its process are so different from that of developed countries, that a new and different approach is necessary when examining developing countries and their latecomer firms (Amsden, 1989; Ernst, 2002; Hobday, 1995; Lall, 1992). In the following part of this chapter, there is discussion of how innovation in developing countries, specifically catching up, is different to developed countries by reviewing literature and theoretical foundation. Catching up innovation models that are based on, and developed from, these doctrines and theoretical perspectives are then presented.

2.3 Review on the concepts of latecomers and catching up

The root of the conceptualisation of the developed and developing countries – or the advanced and catching up countries can be traced back to Alexander Gershenkron (1962) who considered the development problem as a catching up problem, and the role of policies and institutions of the continental European countries as they strove to catch up with the UK. Based on his theory and observations of the pattern of late-industrialisation of Russia, Germany and France, he believed that the more backward the economy, the more rapid industrial growth could be achieved through borrowing the advanced technology from more developed economies. Nevertheless, to succeed, catching up economies need new institutional instruments to mobilise resources, especially financial resource, to undertake the necessary changes that modern technology required (Gershenkron, 1962). Later, his idea of some degree of active intervention for successful technological transfer inspired the discussions of the Asian experience and the development of models.

From the mid-1970s great research attention was given to innovation and the technological development (still late-industrialisation to some extent) of East Asian and Latin American. There were mainly two geographically distinguished strands of studies that highlighted the different experiences of East Asian and Latin American industrialisation. The East Asian branch of work concentrated on the experience of South Korea, and Korean firms' transition in innovation. The Latin American branch was initiated from the work of Katz in the 1970s which highlighted the importance of technological learning and Latin American's market structural reforms.

In the Asian strand, the most notable study was conducted by Kim (1997) who studied Korea's transition from imitation to innovation. His study integrated contributions from others such as Amsden (1989; 1997) and Westphal (1978) and developed the latecomer's different stages of catching up innovation. Later, several studies contributed further by including a widening range of other countries such as India (Lall, 1987) and other East Asian countries cases – for example, Hobday (1995), Ernst et al. (1998), Lall and Teubal, (1998), Mathews (1997;1999) and Mathews and Cho (2002).

The Latin American strand focused more on technological learning and national level of technological capabilities. Similar to the Asian cases, Katz (1987) and Crespi and Katz (1999) pointed out that firm-level technological learning was present in the Latin American countries from the 1950s to the 1970s. However, he suggested a different explanation for the relatively poor long-term performance of Latin American firms. He connected the learning to macro and microeconomic environment, and major changes in market structural and behaviour policies (Katz, 2001). Other recent studies such as Dutrenit and Katz (2005), Dutrenit (2000), Cassiolato (1992) and Figueiredo (2001) investigated the Latin American cases in different industrial sectors.

Interestingly, few studies compared and integrated these two strands. Evans and Tigre (1989) concluded that different strategic policies in state, capital and market in Brazil and Korea bred the different growth rate and results in the computer industry. Mathews (2009) compared China, India and Brazil, and highlighted the importance of systematic economic learning as the key in latecomer innovation. Other studies tried to address why Latin American had failed to achieve impressive economic growth as had been achieved in the East Asian nations, especially Korea. Katz (2001), Dutrenit and Katz (2005), and Kim (1997) which compared Latin American and Korean cases, concluded that an increasing degree of technological capabilities, as an outcome of dynamic learning, resulted in a rapid expansion of labour productivity during the import substitution period in Latin America. The manufacturing exports in Argentina, Brazil and Mexico in 1970s was not sustainable under different macro-economic and trade policies such as market liberalisation, export-orientation, foreign direct investment, natural resource intensive industrial exports and labour market issues with the U.S. Other socio-cultural factors such as effectiveness of national innovation systems, government bureaucracy, education, financial institutions, management strategy and specialisation of labours in specific industries also had an effect.

Despite differences between the strands and experiences of Latin American and East Asian (especially Korean), much of the work in both strands was embedded in two critical ideas. First, they paid considerable attention to Gershenkronian ideas of 'late industrialisation'. By contrast to England, Germany and the United States, economies in the twentieth century transformed their productive and economic structures on the basis of borrowed technology through learning (Amsden, 1992). Some of scholars outlined above such as Hobday (1995) and Kim (1997) developed this Gerschenkronian's perspective at a micro (or firm) level in their idea of latecomer catching up as a unique phenomenon. Second, these technology-centred perspectives also influenced the idea of a national level of catching up between economies in terms of productivity and income levels (Bell, 2009).

According to Bell (2009), the ideas in frameworks in innovation studies have been changing over time. For instance, from the 1960s and 1970s, innovation was seen as clear-cut stages of invention – a process by which an idea of a new way of doing or a new product or service, innovation – the stage that results in the first commercialisation of the invention, and diffusion – the subsequent imitation or application by numbers of other users. This narrow focus on the novelty of technological innovation excluded the successful cases of minor improvements made into existing plants during their lifetimes, not just an invention from major technical change based on new knowledge derived from R&D. Thus, from the mid-1970s, the focus moved to the incremental innovation of imported products or production process by technological users. The significance of incremental innovation was further emphasised in the 1980s when innovation clustering was a phenomenon. Thus, by the early 1990s, scholars started questioning the relevance of the earlier concepts of innovation. The narrow spectrum of innovation activity that concentrated on the novelty of technology started to change to cover a wider range of incremental innovation and pervasive organisational transformations (Bell, 2009).

Within that changed conceptualisation, the research on technological catch up since late 1980s has evolved in three different levels of studies. First, innovation system approaches analyse the catching up and growth of latecomer countries. Originally departed from the concept of National Systems of Innovation, studies in this strand have adopted various dimensions including the institutional dimension, policy framework, interactions and linkages among innovation activities and actors within a system (Freeman, 1987; Nelson, 1993, 2004; Lundvall, 1992, 2010). Similarly, some scholars approached the issue of the policy, institutional framework and market in developing countries in terms of developmental economics perspective. For example, Lall (1992) views the institutional framework as the interplay of national level of capabilities – a combination of physical investment, human capital and technological effort and incentives – the driving force of the use of the capabilities and, indeed stimulate their expansion, renewal or disappearance (Lall, 1992: p.169); Fagerberg and Srholec (2008) focus the role of national level of capabilities in economic development.

Second, a strand of research focused on the latecomer context at the industry level. For example, Perez and Soete (1988) analysed catching up as the industrial development followed by the shift in techno-economic paradigms which evolves from an early phase through growth to maturity in an industry or technological system. Recent studies emphasise the importance of time frame and industrial characteristics for latecomers, related to the emergence of radically new technologies, market demand structure, specifics of institutional and government policies (Landini et al., 2017; Landini and Malerba, 2017; Lee and Malerba, 2017). The concept observes that the emerging combinations of those industrial characteristics facilitate periodic cycles of catching up opportunities for latecomer firms.

Third, some scholars focused on learning and the development of technological capabilities in developing countries and latecomer firms. This strand has evolved in three approaches: the first approach has adopted the product life-cycle and suggested that latecomer's catch up shows a reversed cycle and path in development stages (Kim, 1980; Hobday, 1995). The second approach considered the competitive strategy and resource leverage effects as the main key factors for latecomers' catching up (Mathews and Cho, 2002; Mathews, 2004). The third approach, inspired by Martin Bell, and Bell and Pavitt, focuses mainly on the firm level capability building through the dynamic learning process.

Learning as an important research agenda in catching up

Recently, scholars who have worked in the economic development of the developing world have voiced some scepticism about the traditional theories of catching up (Lall, 1992; Viotti, 2002; Nelson, 2004). In their place, they pointed out the importance of applying reorientation of the concept of a national innovation for the developing countries context. At the national level, while the analysis and concept of classic catching up mainly focuses on the key institutions and national settings such as policy and structure for STI (science, technology and innovation) at the innovation frontier, the newly oriented NSI concept considers the knowledge and learning mode of innovation for economic growth and catch up. Along with globalisation, moving toward a knowledge-based economy (Foray and Lundvall, 1996) and 'learning economy' (Lundvall and Johnson, 1994) in which individuals and institutions need to renew their competencies to cope with the rapidly changing problems, the key to success depends on the importance of indigenous capabilities of learning (Nelson, 2004; Lundvall et al., 2006; Lundvall et al., 2009). It is important to highlight that learning here does not only refer to the process of science-based, but also experience-based learning. The experiences of Latin America and Asia demonstrated that they were not just importers and users of knowledge produced by others. Instead, they created a large proportion of the knowledge they needed and acquired the rest from external sources. Thus, they were simultaneously crossing both sides of the technology supply and demand, being knowledge-users and knowledge-producers. This is of fundamental importance for a developing countries context since it emphasises the fact that competences and capabilities building – either creating or ‘absorbing’ knowledge - through learning is the important component of innovation. Thus, the strategic focus of institutional or policy design and development should be aimed to create, renovate and redirect learning processes to build capability and catch up.

Not only at the national and wider industrial sectoral levels, the speed and effectiveness of learning is also a critical issue at the firm level innovation. Martin Bell sees that capabilities of learning are important in latecomer firms’ catch up. In his early work, he distinguished between ‘doing-based’ learning and ‘dynamic’ learning; the latter form of learning involves combining local and external sources of knowledge through purposive strategy, localised R&D and engineering, financial investment and the accumulation of experience through a variety of learning mechanisms including learning-by-searching, learning-by-hiring and learning-by-training (Bell, 1984; Bell and Figueiredo, 2012; Hobday, 2007).

Later he expanded this dynamic learning into capability building and argued that it is one of the critical components of innovation capabilities for latecomers. His approach to innovation capability was different from other earlier studies of developing countries such as Katz (1987) and Lall (1987, 1992) that involved sequences starting with levels of production capacity to levels of innovative capability. First, Bell and Pavitt (1993, 1995) made a clear distinction between production capacity and innovation capabilities. In common, the idea of technological catch up is considered as the narrowing gaps between the technological capabilities of firms and economies. However, this notion about the gap is often thought mistakenly by combining two different kinds of gaps. Latecomers may catch up in terms of capabilities with respect to the technologies they use in production. The technical and design specifications, and performance of their products may come closer to the advanced products in the market, or close to the product technology frontier. The production processes they use may also incorporate advanced technology, raising productivity and other competitive performance of their products that are close to the technological frontier. This narrowing of technological gaps constitutes catching up in production capacity/capabilities.

On the other hand, firms may catch up in terms of capabilities to generate and manage change in their technologies, progressing from technology imitation on the basis of minimum essential knowledge level to deeper levels of capability that enable them to undertake modest forms of innovations, closer to, or at the innovation frontier. This kind of technological catching up from OEM-ODM-OBM by increasing the level of their innovative capability, as found in many East Asian firms (Hobday, 1995; Kim, 1997), is termed catching up in innovation capabilities (Bell and Pavitt, 1993, 1995).

These two kinds of capability are commonly closely linked in the process of latecomer's catch up. The accumulation of these innovative capabilities are the efforts that latecomers make to create innovation capabilities. The dynamic learning is the critical player in the accumulation process, operating in a wide range of mechanisms beyond learning-by-doing (Bell and Figueiredo, 2012).

With the examples of East Asian firms in the 1970s and 1980s, which frequently used in-house engineering, design and managerial competence to initiate the production of imported technology, the importance of such capability of learning needed to complement external knowledge acquisition for new-to-the-firm and new-to-the-economy was not fundamentally different from the one for new-to-the-world knowledge creation. And, even after the initiation of production with imported technology, subsequent series of incremental innovations of products, processes and organisational modifications were carried out to open up new markets and introduce lower inputs in production. Thus, in contrast to simplistic notions of 'learning-by-doing', the process of passively acquiring advanced technological packages to initiate production, the activities of complex learning involving the integration of external and internal learning, and the creation of internal knowledge competence, contribute to the firm's catching up after initial production (Bell, 1984; 2009; Bell and Pavitt, 1993). Even after successful catching up in production capability, Martin Bell believed that innovation capabilities are important at further stages of transition, when latecomers are reaching out to the innovation frontier where R&D or technological capability become central to competitive advantage. As they draw closer to the innovation frontier, the competitiveness involves reaching a certain level of efficiency in production and technology, rather than a rate of improvement in production efficiency, which can be normally achieved from experience or cumulative production techniques. In order to achieve competitiveness under a constantly changing state achieved by rates of technical change that surpass, or at least cope with the rates generated by other competitors, accumulating the capabilities to generate both improvements in production and technology from the dynamic form of learning is therefore a necessary condition. In other words, innovation capabilities play a key role in the process of technological learning and aggregation of all the components of innovation capabilities are required for catching up and transitioning from imitation to innovation (Bell, 1984; 2009; Bell and Pavitt, 1995; Bell and Figueiredo, 2012).

In sum, as the more lately advanced Asian economies approach the innovation frontier, the speed and effectiveness of learning is a critical issue, and the learning is considered a key dimension in innovation capabilities building. Accordingly, the studies mentioned above commonly point out the dynamism in the process of learning. This can be seen as a shift in the way of considering the role of knowledge as an input, derived from innovation activities and capabilities, for achieving some level of increasing production capabilities to a distinctive component, that operates within the organisational structure of a firm, for undertaking emerging activities and processes concerned with issues of innovation and competitive advantage. This idea is also in line with the concept of 'dynamic capabilities' that emphasises the importance of coordinating and combining capabilities within the organisation as the core process of developing new and innovative competitive advantage (Teece et al, 1997).

Latecomers' capability building and transition

As discussed so far, Bell and Pavitt (1995)'s innovation capability building and learning framework is very useful in this aspect to understand how latecomers create, renovate and reform learning processes to enable capability building. Their framework has inspired other scholars and influenced their studies to map out the catching up and innovation paths of latecomers in developing countries (e.g. Dutrenit, 2000, 2004; Figueiredo, 2001; Lee and Lim, 1999). The major concern is how innovation capabilities can build up the essential knowledge base that latecomers do not possess and allow latecomers to catch up. Thus, less attention has been put on issues and challenges arising in firms that are undertaking a transitional process towards competing at the innovation frontier.

A small amount of research has addressed this transition process: for example, Hobday, Rush and Bessant, 2004; Dutrenit, 2000, 2004). Hobday et al. (2004) approached the transition process as a strategic and technological leadership issue. On the other hand, Dutrenit (2000, 2004) approached it in terms of the building of core/dynamic capabilities. Drawing on Bell and Pavitt (1995)'s framework, she further integrated the technological and organisational dimensions of innovation capability. The core idea is that as latecomers move from basic to innovation frontier, the relative importance of different kinds of organisational issues may vary with different levels of innovative activities in technological dimensions.

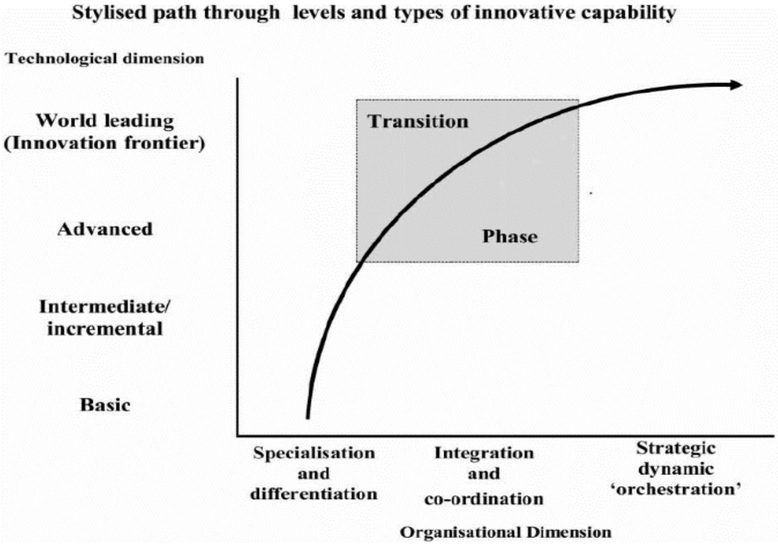

Figure 6. The transition process and types of innovative capability
Source: Dutrenit (2004); Bell and Figueiredo (2012)

As in the figure 6, the associated organisational issues at the initial basic technological stage are organisational specialisation and differentiation. Moving vertically upwards, as firms reach more advanced levels of innovative activity and a transition phase, the main organisational issues are integration and co-ordination.

Dutrenit (2004) points out that the main challenge that latecomers face in the transition process is the imbalance in the levels of knowledge in technological fields and organisational units. In order to accomplish transition, it is argued that strategic capabilities which enable firms to combine simple bases of knowledge located in different units, to build more complex knowledge bases, and to integrate knowledge and coordinate different learning processes in both technology fields and organisational units are essential. If firms successfully move through the transition, they would enter the domain where meta competences and capabilities for orchestrating diversified innovation activities. Deeper levels of knowledge resource bases then become the core of 'dynamic capabilities' (Teece et al., 1997), to create and renovate strategic and sustainable competitive advantage at the turbulently changing innovation frontier.

In sum, the innovation capabilities framework by Bell and Pavitt (1995) and transitioning through capabilities by Dutrenit (2000) provide a strong analytical framework to understand the catching up process in the aspect of capabilities building and accumulation of knowledge base through learning, and the organisational issues when latecomers face a transition phase. Other studies, based on firms in different developing countries such as Brazilian firms (Figueiredo, 2003), a Mexican firm (Dutrenit, 2000), telecommunication firms in four African countries (Marcelle, 2004) and many of Bell's other students and colleagues, provided empirical evidence to support this framework. It is notable that such studies highlight the importance of the increasing levels of integration of different forms of knowledge and capabilities that sourced internally and externally, in different parts of the organisation and capabilities created by different kinds of learning mechanisms. These matters of learning mechanisms have been widely discussed in an area of knowledge management with key contributions in the 1990s by Cohen and Levinthal (1990), Nonaka and Takeuchi (1995) and others, as discussed earlier. Nevertheless, a Korean analysis based on the case of Korean firms, particularly Kim (1997), suggests a different mechanism of learning involving looping a circular sequence of three steps to create a higher knowledge base and innovative capabilities. His model provides strong and wide implications and forms one of the core analytical concepts of the model in this thesis. Thus, it is elaborated upon in the following part of the chapter in order to understand the Korean's answer to the firm level catching up innovation model.

Catching up innovation in Korean analysis

In contrast with the developed countries-based models, innovation models in the context of NICs have not developed further from the model of Kim (1997). He argued that the innovation process in NICs is a reversed process compared to that of firms in developed countries, as firms start from mature technologies by following three stages of implementation, assimilation and improvement.

During the early phase of their development, firms acquire a 'package' of mature technologies and processes from developed economies. As the product, process and its market have been tested and confirmed in advanced economies, firms are required to have the minimum limited engineering and production capability. Once foreign technologies are implemented, technological diffusion occurs within the country. This occurs through local entrepreneurs and technical personnel from existing producers. He found evidence of the high mobility of experienced technical personnel within the country. As a result, the market faces competition from domestic producers who have either acquired a product from the transferral of foreign technology or domestic technological diffusion, but have a similar product. Under this kind of competition, firms diversify their products to satisfy the market needs and obtain an even bigger share of the market. This drives firms to adapt the assimilation strategy of foreign technologies.

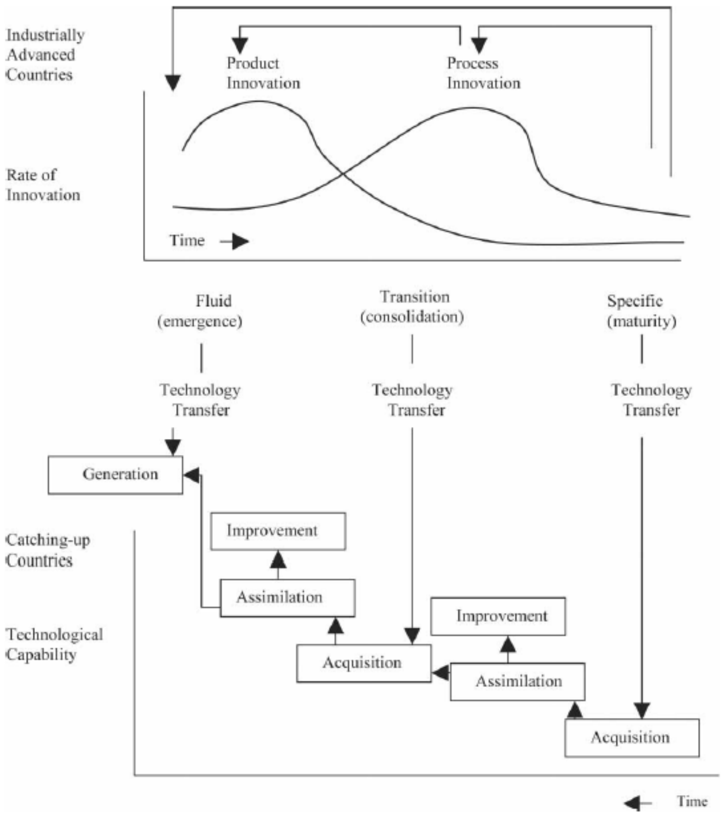

Figure 7. The reversed PLC three stages catching-up model
Source: Kim (1997) and Lee et al. (1988)

In the assimilation phase, they acquire the internal capability of product design technologies and process developments in order to undertake engineering and limited development (E&D) so as to reduce the production costs or develop differentiated products by imitating foreign products. Local technical personnel, who are trained at the technology supplier during the first phase, are key in developing internal capability. In other words, the key tasks in this stage are assimilating foreign technology and diversifying their products through internal E&D in order to cope with increasing market competition.

After successful assimilation, firms face more pressure in both the local and international market that forces them to enhance their competitiveness. Together with their increased internal capability, they gradually improve their own R&D capability, not only for the imported technology, but also for their own novel technology. This generally provides a basis for technological development and the production process without any external influence.

To summarise these three stages of the model by Kim (1997), NIC's catching-up process is reversed, as it starts from the acquiring of mature foreign technologies. Firms then absorb the transferred technology and improve their internal process of development capability with local technical personnel. More pressure from local and international competition leads them to gradually improve their R&D capability for product and process innovation.

Lee, Bae and Choi (1988) extended Kim's idea by linking the stages with Utterback and Abernathy's process and product innovation model, as shown by figure 7. Their model is similar to Kim's model in that they argue that the firms follow three stages –

initiation stage, internationalisation stage and generation stage – at both industry and firm level.

In the early phase of the initiation stage, the mature technologies are acquired from developed countries through formal channels. They noted that heavy industries in particular, such as steel and petro-chemicals, rely on exploiting formal channels, as these large-scale and complex facilities are difficult to imitate. Firms without the resources or managerial capability to employ formal channels stay with a low quality or low-price strategy, or alternatively may develop high technology through their in-house R&D.

New products are produced in the internationalisation stage and existing products are also radically improved through internal R&D. As firms at this stage have successfully assimilated manufacturing and operations technologies, and acquired a low-level design capability, they focus on developing higher-level design technology. Thus, the key to this second stage is internal R&D capability building. This indigenous internal R&D capability allows them to produce their own products and become less dependent on external technologies for product and process development.

Firms who have successfully completed the previous stages and built their own internal R&D capability arrive at the generation stage where they can produce their own products and possess a high level of R&D capability so as to compete against developed countries.

In summary, firms in NICs imitate or acquire foreign technologies and products that allow them to start manufacturing immediately. After they assimilate and manage to master those manufacturing operations, they focus on developing a higher level of technologies for new products and a process for existing products. Thus, the rate of product innovation is relatively high and the rate of process innovation relatively low in the early phase. In the later stages, the rate of radical product innovation becomes lower while the rate of incremental process innovation becomes higher as firms fix on a specific and mature product design (Hobday, 2005).

The critical assessment of the innovation models

Both the models from Kim (1997) and Lee et al. (1988) provide fundamental insights into how the catch-up innovation process is different from that of developed countries. Other researchers have confirmed this reversed pattern of the catching-up process in NICs. For instance, Hobday (1995, 1998) studied the theme in electronics in Korea and Taiwan; Hobday, Rush and Bessant (2004) studied the latecomers' transition phase from catching up to leadership with 25 cases in different industries in Korea. Many Korean scholars have also contributed to this theme with studies of Korean firms, including case studies of a Korean semi-conductor by Y. Choi, 1996.

It can be clearly seen that innovation literature in the context of developed countries and developing countries show bi-polar research streams. The developed countries models have been developed from the linear to the latest network perspectives. The focus of each generation has also been moved from a simple economic perspective to a more complex managerial perspective. This ranges from the technology push or demand pull model, to the recent Chesbrough (2003) and Chesbrough and Bogers (2006)'s definition, which highlights the commercialisation of technology into products and the management of knowledge and R&D that affects business models and systems. Along with the definitions, the theoretical framework of the firm supporting these models has also been developed and revised in the transaction cost, resource-based view, knowledge-based view and, more recently, the dynamic capability view.

However, developing countries models have not made remarkable progress since Kim (1980) and Lee et al. (1988). There are clear constraints that apply to their models of the modern business environment and academic management research. One of the main problems is that it is inappropriate to follow the linear process under the modern dynamic environment. Despite the fact that they provide a useful role model for other latecomers to follow, this process does not pilot a way of dealing with a new business model or innovation as a strategy. The cases in previous literature prove that there is a unique pattern to catching-up innovation in developing countries, but they do not consider what the driving factors are in terms of the innovation strategy and management during the catching-up process, as they are 'high-level' studies. Hobday (2005) pointed out a similar concern that "innovation is more than likely to be embedded within other major business processes and guided by the strategic management of the firm… [innovation] also likely to be heavily influenced by the culture of the firm …" (p.134-5). He also gave learning or static organisations as an example of the culture. Furthermore, from his point of view, existing innovation models are high-level studies and innovation should be approached in a heterogeneous manner. A firm level approach is then required to identify the catching-up innovation dimensions of the strategy, organisation and management areas.

If innovation research in the context of developing countries is stagnant and NIC's innovation activity is different, it is crucial to find a new approach with different theoretical perspectives. A few NIC-based innovation researches have attempted to apply a network and open innovation paradigm to catch up with mainstream research in the context of developed countries. For instance, Lee et al. (2010) proposed an intermediated network model in the context of Korean SMEs, while Kang and Kang (2009) analysed the degree of open innovation and knowledge sourcing methods in Korea. Although these pieces of research show some degree of analogous evidence to mainstream research, specifically the recent dominant theme of open innovation, their cases are SME specific or industry specific – mostly the IT industry, where external interactions are very often emphasised. As they have applied mainstream theories to NICs, they are intentionally based on the resource-based view of the firm, which is discussed in-depth later. This view provides a useful theoretical base for the innovation theory in the context of developed countries as firms face market conditions, strategic positions, innovation paths and processes that are shaped by history. On the contrary, firms in developing countries have different market conditions, specifically the newly evolving markets, and other many different innovation factors. In a very strict way, the resource-based view is inappropriate because they acquire technology from external/foreign sources in the beginning of the catch-up process. This research believes that a new perspective can be constructed by critically problematising the existing theories of Sandberg and Alvesson (2010).

Problematization of the existing models – the weaknesses of the models

From the literature review of the innovation and NIC-based models, it was noted that the fundamental root of the NIC innovation research departed from a rigid dichotomy between the innovation leader and follower. This narrow dimension implies that there are three critical limitations of the analysis and theoretical framework that have been used for the catching-up innovation process in the existing literature.

First, it is important to examine the definitions of the innovation leader and follower. According to Porter's competitive advantage and contingency theory, the innovation leader can be defined as someone who, or something which, stands along the technological frontier and creates a new kind of product or service through innovation activities. In contrast, the innovation follower runs from behind the frontier, observes and passively follows the technological trajectory that is set by the leader. Under this definition, the context of the technological catching-up innovation process is narrowly limited to the innovation activity that is undertaken to reduce the gap between the leader and follower. The context of this innovation activity is also precisely limited to the follower strategy by imitating or learning from the leader or advanced technologies and products. Thus, the Korean catching-up models in existing literature only focus on the analysis of incremental innovations through the process of the accumulation of external knowledge. It might be seen as having been correct before the 21th century, or until recently to some extent, that latecomers should focus on incremental innovations to follow a given contingency, the technological trajectory, and facilitate the learning process to absorb externally acquired knowledge. Whilst both Kim (1997) and Lee et al. (1988) briefly explained the organisational structure and process for learning, the ‘dynamic learning’ by Bell (1984) and Katz (2001), (e.g. joint venture or technological agreements with the U.S. or Japan), they barely considered the role of the firm’s capabilities in the catching-up process. It is clearly argued in their models that internal R&D capabilities (and external to some extent, such as foreign subsidiaries) are developed to carry on incremental innovation for existing products or manufacturing/production processes and radical innovation for the design of new products. However, they did not explain how those two capabilities can be built through the process and how it affects the organisational development in a more competitive and rapidly changing environment after they have achieved some degree of catching up. There is also a lack of clarification of the internal, external, technological and R&D capabilities in their models, and the exploration and exploitation of firm-level capabilities. For instance, it is not clear how firms set their innovation strategy, R&D structure and capability to explore innovation or catching up opportunities, and how they exploit technological opportunities during the catch up.

Second, the existing models also neglect to explain the latecomer’s approach to the innovation frontier. They do not take into account innovation activity after successfully catching up. Rather they suggest that latecomers repeat the same strategy, if there is a piece of advanced technology that has been invented by other competitors. Later, this lack of consideration drew out a piece of research into how latecomers react when they reach a more advanced technological stage. Hobday, Rush and Bessant (2004) argue that latecomers who successfully achieve catch up through assimilation face the transition phase to leadership. Their important findings suggest that as increasing numbers of Korean firms become technologically advanced, they face 'the innovation dilemma'. This dilemma occurs when they recognise that the catch-up model, that has served them well in the past, is no longer appropriate for them to pursue. The cases in Hobday et al. (2004) revealed that Korean firms are caught in the middle between mass production of existing low cost, low price and high-quality products, and new product creation that is higher in price, is design intensive and involves complex products and systems (CoPS). Some of the firms preferred to stay one step back behind the frontier to cope with the existing strategy of 'copy and improve' in the hope that the international markets for low cost, high technology products would continue to expand. Others, especially chaebols[2], which normally possess a degree of power in both finance and resources, followed a portfolio strategy with differentiated innovation approaches that depended on the development stage of each product (Hobday et al., 2004).

This finding provides an explanation as to why successful latecomers still lag behind the leaders and the frontier. However, in practice, successful latecomers face a more challenging environment that forces them to abandon low cost and low-price strategy,

[2] A chaebol is a large conglomerate that is run and controlled by an owner or family in South Korea. A chaebol group often consists of a large number of diversified affiliates in different indsutries.

as they cannot compete against new entrants who offer lower costs and a cheaper price. For instance, the smartphone industry has become more competitive because of the entry of Chinese manufacturers. The low capital goods and low complex products industry in Korea have almost collapsed as Korean firms cannot compete against producers from foreign countries, such as East Asia, where the cost of production is significantly lower. Within this more competitive and dynamic environment, firms are aware of the importance of producing more complex and higher priced products in the mainstream and upper market. The findings from the case studies of this thesis have revealed that successful latecomers develop a new complex, highly technological product through radical innovations. Furthermore, the radical innovation that brings a whole new product to the world and pushes the frontier further rarely happens in reality. Rather, firms switch their mode between exploration and exploitation, and radical and incremental innovation, depending on the innovation opportunity they face. An innovation opportunity is also a factor of a dynamic environment. Therefore, using this logic, it can be argued that a latecomer's dynamic capabilities are important if they are to switch from incremental to radical innovation, the leader to follower strategy, or *vice versa*. This argument is discussed in the next chapter.

Third, the attention of the NIC innovation models is narrowly focused on the successful commercialisation of assimilated technology. From this narrow perspective, the innovation activities of latecomers are interpreted as being a necessary product or process development of a specific product or service. However, even in mainstream innovation research, there is another approach. This is that innovations not only provide a new way of bringing about product and process developments and improvements, but also provide new changes to business models, organisational structures, organisational routines and systems. In the scenario where a firm is ‘stuck in the middle’, and it has to make a decision between striving to become a leader or staying as a passive follower, then radical or incremental innovations must be carried out, depending on the choice. Accordingly, the business model, organisational structure, routine, R&D system and capability must fit the choice. This is where there are limitations in the existing models’ ability to explain how firms develop their capabilities to adapt to a new environment.

Chapter Summary

This chapter has reviewed three main aspects of the literature addressing the key theories, concepts and models of innovation. First, a generic review of innovation was presented. The long history of the innovation field has inspired different disciplines, perspectives and approaches within the area. At a national level, the concept of the systems of innovation provides a strong framework to understand the effect of technological innovation on the economic growth of nations and the role of governing the state and policy. NSI’s core concepts and frameworks have been extended and applied to organisational level innovation studies. After reviewing the broader picture of innovation, four innovation subjects were introduced and discussed. Innovation in organisational learning and knowledge management improves understanding of how firms are able to accumulate technological knowledge through the learning process.

The key idea in this area is that learning is a routinised and continuous process. Innovation or technological R&D do not only create technological artefacts, but also generate firm specific capabilities. These capabilities can be employed to undertake technological developments through a combination of internal or external searching and exploitation. They also create new routines by 'learning-by-doing' which benefits firms by increasing their productivity.

Second, the innovation review is linked with organisational strategy. Two important concepts in this area were introduced: competitive advantage and contingency theory. Competitive advantage is helpful in developing an understanding of how firms stay competitive in the market and use technological advances to set an appropriate strategy to deal with a changing environment. The contingency theory offers a good explanation of the relationship between the environmental change caused by any given contingency (complexity and uncertainty) and the firm's strategy. These ideas of environmental change and strategy provide a solid theoretical framework for the analysis of this thesis' case findings. In product and process management, innovation is viewed as two distinguished processes: product development and process development. The product lifecycle model by Utterback and Abernathy (1974) explains the dynamic shift of the rate of product innovation and process innovation, according to the life stage of a product. This model was applied as the theoretical foundation for Kim's (1997) reversed stages of the NIC innovation model.

Third, innovation in project management was reviewed. Innovation in project management is distinct from other subject areas due to the unique characteristics of each project. Project-based innovation has three essential features. Project production ranges widely from a very unique and highly customised project that creates and delivers an innovative product and services, to a standardised project that normally proceeds through existing routines and processes. Project-based development refers to R&D and commercial product development across all of the stages and systems of production. Breakthrough projects – vanguard projects in Davies and Brady's (2016) terminology – support disruptive innovation that generates a whole new non-routinised production system and process. The concept of dynamic project capabilities, introduced by Davies and Brady (2004), suggests a fruitful insight into how project firms can create a balance between innovation and routinised activities in complex projects that contain various uncertain and changing environmental conditions. This concept has been applied as a critical theoretical foundation in this thesis in the analysis of the case study firm in construction.

Various approaches and perspectives, as well as innovation models in the context of developed countries and developing countries were introduced and discussed after the review of theoretical concepts. Mainstream innovation research has been developing from the linear push kind to a network model, called the open innovation. In contrast, the developing countries model is a linear catching-up innovation that latecomers use to initiate their initial production by acquiring both external technology and product as a whole package. As the business cycle and product cycle of an acquisition becomes mature, they undertake innovations to improve the technology and product to meet the needs of the market in which they perform. However, the limited analysis of the implications of the latecomer's catch-up model that restricted it to the process of 'from imitation to improvement', calls for a new approach and perspective as has been discussed in-depth in this chapter. The concerns and arguments were drawn from the reassessment of the latecomer's model. In the next chapter, new relevant perspectives will be introduced and discussed. By applying them as a theoretical foundation, a conceptual framework will be both developed and introduced.

Chapter 3

Towards a new NIC innovation model

As mentioned in the previous chapter, it is doubtful whether the fundamental theoretical lenses of conventional innovation theories can be applied to the context of NICs. Thus, a rigorous review of the fundamental theoretical lens is required due to the following unique features of NICs. First, latecomer firms are able to catch up the technological gap without building internal competencies and employing internal resources as they can rely on the import of external technologies. Second, the dynamic Schumpeterian market condition rarely exists, as they use low-cost production to break into externally proven existing markets. Therefore, their strategic competitive advantages come from the low end of the market. Considering these features, a resource-based view is not appropriate to NIC innovation theories. This research argues that the dynamic capability view of the firm is a more appropriate approach to examine the dynamics of latecomer innovation. A further important theoretical foundation discussed in this chapter is disruptive innovation. Bred by Christensen's (1997) original theory of disruptive technologies, disruptive innovation has been used to explain all kinds of disruptive phenomena. It appears that the wide usage of the term causes misunderstanding of what constitutes disruption and disruptive innovation. This chapter provides a review of the theory and reformulates the idea in the application of a NIC innovation setting.

Based upon the evaluation of the theoretical perspectives, a new conceptual NIC innovation model is presented.

3.1 Dynamic capabilities of the firm and ambidexterity

Before considering the theoretical perspectives of dynamic capabilities, it is important to re-examine the resource-based view, in which the majority of research on dynamic capabilities is grounded. The resource-based view of the firm has been a dominant perspective in strategic management literature. Accordingly, it has been debated and extended widely from Barney's original idea. His basic framework has two fundamental assumptions. First, resources are heterogeneous and distributed across the firm, and second, these resources cannot be transferred to others without cost. Thus, a competitive advantage comes from a firm's idiosyncratic and uniquely valuable sets of assets that are inimitable (Barney, 1991; Priem and Butler, 2001; Teece, Pisano and Shuen, 1997). In terms of their technological capability, a firm's competitive advantage derives from its technological capability and resources, which are a set of tangible and intangible assets that satisfy the argument of the resource-based view. Thus, in order to obtain and maintain its competitive advantage, a firm needs to acquire technological capabilities that enable the exploitation of internal resources and ensure that competencies can lead the product and process improvement.

Dynamic capabilities refer to the strategic innovation process of integrating and reconfiguring a firm's internal and external resources, competences and routines that are used to adapt to rapidly evolving and changing environments. Dynamic capabilities fall into two main perspectives: the resource-based view approach (Teece et al., 1997, Eisenhardt and Martin, 2000) and the evolutionary theory (Helfat and Peteraf, 2003, Zollo and Winter 2002).

The majority of the resource-based view perspective-based research on dynamic capabilities has been inspired by Teece et al. (1997) and Eisenhardt and Martin (2000) who extended the idea in order to explain how strategy could be employed to deal with dynamically changing environments. As its roots are grounded in the resource-based view, the dynamic capabilities view of strategy is related to the resource-based view, however, it places emphasis on learning, patterns of repetitions and innovation that are embodied in strategic processes and routines (Davies, Dodgson and Gann, 2016). The first stream, inspired by Teece et al. (1997), focuses on technology, firm strategy and performance. The concept of dynamic capabilities from this perspective observes rapidly changing environments, and analyses how firms adapt, integrate and reconfigure their internal and external resources in order to compete. Recently, Teece (2007, 2010) stated that dynamic capabilities depend on the cognitive ability to recognise, adopt and reconfigure assets and competencies according to changes in the environment.

The second stream is inspired by the work of Eisenhardt and Martin (2000) that explains dynamic capabilities in terms of the organisational design and contingency theory. They argue that there are two types of dynamic capabilities, depending on the degree of change and uncertainty in the market environments. Under stable and moderately dynamic conditions, dynamic capabilities are based on tacit knowledge, experience and internal organisational routines that are established over years and which are employed to deal with changing but predictable conditions. In high-velocity conditions that change the environment rapidly and that continuously evolve, dynamic capabilities are based on simple routines, organisational disciplines, real-time learning and improvisation in order to deal with unpredictable, rapidly shifting changes (Eisenhadt and Martin, 2000).

Another perspective on dynamic capabilities is associated with evolutionary theory and emphasises learning and adaptation in a changing environment (Nelson and Winter, 1982). According to Helfat and Peteraf (2003), capabilities can be distinguished as either 'operational' or 'dynamic'. Following Nelson and Winter's (1982) 'dual-routines' framework, dynamic capabilities are higher order routines that can be employed to modify or create new lower order operational capabilities (Helfat and Peteraf, 2003, Zollo and Winter, 2002). Organisational resource is "an assets or inputs to production that an organisation owns, controls or has access to on a semi-permanent basis" and operational capability is "the ability of an organisation to perform a coordinated set of tasks, utilizing organisational resources, for the purpose of achieving a particular end result – [producing and selling products or services]" (Helfat and Peteraf, 2003: p. 999). Thus, the key to the theory is the high-level management of routinised repetitive activities that use a collection of organisational routines to create innovation by creating, modifying or recombining lower level operational capabilities (Helfat and Peteraf, 2003, Zollo and Winter, 2002, Winter, 2003, Davies et al, 2016, Davies and Brady, 2016). In other words, dynamic capabilities allow firms to adapt by managing their existing operational capabilities and resources in keeping with the rapidly changing environment.

Thus far, it has been argued that dynamic capabilities are essential for firms' survival. But, one might raise the question of what conditions comprise the rapidly changing environment or which degree of velocity refers to the dynamic environment. The term environmental velocity was introduced by Bourgeois and Eisenhardt (1988). They described high-velocity environments as situations "in which there is rapid and discontinuous change in demand, competitors, technology and/or regulation, such that information is often inaccurate, unavailable, or obsolete" (p. 816). They further explained the definition, "in high velocity environments, there is continuous "dynamism" (Dess and Beard 1984), or "volatility" (Bourgeois 1985), but these are overlaid by sharp and discontinuous change (Meyer 1982; Sutton et al. 1986). Using this definition, microcomputers, airlines, and banking are high velocity industries. In contrast, although they score high on dynamism and volatility indices (Dess and Beard 1984; Bourgeois 1985), "cyclical industries such as forest products and machine tools are not" (Eisenhardt and Bourgeois, 1988: p.738). Their definition implies that environmental velocity consists of changes in terms of rate and direction, in multiple dimensions of demand, competition, technology and regulation.

However, existing research tends to lack explicit measurements or justifiable indicators for the categorisation and determination of the velocity of specific industries - the rate and direction of change. McCarthy et al. (2010) expressed a similar concern that variations and exceptions in the understanding of velocity has resulted in some counterintuitive and inconsistent categorisations of industry velocity. Most available studies used illustrative statistics and examples as the measures of velocity. The table 4 by McCarthy et al. (2010), shows example studies that have environmental velocity at the centre of their research.

Example studies	**Management/ Organisational phenomena**	**Level of velocity (Industry context)**	**Conceptualization of velocity**	**Velocity measures used**
Bourgeois & Eisenhardt (1988)	Pace and style of strategic decision making	High (Microcomputer industry)	Uniform change in the rate and direction of demand, competition, technology and regulation	Illustrative statistics and examples
Eisenhardt & Tabrizi (1995)	Rapid organizational adaptation and fast product innovation	High (Computer)	As per Bourgeois & Eisenhardt (1988)	Illustrative statistics and examples
Davis & Shirato (2007)	A firm's propensity to launch WTO actions	High (Computer), medium (Auto), and low (Steel)	The number of product lines and the rate of product turnover	R&D expenditure/ total revenue
Nadkarni & Barr (2008)	How velocity affects managerial cognition, which in turn affects the relationship between industry context and strategic action	High (semiconductor, cosmetic) and low (aircraft, petrochemical)	As per Bourgeois & Eisenhardt (1988)	A review of existing literature and matching using industry attributes

Table 4. Environmental velocity in example studies

Source: McCarthy et al., 2010

For instance, Eisenhardt and Tabrizi (1995) studied the computer industry as it has short product life cycles, intense and international competition and an evolving scientific base. Davis and Shirato (2007) identified the computer industry as high, the automobile industry as medium, and the steel industry as low velocity industries.

While acknowledging the lack of empirical and numerical measurement models, environmental velocity in this thesis mainly follows the original idea of Bourgeois and Eisenhardt (1988) with the industry contexts of the cases studied in this thesis and their attributes taken into consideration. Bourgeois and Eisenhardt (1998) suggested that the direction of change is related to the degree of continuity-discontinuity. Continuous change refers to an extension of past development (e.g. memory size of the chips in of a semi-conductor), whereas discontinuous change refers to a shift in direction (the shift from floppy disk to usb/cloud storage). Thus, discontinuities can be represented by radical shifting points in the trajectories that describe velocity in technology, product and market demand dimensions over time. McCarthy et al. (2010) defined each of these dimensions. Technological velocity refers to “the rate and direction of change in the production processes and component technologies that underlie a specific industrial context” (p. 609); product velocity refers to “the rate and direction of change in new product introductions and product enhancements” (p. 610); demand velocity refers to “the rate and direction of change of the willingness and ability of the market to pay for goods or services, including changes in the number and types of transactions and market segments” (p.610).

Though detailed discussion is presented in Chapter 6, these definitions and the literature advise defining the environmental velocity of the cases in this thesis as follows: 1) semi-conductor (computer) industry has high velocity; 2) automotive steel industry has medium-high velocity; and 3) construction industry has low velocity.

The idea of dynamic capabilities in a dynamic environment, however, has faced criticism that it cannot be a sustainable source of competitive advantage, as market conditions and environments change so rapidly. Generally, valuable capabilities at any given time may no longer be valuable in future when the environment changes (Eisenhardt and Martin, 2000). O'Reilly and Tushman (2008) argue that ambidexterity is the answer to how firms can survive in the face of environmental shifts. The core of their idea is that a firm should be able to maintain its routinised operations whilst exploring breakthrough innovations that alter the structure and capability at the pace of environmental change. Thus, they argue that ambidexterity is also a form of dynamic capability that facilitates a way of manipulating resources in order to gain a new competitive advantage through 'exploitation and exploration', the terms that were originally used by March (1991).

In studies of organisational learning, the problem of balancing exploration and exploitation is in regard to the distinctions between refinement of an existing technology and invention of a new one (March, 1991). The dilemma of exploration of new developments is that it reduces the resource allocation available for the improvement of existing ones, and that improvements in existing competence make new experimentation less attractive (Levitt and March, 1988). In evolutionary organisational studies, this matter is framed in terms of balancing between variation and selection. Effective selection of the most appropriate form, routine or practice is crucial for firms to survive, but also for the generation of new practices to cope with a changing environment. Because of the links amongst environmental turbulence, organisational diversity and competence and competitive advantage, organisational issues are sensitive to the relation between the rate of exploratory variation and the rate of change in the environment, and the selective efficiency. March (1991) argued that learning, analysis, imitation, regeneration and technological change are the components of any effort or input to improve organisational performance and generate competitive advantage. Each involves a trade-off between exploration and exploitation. Exploitation, the refinement and improvements of existing competences and technologies, promises positive, proximate and predictable returns. On the other hand, exploration, the experimentation with new alternatives, does not promise those as its returns are uncertain, distant and possibly negative. Thus, it seems conventionally rational to choose exploitation over exploration to increase the reliability of performance, due to the increased risk from uncertainty of exploration. However, he argued that this could lead to self-destructive and degrading organisational learning. The best scenario in the model is the balancing of choices between exploration and exploitation choices – in his terms, ensuring 'current viability' and 'future viability' - for a firm's long-term survival (March, 1991: p. 105).

Echoing the March's idea, scholars in the strategic management domain have been focusing on how firms can achieve long-term success by possessing the operational capabilities and competencies to survive in existing markets, but also the capability for recombination and reconfiguration of organisational structures and assets to adapt to new markets and technologies (Teece, 2006; Teece et al., 1997; Benner and Tushman, 2003). This idea is at the core of the concept of dynamic capabilities.

By building on their dynamic capabilities, O'Reilly and Tushman (2008) extended the terminology of capabilities and competencies and extended the idea from the strategic perspective in organisational terms. They argue that dynamic capabilities are the critical key for a business to be ambidextrous – to compete simultaneously in both existing and new markets, to simultaneously explore and exploit. "[In order to achieve long-term success] firms are required to possess not only the operational capabilities and competencies to compete in existing markets, but also the ability to recombine and reconfigure assets and organisational structures to adapt to emerging markets and technologies" (O'Reilly and Tushman, 2008: p.189). This implies that firms have to possess the ability to both exploit and explore in order to succeed in both the short-term and long-term. The key success factors of exploitation are efficiency, discipline, incremental improvement and continuous innovation. On the other hand, the key success factors of exploration are autonomy, flexibility, risk taking, radical innovation and less formal systems and control (Tushman and O'Reilly, 1997; O'Reilly and Tushman, 2008). This is consistent with Teece's sensing, seizing and reconfiguring in dynamic capabilities (Teece, 2007), and they argue that "ambidexterity requires a coherent alignment of competencies, structures and cultures to engage in exploration, a contrasting congruent alignment focused on exploitation, and a senior leadership team with the cognitive and behavioural flexibility to establish and nurture both" (O'Reilly and Tushman, 2008: p.190). In this sense, firms which develop the dynamic capability for organisational ambidexterity are able to achieve the exploration of radical innovations that are needed develop new technologies or create new markets beyond the existing customer base, whilst making incremental improvements in their existing technologies, products and markets.

It is important to bear in mind that the definition of ambidexterity of O'Reilly and Tushman (1996) is different from the original term by Duncan (1976). In Duncan's view, ambidexterity occurs temporally and sequentially, not simultaneously, as organisations switch structures as innovations evolve – as 'the trade-offs'. Tushman and O'Reilly (1996) are sceptical about temporal sequencing, arguing that it only happens when the rate of change in markets and technologies proceeds at a moderate enough pace that allows firms to make choices of alignments accordingly. Alternatively, they suggest firms are required to pursue exploitation and exploration simultaneously due to the complexity and rapid pace of change, and the time needed to develop new products and services (O'Reilly and Tushman, 2008). This type of ambidexterity is latterly labelled as simultaneous or structural ambidexterity (O'Reilly and Tushman, 2013). Throughout this thesis, ambidexterity refers to this idea of simultaneous or dynamic ambidexterity. In this conceptualisation, O'Reilly and Tushman (2008) suggest the ideal structure of ambidextrous organisations would be to spin out a sub-unit or set up another separate organisation for exploitation and exploration. Christensen and Bower (1996) agree that firms must create a separate unit for the exploratory business that will serve a new set of customers.

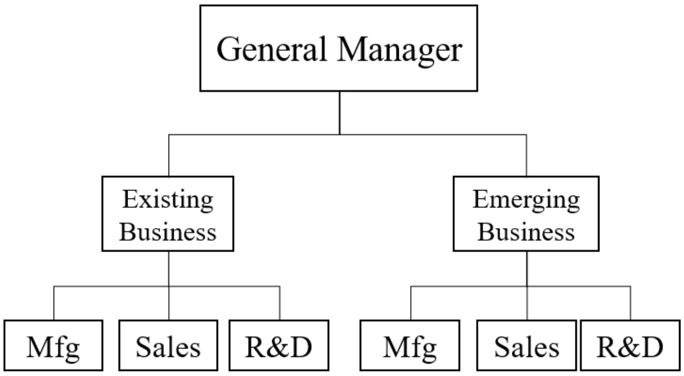

Figure 8. An example of an ambidextrous organisational structure
Source: O'Reilly and Tushman, (2008)

New exploratory units that have been set up for radical innovations from traditional exploitative units create their own appropriate structures, processes and cultures, but are integrated into an existing management hierarchy. Figure 8 shows a sample and the basic structure of a successful ambidextrous organisation.

In summary, dynamic capabilities provide a theoretical perspective that facilitates an understanding of how firms operate in a rapidly changing environment by knowing how and when to adjust their structures and capabilities. Organisational ambidexterity suggests that dynamic capabilities are critical if firms are to exploit their current routines, whilst also exploring new opportunities. This concept is the most important idea in developing a conceptual model in this thesis. An additional significant concept in the next part of this chapter is disruptive innovation. It offers the potential to understand how market latecomers operate, focus and plan to move once they have reduced the technological gap successfully.

3.2 Disruptive innovation – where do latecomers belong in the market?

Christensen (1997) explored how disruptive technologies promote new entrants and compete successfully with incumbents that seemingly possess superior technologies. A clear distinction is made between sustaining and disruptive technologies. The former fosters the improvement of existing products' performance, along the market need and technological trajectories that are formed by mainstream customers in most valued market segments, whilst the latter enables new markets to emerge. A product developed from disruptive technology brings a very different or new value to markets and customers, whilst a product from sustainable technology serves the existing market by providing an accurate analysis and understanding of customer needs. Thus, disruption occurs when entrepreneurs invest in high-risk disruptive technologies which existing customers may not demand but promise to open up new and growing markets or segments for an entirely new base of customers (Christensen, 1997).

There are two conditions required for disruption to occur. First, there is a rate of improvement that customers can utilise or absorb, such as the automobile where the performance of new and improved engines cannot be experienced by customers due to constraining factors such as traffic, speed limits and safety issues. Second, the pace of technological progress always outstrips the ability of customers' usage, as innovating companies keep striving to make new or improved products that they can sell for higher profit margins to customers who are not yet satisfied with the current available products in market. An example is the processor chip inside personal computers. Compared to those in the 1980s, today's processors offer much faster speed than mainstream customers can utilise for most purposes of PC usage.

With this concept of disruptive technology, Christensen (1997) has made a critical contribution to the strategic management literature. However, his theory also suffers from an ambiguous definition of disruption. His categorisation of sustaining and disruptive technology has a lack of common criteria for the classification of different types of technologies. For instance, he provided the internet as an example with different industries and types of firms (e.g. Christensen, 1997; Christensen and Raynor, 2003; Christensen et al., 2015). His explanations of those examples are problematic. The internet is disruptive to some but sustaining to other firms, depending on whether it is consistent with incumbents' business models. In the case of Dell, the internet was a sustaining technology as it improved Dell's existing core business of selling PCs. On the other hand, Amazon.com is a disruption to traditional bookstores as it re-defined the business model. In later work, Christensen (2005) acknowledged this anomaly and attempted to solve this ambiguity through improved categorisation. Yet, Christensen and other academic researchers have not made clear-cut criteria despite a discussion in the special issue in *the Journal of Product Innovation Management*, 2006.

In a very strict definition in Christensen (1997), disruptive technology is mostly related to radical product innovations as disruption only occurs when a new, never-existed-before type of product is introduced to the market, and serves the low end segment. However, this original theory cannot explain disruptions by technologies and innovations developed in incremental innovations. This anomaly in the definition calls for a careful set up of the boundaries of definition of disruptive innovation. As Bell (2009) classified, there are three types of innovations: new to the world, new to the market and new to the firm. If, disruption only refers to the new to the world type of innovation, the meaning and usage of the concept in practice is very limited. For instance, the media and press routinely cite Tesla Motors as an example of disruptive innovation. However, Christensen et al. (2015) and Bartman (2015) concluded that Tesla Motors does not genuinely fit to the theory of disruption because the products of Tesla did not create a new market – indeed, it offered products that have an incrementally better performance at a higher price. Tesla and its products can be seen as an example of sustaining innovation that offered a high end and high margin product to the market by carrying a radical innovation to the firm through incremental innovations by the accumulation of existing technologies. An additional example from Christensen et al. (2015) is Uber. They noted that “it is difficult to claim that the company [Uber] found a low-end opportunity: that would have meant taxi service providers had overshot the needs of a material number of customers by making cabs too plentiful, too easy to use, and too clean. Neither did Uber primarily target non-consumers - people who found the existing alternatives so expensive or inconvenient that they took public transit or drove themselves instead … Uber’s customers were generally people already in the habit of hiring rides” (Christensen et al., 2015: p.5). However, they continued, in terms of the limousine or “UberBLACK” option that provides more luxurious cars, Uber is more likely to be on a disruptive path as this offering appeals to the low end of the luxurious taxi or limousine service market. As these examples show themselves, the confusion of the definition from the strict conditions to be a disruption has exposed the theory to criticism.

Even though Christensen (2005) acknowledges the anomaly of his theory and explains the importance of refining the theory around anomalies, the narrow definition of disruption brings further criticism. Markides (2006) also noted a similar concern that the original concept cannot explain all kinds of disruptive or technologies innovations as different kinds of innovations bring different competitive effects, so they should be treated as distinct phenomena. In the context of NICs, Christensen's (1997) original idea of disruptive technologies is less applicable because latecomers in NICs typically start by acquiring technologies which are sustaining for incumbents and improve them through their business growth cycle. Recalling the definition of innovation in this thesis, inspired by Van de Ven's (1986) and Bell's (2009)[3], this thesis argues that disruptive innovation in NICs context may not be about a completely new technology that opens up a new market. Rather disruption is more about challenging the incumbents and the present market order by introducing a new business form or approach to the firm. Disruption does not necessarily have to form radical product innovations, but could be incremental product or process innovations, no matter it completely opens up a new market or not. If any innovation activity is able to bring a

[3] Van de Ven's (1986) and Bell's (2009) definition of innovation mentioned earlier in page 13-14.

creation of products and services that is power enough to revamp the market, and a change in a business form or approach to a firm, that can be defined as a disruption.

In more recent works, Christensen and Raynor (2003) and Christensen et al., (2015) widened the application of the term to include not only technologies but also a broad range of innovations such as products, business models, markets. It seems that Christensen (1997) did not fully elaborate the differentiation of low-end disruptors and new-market disruptors in his original book, later he clearly distinguished those two market footholds. Low-end disruptors come into the bottom of the market and operate within an existing value network before moving upmarket (his example is mini steel mill companies move up towards integrated steel mills). New market disruptors create new value network and generate an entirely new market by appealing to under-looked customers (Christensen and Raynor, 2003 and Christensen et al., 2015).

Based on the wider definition made in this thesis, how disruptive innovation happens in the NICs can be understood by following Christensen's (2005) three approaches in terms of use of disruptive business model innovation to creating new growth business. He suggests three strategies that firms might pursue in table 5. It compares the targeted product performance or features, the targeted customers or markets (and segments), and the business models that each disruption entails. In the low-end market disruption context, disruption is re-defined as a process where a company with fewer resources challenges incumbents by successfully targeting overlooked segments of the market. Entrants then move upmarket by delivering the performance that mainstream customers demand while maintaining the advantages of their early success.

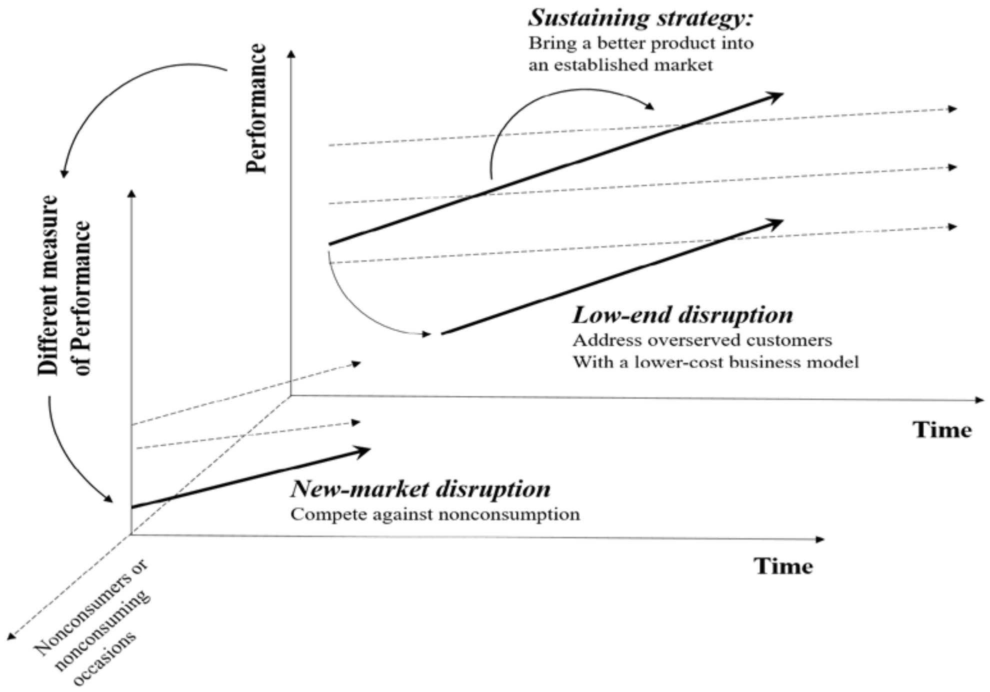

Figure 9. Disruptive innovation

Source: Christensen and Raynor (2003)

Disruption has emerged when the entrants offer products or services in volume to satisfy customers in the mainstream market (Christensen et al., 2015). He also clarified two conditions of disruptive innovation; it has to originate in low-end or new market footholds; it does not appeal to mainstream customers until its quality can match their standards. The first condition explains why incumbents normally focus on the most profitable and demanding customers rather than the less demanding customers. To put it simply, the incumbents' offerings provide excessive performance rather than meeting the needs of low-end customers.

Dimension	Sustaining innovations	Low-end disruptions	New-market disruptions
Targeted performance of the product or service	Performance improvement in attributes most valued by the industry's most demanding customers. Incremental or breakthrough.	Performance that is good enough along the traditional metrics of performance at the low end of the mainstream market.	Lower performance in traditional attributes, but improved performance in new attributes.
Targeted customers or market application	The most attractive (profitable) customers in the mainstream markets who are willing to pay for improved performance.	Overserved customers in the low end of the mainstream market.	Targets non-consumption: customers who historically lacked the money or skill to buy and use the product.
Impact on the required business model (processes and cost structure)	Improves or maintains profit margins by exploiting the existing processes and cost structure and making better use of current competitive advantages.	Utilises a new operating or financial approach or both.	Business model must make money at lower price per unit sold, and at unit production volumes that initially will be small.

Table 5. Three approaches to creating new-growth businesses

Source: Christensen, 2005

Disruptive innovators serve those customers with a reasonable standard of product. The second condition indicates that mainstream customers prefer to stick with incumbents until the entrant's quality and performance improves so that it satisfies them, even if the disruptors' products offer a lower price (Christensen and Raynor, 2003; Christensen et al., 2015).

By applying this theory of low-end disruptive innovation to the NIC context, it is possible to identify latecomers' strategy and market positioning. There are clear differences in innovation strategies and the market positioning of latecomers and advanced incumbents. Incumbents who are technological leaders in their market and industry are constantly pushing the innovation frontier. Their advanced products serve upstream market customers who demand highly technologically advanced, customised products. On the other hand, latecomers in NICs start from the low-end market with fewer resources (which are sustaining for incumbents) that are mostly acquired from foreign incumbents. As the previous literature review revealed, the strategy of these latecomers is to offer low cost, low price and low quality products that have been acquired from other advanced firms. The higher they develop their capabilities through innovation activities, which are mainly incremental innovations, they more they catch up with the performance level and quality level of their competitors in the upper and mainstream markets.

Although Christensen's idea of low-end disruption ends when latecomers successfully penetrate into the mainstream, this thesis extends his idea further by arguing that latecomers are eager to enter the high-end market by developing their own high technological products or services. The logic behind this is that if latecomers stay in the lower-end and mainstream markets, ultimately they will be in a vulnerable position as new entrants enter the market. New entrants might have the same low-cost, low-price strategy. In order to keep their competitive advantage, firms have to move to the high-end market where they can gain much bigger profits. Thus, the most critical issue for successful latecomers is their dynamic capability. An ambidextrous form of organisation benefits firms by helping them to develop more complex, high technology, highly profitable and customer specific products and services through radical innovations while still serving the existing market and customers at the same time.

In summary, low-end disruptive innovation has the potential to explain the market positioning of latecomers. As they move up to a higher market, their strategy should change according to the need of new customers who seek better quality and more complex, higher technological products and services. The next part of this chapter develops a conceptual framework for these concepts of dynamic capabilities, the ambidexterity of the firm and disruptive innovation that will suggest a radical way of thinking and approach to NIC-based catching-up innovation.

3.3 Ambidextrous and disruptive NIC innovation model

Before suggesting a new conceptual NIC innovation model, it is important to clarify the definitions of the key terms. Existing literature has used the term 'catch-up' as being close to reducing the technological gap. According to this aspect, catch-up finishes when latecomers enter into the low-end market and start producing their own low-price products that they can modify from externally acquired technologies. However, the technological frontier is dynamic and constantly being pushed forward by innovators. Therefore, this definition does not capture the latecomer's continuous catch-up innovation which they continue until they have successfully competed against incumbents in the mainstream market.

Therefore, this research defines ‘catch-up’ in a broader sense. The term should also include the later circumstances when latecomers actually compete with their own products and services against other technologically advanced competitors to take a share in the mainstream and upper tier market.

Building upon the literature review, this research suggests a new conceptual model for NICs. It argues that dynamic capabilities and organisational ambidexterity views are more appropriate for NICs and a set of propositions are offered to build a conceptual model.

Proposition 1. The catching-up process is also a dynamic capability building process.

Considering the fact that latecomers acquire external technologies and enter into a low-end market, before internally developing their design capabilities for both the production process and product lines, this process can be seen as a form of capability building. This research argues that even from the point when they acquire foreign technologies, they start building up their capabilities. As Lall (1992) pointed out, learning is necessary during technology transfer because technologies are tacit. This is also related to the concept of absorptive capacity. Absorptive capacity, originally described by Cohen and Levinthal (1990), is the internal ability of recognising, assimilating and applying external knowledge. This framework has been widely appreciated within Chesbrough's open innovation paradigm and used to support the view that firms explore external technological opportunities and absorptive capacity enables them to exploit this (Chesbrough, 2003; Cohen and Levinthal, 1990). Knowledge management researchers have recently reconceptualised it with wider dimensions by differentiating between the potential and realised absorptive capacity, and distinguishing knowledge exploration that includes acquisition for the former, and assimilation and exploitation, which includes transformation and exploitation processes, for the latter (Zahra and George, 2002; Lane et al., 2006). Zahra and George (2002) argue that absorptive capacity is a dynamic capability as it influences the firm's ability to create and deploy the knowledge to generate and sustain a competitive advantage.

Kim (1997) linked this absorptive capacity with organisational learning and the capability of building in the catching-up process and crises. Without recognising it himself, his argument was deeply related to the dynamic capability view. "Cumulative or linear learning along the current trajectory can take place under normal circumstances [stable and predictable environment]. Discontinuous or nonlinear learning, however, takes place normally when a firm perceives a crisis and deploys strategy to resolve the critical situation [unstable and high-velocity environment]." He further noted that: "Some firms manage to turn a crisis into an opportunity by transforming absorptive capacity in a discontinuous way to reap tremendous growth through enhanced competitiveness" (Kim, 1997: p.509). The crisis here refers to an internal crisis at both management and team levels, and external market turbulence.

In line with his idea, this research argues that the catching-up process is also a dynamic capability building process. However, the capability should not be limited to the exploration and exploitation of external knowledge, as firms might also build up their internal knowledge and innovation capability for radical and incremental innovation that they would create in the later stages of catching up.

Proposition 2. Once they possess the capabilities to develop and produce their own products/services, they will transform themselves into an ambidextrous organisation.

Once latecomers have successfully acquired and absorbed foreign technologies, they develop the production/manufacturing process for existing products to obtain either cost-reduction or efficiency as they compete with low-cost strategies (Hobday et al., 2004; Hobday, 2005; Kim, 1997). However, this low-cost based price competition strategy could soon be challenged by another competitor with similar strategies. The acquisition of higher technologies could also be constrained by the objection of technology holders who are against the license or transfer (Hobday et al., 2004). In other words, latecomers at this stage reduce their dependency on external exploration and exploitation, and instead rely on their internal capabilities. The dynamic capabilities will be employed for creating radical innovations to develop their own technologies for future products or services. Thus, this can be seen as the stage when they transform into an ambidextrous organisation.

Although Tushman and O'Reilly (1996) clearly stated that a separate unit/organisation is a necessary condition for ambidextrous organisation, firms in NICs do not clearly distinguish between existing business units and new business units in their structure (Tushman and O'Reilly, 1996; O'Reilly and Tushman, 2008;2013). It is important to consider that unlike firms in developed countries Korean business groups, such as the well-known chaebols, offer an interesting organisational setting. The group-level management individual or team controls legally independent affiliated firms through both direct equity stakes and an 'octopus-like structure'. This governance structure sets up individual affiliates that function as sub-operating divisions controlled by central group management (Chang, 2003; Ernst, 1998). Thus, this conceptual model in this research assumes that firms might have a different ambidextrous structure.

Proposition 3. Ambidexterity plays an important role in overcoming 'an innovation dilemma'.

Hobday et al. (2004) argue that the leading firms who approach the innovation frontier and begin to compete with new products that come from internal R&D face 'an innovation dilemma' at the transition stage. Their study of 25 Korean firms shows that even when some of these firms reached the innovation frontier, they adopted the same strategy by repeating incremental innovation on existing designs and processes and producing high quality but low-cost products. This was due to having a risk aversive attitude towards the risks and costs of carrying out radical innovation (Hobday et al., 2004). In other words, latecomers tend to step backwards once they reach the innovation frontier. They prefer to stay in the ‘specific phase’ of the PLC model until a new radical technology or product paradigm appears in the market. Once the market is replaced by a new product design, they repeat the catching-up innovation process. Or alternatively, as mentioned in the previous chapter, the Korean firms used hybrid innovation strategies that carefully tailored their latecomer innovation approaches with innovative leadership, depending on the stage of the product development and managerial decision making, in order to judge how they can acquire or develop technology and what they need to do to achieve this.

Their argument, however, has a limitation in that it does not explain how latecomers who reached the innovation frontier defend their position in terms of technology and the market. If a firm steps back from the innovation frontier, and the firm’s core business reaches the ‘specific phase’ of the product life cycle, the strategic choice for innovation is limited to only reducing the cost of its existing products. Competitors that offer a much lower price and lower cost products can threaten the firm’s position in the market. A practical example is the shipbuilding industry. Korean firms used to dominate the international market, but before long Chinese ship manufacturers threatened them by offering to build ships at a much lower cost and by price bidding. The shipbuilding industry in Korea has now completely collapsed and some latecomers who successfully caught up and bridged the gap are now leading the market after introducing a new product or technological paradigm (e.g. the IT industry – smartphones and PC components).

According to Christensen (1997), new entrants who entered into less profitable segments of the market gradually improve the quality of their offerings and move upmarket where the profitability is higher, as described above. This disruptive innovation theory suggests that once latecomers have fulfilled customers in the low-end market with a low cost and low price strategy and moved to the mainstream and high-end markets, they need to set up a new strategy and form of innovation management that accommodates the needs of both existing customers and new customers. The conceptual model in this research assumes that firms adopt a disruptive and ambidextrous strategy for this reason. Ambidexterity might help with the exploitation of existing market segments, normally the ‘cash cow’, as is the case in portfolio management, and with the exploration of new innovation opportunities to move up to higher markets.

Proposition 4. Firms who successfully exercise dynamic capabilities will move into the transitional phase where they compete against incumbents in the mainstream market.

Although previous models of the catch-up process had three stages, this research suggests that there is another step after the accomplishment of these stages. According to Hobday et al. (2004), there is no static innovation frontier as the technology leaders – European, Japanese and American firms – constantly expand the technology frontier and remain ahead in new product development and offer higher price, design-intensive, complex products and systems.

In contrast, Christensen (1997) and Christensen et al., (2005) argue that new market entrants who competed with low price products in the low-end market move upmarket in order to gain more profits from the mainstream and the high-end market where the profit margin is greater. It is, therefore, logical to assume that latecomers who have successfully reached the stage where they are close to the technology frontier will develop new products by exploiting their accumulated R&D capability. This stage can be seen as the transitional phase where latecomers compete against incumbents by improving the quality of their existing products or services, as well as their own new internally developed products. In other words, the latecomers reach a position in the low-end markets where they have foreign acquired but cheaper products. As their capabilities rise higher, they start producing products for upper market customers who demand a reasonable standard of quality and performance from their products. This is when the latecomers' disruptive innovations occur.

3.4 Transformational Innovation Capability model

To build upon these propositions, this thesis puts forward a new conceptual model that consists of four stages: capability building, catching up, transitional and leading phases. Figure 10 shows a simple illustration of the model. Unlike Kim (1997) and Lee et al. (1988), this research views the early three stages of 'acquisition, assimilation and improvement' as a capability building process. Thus, the R&D capability building phase refers to the early stage where a latecomer creates an internal capability by acquiring and assimilating foreign technologies. Then, with an internal R&D capability, the firm can continue its incremental innovation along with the PLC, whilst also seeking new technological opportunities and aligning their capability for radical product innovation. The catching-up phase refers to the stage where the firm transforms themselves into an ambidextrous organisation. Whilst offering existing products or services to existing customers in the low-market, the firm also offers higher and more complex technology, and more profitable products for customers in the upmarket. They then compete against incumbents and technologically advanced firms in the mainstream market. Thus, this stage can be seen as the one where the catching up really occurs. The transitional phase refers to the stage where the firm successfully lands in the upmarket by introducing a new product or service that it has developed from its own R&D. Thus, it is assumed that the importance of radical product innovation is higher than incremental process innovation. Once the firm successfully introduces a new product into the market, the rate of incremental innovation will be higher than the rate of radical innovation so as to improve the quality of the product in response to feedback from the customers. It is worth noting that new products do not necessarily create a new market or generate a new radical paradigm.

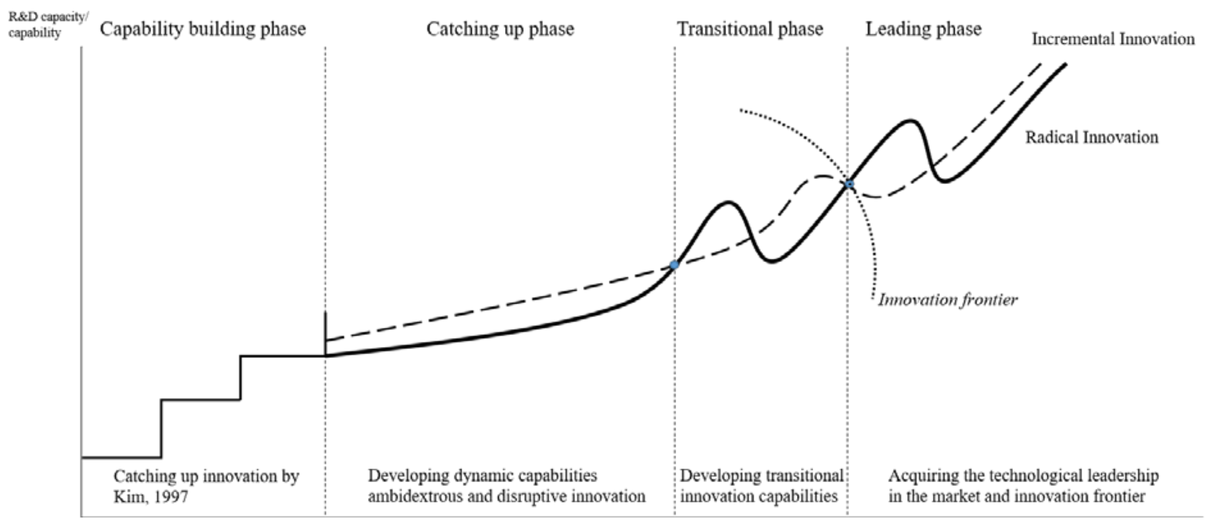

Figure 10. A new conceptual model of transformational innovation capability

A firm that successfully arrives at the leading phase might repeat the dynamic ambidexterity with incremental innovations to secure their competitive advantage in the existing market and use radical innovations so that they can lead at the innovation frontier.

Chapter Summary

In summary, the conceptual model has been built from the rigorous literature review. The model has four important features that propose a new and different approach to catch-up innovation. First, it views the catching up process as occurring until the latecomers shift into the mainstream market. Previous models have viewed the process as finishing when firms start to produce their own products with a low-cost and low-price strategy in a lower market. Second, the focus of the process is on the firm's capability building, rather than its assimilation and exploitation of acquired technologies. Third, the innovation dilemma that causes latecomers to hesitate before competing at the innovation frontier might be resolved by both dynamic capabilities and ambidexterity. Fourth, the previous studies neglected to consider how important the market positioning of latecomers is, but this model suggests that latecomers shift from the low-end market to the mainstream by following the idea of disruptive innovation.

This conceptual model is revised later in chapter 7 by using the findings of this thesis' empirical data. The next chapter explains the research philosophy, methodology and method that this thesis employed.

Chapter 4

Research methodology and methods

In this chapter, the research methodology and methods employed in this thesis are presented. It begins by identifying the theoretical and philosophical stance used. This thesis adopted the abductive mode of research that departs from existing theory, determined ‘known’ and ‘hidden’ facts, and set up a new theoretical set of concepts, which will be then examined later with empirical data. For the empirical data, the data collection method used was qualitative case studies, with employees at different managerial levels being interviewed. The chapter finishes with a detailed explanation of the research process undertaken in this thesis.

4.1 Research methodology

Research philosophy

This dissertation uses the abductive theory construction, which was inspired by Weick (1989), Van de Ven (2003), Van de Ven and Johnson. (2006), Alvesson and Karreman (2007, 2011) and Alvesson and Sandberg (2013). In general, abduction is a method that has some of the characteristics of both induction and deduction, as it starts from an empirical basis, but it does accept theoretical preconceptions. The analysis of empirical facts may be combined with reviews and studies of previous theories, which are the source of inspiration for new discovery (Alvesson and Sandberg, 2013). Thus, the abductive research process is the alteration of theories and empirical facts, where both are reflected and reinterpreted in the light of each other (Alvesson and Sandberg, 2013; Alvesson and Karreman, 2007, 2011). This abductive approach has benefited this research for three reasons. First, the research aims to revisit previous theories and reinterpret their confirmed empirical facts in order to 'disconfirm'. 'Disconfirm' is placed within quotation marks because it refers to the idea of Weick (1989). He noted that: "a disconfirmed assumption is an opportunity for a theorist to learn something new, to discover something unexpected, to generate renewed interest in an old question, to mystify something that had previously seemed settled, to heighten intellectual stimulation, to get recognition, and to alleviate boredom… they [disconfirmed assumptions] accelerate the completion of their intention to build interesting theory" (p. 525-6). Following on from this idea, this thesis attempts to build an interesting theory by questioning the previous theories. Second, this research attempts to conduct a conceptual framework that consists of theoretical preconceptions and assumptions that have arisen in the light of both existing theories in literature and empirical data. Third, this conceptual framework is confirmed by the new empirical data this research has undertaken.

This thesis also employs Peirce's idea of abduction as an explanatory model. This idea is that abduction is the process of forming explanatory hypotheses that may be assessed later in the context of subjective tests (Burks, 1946; Park, 2017). This is also in line with what is called 'a perspectival approach' which concludes that "facts are always theory-laden” (Hanson, 1958; Alvesson and Skoldberg, 2009). At the core of Hanson’s argument, the interpretation of data is inseparable from perspective, so data is always contextually inserted in a semantic frame that is perspectival. Thus, Hanson rejects both induction and reduction for research process. Instead, he argues that with the use of empirical data a pattern emerges through the work. This process of pattern finding is called ‘abduction’ (Hanson, 1958; Alvesson and Skoldberg, 2009).

Using existing theory to develop a new theory is deeply related to the hermeneutics way of thinking. Specifically, this thesis follows alethic hermeneutics that “dissolves the polarity between subject and object into primordial, original situation of understanding, characterized instead by a disclosive structure” (Alvesson and Skoldberg, 2009: p.96). In saying that, the revelation of what is hidden between pre-understanding and understanding is emphasised.

Research approach – the theory development process

Based on the philosophy behind this research, this thesis follows Weick’s (1989) and Van de Ven’s (2007) views of theory construction. In Weick’s (1989) view, theory-building is a process of ‘disciplined imagination’ that involves a series of thought trials that generate conditions and imaginary scenarios. In doing this, a researcher develops a set of conjectures in the statement form of ‘if/then’. This generation of conjectures, imaginary scenarios, is free from any empirical validation. This imagination must be ‘disciplined’ and the conjectures are selected or rejected by the researcher’s selection criteria that judges whether the conjecture is ‘interesting’, ‘obvious’, ‘connected’ or ‘believable’ (Davis, 1971). The judgement of ‘that’s interesting’ as a selection criterion leads the researcher, who is experiencing a feeling of interest, to dig deeper inside the conjecture to find out what currently makes him disconfirm past experience and understanding. In doing so, current understanding and experience are tested, whilst past understanding has been found to be inadequate. Thus, the use of interest as the criterion allows theorists to find an opportunity to discover and learn something new and unexpected, and to question something that has previously been confirmed. ‘That’s obvious’ leads the researcher to find the relevant boundary conditions that the conjecture is only admitted within. ‘That’s connected’ generates doubt about the connection between the two and activates conjecture to discover a new set of implications that connects what was previously seen as unrelated and independent. ‘That’s believable’ is the criterion used to judge a conjecture that is universally admitted. If not, the conjecture is likely to be rejected.

This research interprets theory building as ‘the disciplined imagination’ under the interest criterion. The series of thought trials that occurred during the literature review helped the author to develop a set of conjectures (theoretical assumptions) that previous understandings of NIC innovation might have missed out.

Starting from Wieck’s wisdom for social scientists, this research also follows Van de Ven’s (2007) idea of theory construction in the management subject. He argues that “a central mission of scholars in a professional school [such as business and other social science] is to conduct research that contributes knowledge to a scientific discipline, on the one hand, and to apply that knowledge to advance the practice" (Van de Ven, 2007:p.1). His argument provided food for thought for this thesis as he believed that management studies are an interaction between both theory and reality, which can interpret each other's contexts.

Van de Ven (2007) proposes a diamond shaped baseball model, as shown in the figure 11 below. He argues that scholars can begin from any base that allows them to apply

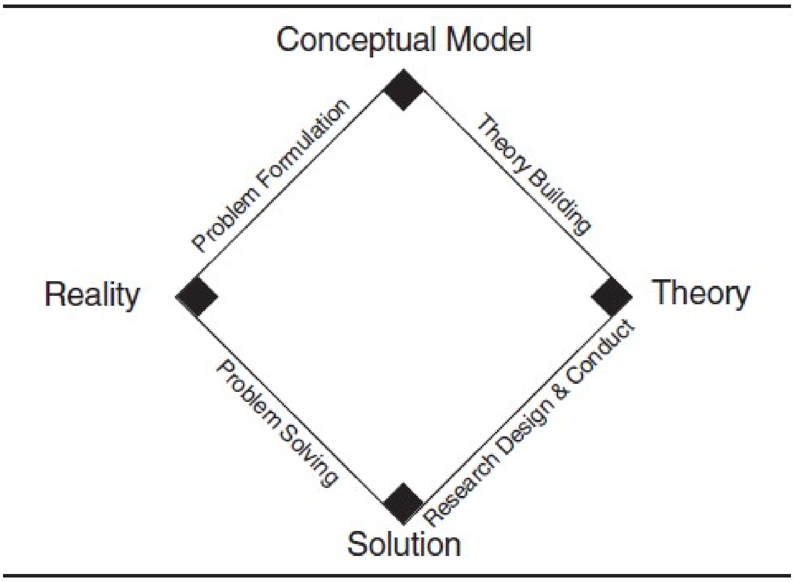

Figure 11. Diamond baseball model for theory construction in management
Source: Van de Ven (2007)

different methods and styles of inquiry. Problem formulation consists of recognising the unorganised perceptions and facts that exist in the real world and then developing a solid description of the problem of a topic or issue (Van de Ven, 2007). In other words, this starting point is where scholars form a research question from their own recognition of a problem, opportunity or issue in a realistic situation. Theory building is where scholars create, construct and justify a theory by their own methods with a relevant literature review and empirical data. In his method, there are three key activities in theory building process. First, creative theoretical assumptions that are created through a process of abductive reasoning to resolve an anomaly observed in the real world. Second, a theory is constructed to elaborate on the conjectures through logical deductive reasoning. Third, the theory is then justified through inductive reasoning to empirically evaluate the model of the theory. This process is also in line with an abductive process of ‘disciplined imagination put forward by Weick (1989). Research design consists of conceiving a way to connect a theory with empirical evidence. Van de Ven (2007) points out that “the how question process theory explanation of the temporal order and sequence in which a discrete set of events occurred based on a story or historical narrative” (Van de Ven, 2007: p. 23). Problem solving involves the execution of the research design in order to produce empirical evidence to find a solution to the research problem. This will entail a discussion of the implications of the findings for theory and practice.

By adopting Van de Ven’s process, this research starts from problem solving. By recalling the research question of this research, which is ‘how technological latecomers strive to become leaders?’ it generates the research problem by spotting under-investigated area in the existing theories. This is also a critical case of ‘neglect-gap spotting’, as defined by Sandberg and Alvesson (2010). A conceptual framework was then created, as suggested in Chapter 3, which consists of theoretical propositions through the acknowledgement of reality and the review of existing theories in literature. The qualitative research method has been employed to collect empirical data and analyse them as case studies. These case studies provide an in-depth way to elaborate on the conceptual model. By evaluating and reflecting on the empirical facts, the research finally suggests a theory that is empirically justified.

Research quality – the cases and validity

To build a theory, it is important to ensure both the validity and the selection of cases. According to Yin (2009), validity can be classified into the construct (which identifies the relevant measures for data collection), internal (finding relationships between conjectures or conditions) and external (defining the domain where the findings can be generalised) validity, and reliability (so that repeating the data collection procedures brings about the same results).

In order to increase construct validity, this research has adopted triangulation by collecting data from multiple sources. The case studies have been conducted with interviews, empirical data from existing research in literature, corporate documents and other media published resources.

To ensure the internal validity, this research follows Yin (2009) by using pattern matching as explanatory building in multiple cases. In order to increase the external validity, the context of the case studies has been limited to Korean firms that have achieved rapid technological development and are now producing their own developed products. A limitation of this research is that the case studies are Korea and Korean firms, and that it might not be appropriate to apply them to other countries. However, Davis (1971) argues that “a theorist makes an interesting localization when he asserts that some property belongs merely to one social category and not others” (p. 318). This is also related to the issue of validity. The validation in this research, however, is a primary concern as Weick (1989) noted that “the contribution of social science does not lie in validated knowledge, but rather in the suggestion of relationships and connections that had previously not been suspected, relationships that change actions and perspectives” (p. 524). This thesis instead considers its plausibility by fully acknowledging its own limitations.

4.2. Research method and empirical data

In this research, the case studies were conducted by employing the qualitative method. The three major Korean multinational companies studied are in the semi-conductor, automobile & steel, and construction industries. These were selected because all of these firms have achieved a rapid technological catch-up, and are also now operating in both the mainstream market and innovation frontier. The qualitative research and case study method is employed in this study. According to Yin (2009), a case study is the preferred method to explain the ‘how’ or ‘why’ questions in qualitative analysis, as well as produce in-depth research on a contemporary phenomenon within a practical context. As was clarified in Chapter 1, the purpose of this research is to understand how latecomers become technological leaders by using catching-up innovation. Thus, it is believed that the case study method is the most suitable for the purpose and aim this research. Interviews were employed as the primary instrument for data collection, and secondary data was also gathered to increase understanding of the cases and support their contexts.

Interviews

There were a total of 45 interviews with top managers, middle managers and selected employees in the R&D departments and strategic departments, conducted in 2016-2017. Employees at senior level were selected because they could provide details about the history of the firms and their experiences, as they had been working in the firm for about 10 years. Moreover, the fact that low-level R&D staff focused on low-level tasks (e.g. doing daily routinised given tasks) limited the selection of the interviewees.

The interviews were conducted in the Korean language with Korean interviewees. The interviews were recorded and electronically documented. The transcripts were translated into English by a professional translator and then cross-checked by the researcher, in order to reduce any bias that could occur during the translation. Despite these efforts, there were some inevitable cultural and language differences. For example, Korean people use ‘We’ instead of ‘I’ when they represent a group or a society that they belong to. However, this did not harm the reliability of data as the main idea of each phrase was translated directly.

The interviews were semi-structured and reasonably open-ended. The aim of the interviews was to obtain a contextualised explanation of how the firms structure and exploit their R&D, their capability for radical or incremental innovation, and how they treat those two different types of innovations and what strategic perspectives they had in mind.

Furthermore, it was possible, depending on the level and role of the interviewee in the company, to draw discussions about how they started and achieved innovation, as well as their current position and their future plans, expectations and directions. When the interviewee did not fully understand the meaning of a question or when the author doubted the meaning of a response, immediate clarification or detailed sub-questions were asked so as to avoid any misunderstandings or misleading conclusions. This allowed for the clarification and consolidation of the data. It was noticeable that senior level interviewees were able to grasp and understand the academic theories and models. In fact, most of the senior managers possessed higher qualifications of education, at least a master's degree on their subject. Thus, they often asked the author to clarify important terminologies and perspectives during the interview. For example, they were interested in discussing the gap that exists between the academic and practical perspectives on the categorisation of radical and incremental innovation, capabilities and strategies. To avoid any bias, those discussions were carried out after the interview.

In order to ensure that the interviewees acknowledged the core idea and purpose of the research, a brief explanation of it was given, which was: “This research aims to find how latecomers like your company have achieved a rapid technological development and become the technological leader.” Then three main questions were asked: a) “How and what did you do to overcome the lack of R&D capability when the firm started its business”; b) “How do you do/manage innovation at the moment” and c) “what is the firm’s innovation plan in/for future?” Depending on their level and role, interviewees were also asked, “Is the firm’s innovation strategy and perspective about radical and incremental innovation.” Each interview lasted from 45 minutes to 1 hour. The interview transcripts were in the form of notes, memo and recordings. It was agreed that the recordings, however, would be excluded from the thesis, as were all of the sensitive materials, such as company names, detailed employees’ roles and positions, and information about technology. This is one of the limitations of the interviews in this research. Thus, each interviewee received the findings, as well as a summary of the meeting and interview over the period of the research. For case A, there were 13 interviews with three senior level managers, six middle level managers, two middle-lower level employees and two lower level employees. It is worth noting here that the company had a precise hierarchy. There were only four levels: CL1 – engineers, CL 2 – middle and lower level engineers, CL 3 – middle level managers and CL 4 – senior level managers. For case B, there were 14 interviews with four senior level managers, seven middle level managers and five lower level employees. For case C, there were 16 interviews with five senior level managers, seven middle level managers and two lower level employees. In addition, two government officers in charge of the project, and two managers from the supplier firm were interviewed. This was due to the fact that large scale projects involve many different actors, suppliers and stakeholders.

	Case A	**Case B**	**Case C**
Senior level	3	4	5
Middle level	6	7	7
Employees	4	5	2
External stakeholder			2
Total number of interviews	13	16	16

Table 6. The number of interviews

Documentation and other materials

In addition to the interviews, this research used and referred to documents and materials from previous research in the literature. As the companies studied were multinational conglomerates, there was a sufficient amount of qualified and published materials. All three case companies had a well-established archive of historical annual reports and sustainability reports that contained the goals, vision and everyday activities of the companies. For case A, nine years – from 2008 to 2017 – of periodic annual and sustainability reports were studied. For case B, eleven years – from 2007 to 2017 – of periodic annual and sustainability reports were studied. For Case C, seven years – from 2010 to 2017 – of periodic annual and sustainability reports were studied. These provided some useful information that increased understanding of how their organisational structure, R&D system and strategic management had changed over the period. For case C, reports from the city government's body, which was the customer of the project, were also studied. Other relevant reports from the project's partners and prime suppliers were also archived. Relevant information collected from annual reports was coded. With basic but important findings from the initial research with secondary documents, the research moved on to an analysis of the data collected from the interviews. The documentations, such as company annual reports, published history books about the company, website materials and media interviews with CEOs and senior managers, all helped to increase the level of knowledge about the firms' strategy and historical technology development.

Empirical data and findings from previous research was also used to help formulate the interview questions, produce the findings and for reference purposes. Research into each company was used to obtain a wider knowledge of the firm and also increase the reliability of this research.

Data analysis process

The data analysis process began with the collection of contextual insights and general information from the company's official documents. The coding method was a directed content analysis approach that used the concepts and categories that were drawn from existing literature (Hsieh and Shannon, 2005). Using existing theory and prior research, it began by identifying key concepts as initial coding categories. In this research, six core concepts were identified from the literature review: firm and R&D

strategy, firm and R&D structure, capability, industrial characteristics, product innovation and process innovation. Next, from the data and text, the exact words and sentences that appear to capture and represent the key thoughts of the above six core concepts were highlighted. Initial analysis enabled the development of an initial coding scheme that labelled for the emerged and emerging codes. Texts that could not be categorised with the initial coding scheme from literature were given a new code. These coded concepts were then categorised into four dimensions – catching up, post-catching up, disruption and ambidexterity.

The draft findings were derived from all of the relevant information that was collected following the coding of the data. The final case study was written after analysing all of the relevant information and data from the interview and the secondary documents. This data analysis process was beneficial in order to report the study findings by focusing on the validation and extension of a theoretical framework. Hence, this approach has some inherent limitations in that the data could be conceptually biased. This limitation is fully considered and clarified as one of the limitations of this research.

Chapter summary

This chapter presented the research philosophy, methodology and data collection methods adopted in this research. The abductive mode and theory-laden stance of the research was explained. The research approach was deeply inspired by Weick (1989) and Van de Ven (2007), whose philosophical ideas about research were fully discussed and explained. The methods of data collection and analysis were followed. This chapter finished with a presentation of the data analysis process. In the next chapter, Chapter 5, the case studies will be presented.

Chapter 5

Case studies – report of the findings

This chapter presents three case studies that are presented in a narrative style. Power quotes from the raw data, findings and preliminary analysis appear alternatively in order to investigate what has been observed and found in the primary empirical data from the interviews and in the secondary materials. The chapter provides background on the historical development of each company, and mainly focuses on how the company has grown and developed; it identifies how innovation and other success factors have occurred during each of their development phases; it describes how the firms structure their innovation as a strategic system; and explains how technological innovation is exploited in each of the phases.

5.1. A brief overview of the cases

Company A

Case A is an electronics company with a wide-ranging product portfolio, from consumer electronics to electric components, such as mobile phones, televisions, refrigerators, memory disks, semi-conductors and so on. This research considers the semi-conductor business only as it is the largest business of the company and it is one of the most advanced technological industries where the technological velocity is rapid and competitive. The company is owned by a large multinational group, but electronics is the most important and largest affiliate within the group.

The semi-conductor industry started in 1965 when American firms established joint ventures in Korea to manufacture semi-conductors under the OEM production system. The company was established in 1974 when company A acquired a domestic H semi-conductor, which was a joint venture of two American firms, but suffering from the economic recession due to the financial oil crisis in 1970s. Later, the company was acquired by the large conglomerate group that currently owns various affiliates and businesses. Electronics is the largest and most profitable business of the group. The company made rapid technological development and growth in 1980s. There were many factors behind this success, such as the Government's cultivation plan for the computer industry, however this case study focuses on the firm's R&D and innovation strategy. Through rapid technological catch-up, the company became the technological leader of the dynamic random-access memory (DRAM) industry in 1992 and continues to this day. According to the company's annual report, international sales in 2016 were 40 billion USD and there were 62,546 R&D employees out of a total of 308,745 employees.

The Semi-conductor industry

The leading company in the Korean semi-conductor industry has been studied abundantly as it represents one of the most successful cases of NIC's rapidly catching up. Previous studies have examined this company from the perspective of technological learning (Kim, 1997), latecomer strategies (Hobday, 1995; 1998, Hobday et al., 2004), and both the national-level and systems of innovation level (Kim, 1996 in SPRU working project[4]), as well as other levels of studies.

The manufacturing activities of semi-conductor firms are divided into four stages. Namely: 1) the design process that draws electronic circuit and circuit patterns on a wafer by using CAD; 2) the fabrication process that imprints circuit patterns and fabricates the micro-structure on the silicon wafer; 3) the assembly process that cuts wafers and attaches individual chips onto the frame and then finishes in packaging designed to protect the chip circuit from external damages; and 4) the final testing of its functionality. The first and second process – the design and fabrication processes – are the stages where the most radical technological innovation occurs. The assembly and testing processes normally depends on existing facilities and incremental process innovation.

Company B

Case B is a steel company that mainly produces steel plates for automobiles. One of its unique characteristics is that the company is owned by an automobile company within the same conglomerate/group. The company was established in 1953, just after the Korean War. For over 60 years, the company did not experience rapid growth until the 1990s, as up until then it was a back-end steel producer. Recently, the company

[4] Kim, 1996. 'The Korean system of innovation and the semiconductor industry: a governance perspective'

acquired upstream facilities that have enabled it to become an integrated steel producer. Specifically, the company has become one of the market leaders since it built an integrated blast furnace in 2009. Before 2009, the company only had an electric arc furnace that could produce basic steel construction materials, such as H sections and steel beams for frame structures. After 2009, the company has been concentrating on producing automotive steel sheets and components for engines, transmissions etc. Since 2009, its strategy has been: “From the iron pig to the car.”

In 2016, the firm had a total 11,344 employees, including 600 R&D employees. Total sales were 11,144 million GBP (16,132 billion in Korean Won) and the total production was 21,181 tonnes.

Steel industry

In steel manufacturing, there are two types of furnaces: electric silo and blast furnace. Electric silo generates pig iron from scrapped or recycled metals. The melted pig iron goes through the refinement, casting, heating, pressing, rolling and cutting processes. More processing steps, including cooling, coiling and pickling are added for stainless steel or special steel products. In the manufacturing of high quality steel products, electric silo furnaces have a limitation as the raw material and scrapped metals are of low quality. On the other hand, an integrated milling with a blast furnace can produce high quality products as it generates the pig iron from iron ores and cocks. High purity iron that comes from a blast furnace can be used to produce more complex, high quality products, such as car steel plates, electric devices, consumer electronics and other construction materials through the cold/hot or pressing rolling process.

Company C

Case C is a construction and engineering company that comes under a steel group. It was established by a merger of two internal companies within the group. The engineering company was established in 1970 to help the group's blast furnace project. During the 1990s, the company expanded its business to civil engineering and plant engineering. The construction company was established in 1982 as one of the group's subsidiaries to manage the steel manufacturing maintenance supplier. From the company's accumulated construction management knowhow, it expanded its business area to construction project management and became a supplier for heavy plants in 1980s. The group combined these two companies to start engineering and construction-based projects in 1994. The internal structure of the merged company was also transformed into a project organisation by setting up separate divisions: the project operations division, including everything from design to closeout, and the administrative division, including business planning, finance, HRM and supply chain management teams.

Before the 1990s, the company's main business was steel and energy plants. The company had accumulated knowledge from the construction projects of its owner group's steel plants. However, the company realised its narrow product portfolio was a risk, so it started to expand its business area to civil engineering, real estates and construction. More recently, the area has been expanded to include city planning.

For case C, a large-scale project for a new city development was considered. As Brady and Davies (2004) first identified, this project is a 'vanguard project'. Contrary to cases A and B, this company is a project-based firm that provides a CoPS product. As discussed earlier in the literature review, one of the characteristics of CoPS and a project-based firm is that the innovation occurs from project-based learning and business-led learning (Davies et al., 2011). Thus, this case study focuses on the innovation and capabilities that are exploited and developed in the project.

The project involves the development of a district in the city called Songdo international city in Incheon metropolitan city[5], South Korea. The city has been built on reclaimed land that is still being reclaimed. The reclamation project started in 2003 and it is expected to finish by 2020. The city was part of the government's plans and efforts to promote an economic growth plan. The Incheon Free Economic Zone (IFEZ) consists of the three regions of Songdo, Cheongna and Yeongjong. The strategic goal of the plan is to build these areas into a global hub for logistics, business, leisure and tourism. Songdo is designed as an international business area. The case study project, Songdo International Business District (Songdo IBD), is the centrepiece of the city that was built between 2003 and 2015. The total size of the land of the project is

[5] In Korea, there are different levels of administrative divisions: Provincial level – Special city (Seoul, the capital), metropolitan cities, provinces, special self-governing provinces etc. Municipal level – specific city, city, county and autonomous districts. The project is a city district within the metropolitan city. The closest comparison might be the financial district in Manhattan in New York City.

approximately 53.4 km^2. The estimated development cost of the project is 20 billion in USD. In 2001, the city of Incheon initiated the city development project. The case study company, which was searching for an opportunity for growth by moving beyond the firm's traditional business base, decided to take a part in the project. It formed a joint venture, called NSIC LLC, with an American developer, Gale International.

Construction industry

There are four main sectors of construction: buildings, infrastructure, industrial plants and city developments. Building construction is normally divided into residential (estate) and commercial. Infrastructure is sometimes also called civil infrastructure and includes bridges, rails, motorways or large-scale public works. Plant construction includes refineries, steel furnaces, chemical plants or large-scale manufacturing plants. City development, more generally called urban planning, is not new or a common type of construction either. It involves lots of factors, actors, interests, politics etc.

The construction industry is primarily organised as a project basis. In general, when a client initiates a project and the firm wins the bid, the construction process starts from a design process. A design team is then formed to plan the physical proceedings of the construction. The design team may include architects, engineers, consultants etc. Once the design is completed, a number of construction companies then make a bid for the project. Following the bidding, the client awards a contract to the successful bidder. In the modern construction industry, construction companies normally offer turnkey (EPC) or design & build where a constructor manages all of the processes, from the design stage to final delivery. Although each project has its own internal economy, governance structure and system of production, a large-scale project involves much higher risks and challenges due to its very nature. The outcome of a large-scale project is made up of millions of components that are designed and produced by many different companies. Even the components all have sub-components and their own systems. Thus, a large-scale project is associated with a high level of uncertainty and complexity.

5.2 Case study A – Semi-conductor company

The history of the company A's developments

1970s-80s

In 1974, the group acquired 50 percent of the shares of Korea Semiconductor Company, a joint venture of two American companies that produced linear IC and transistors. Four years later, the company was wholly acquired and transferred into the Group's electronics affiliate. The company succeeded in developing its own designed transistors and linear IC for colour televisions and electronic watches, which provided it with valuable experience of product design innovation for semi-conductors.

In 1983 the company started a semi-conductor business, encouraged by the government's selective national growth plan and a managerial decision of the CEO of the group. This managerial decision was based on the semi-conductor industry being recognised as a feasible and profitable industry in the future, and it was seen as an opportunity to expand the company's product portfolio from basic consumer electronics to high-tech product lines. The company launched its memory business in 1983, and at the same time established its first R&D centre in Silicon Valley in the U.S. in 1983. More than 20 highly qualified Korean engineers were recruited from other high-tech companies and academia and played a crucial role in transferring tacit knowledge and leading the catch-up development in the 1980s.

1990s and onwards

The company made a rapid technological catch-up from the late 1980s and 1990s onwards. In terms of the technology, the gap between the company and the advanced firms in the US and Japan was 4 years, when it started developing its first product 64K DRAM. Until then, the innovation used to catch up was mainly from external technologies that had been adopted or learned from other's samples. However, as the company drew close to the innovation frontier, an R&D capability was required. Thus, the company built a R&D centre that focused only on DRAM development in Giheung, Korea, in 1988. The company also expanded its mass production facilities in 1991. Table 7 presents a summary of key statistics of the company. Although, the research method employed in this thesis was not intended to concern a statistical analysis, these information provides qualitative information to understand the company's performance and strategic insights into R&D. Since the company started the semi-conductor business, the sales, number of R&D employees and R&D investments have continuously increased. It is notable that the sales of semi-conductor products have continuously increased every year. The only exception was 2012, but this was due to the decline in demand and price because of the global financial crisis.

Year	Annual sales (billion USD)	Semi-conductor sales (billion USD)	Numbers of employees/ R&D employees	R&D investments (billion USD)
1977	1.3	-	-	-
1987	2.4	-	-	-
1993	10.7	3.1	-	-
1999	22	10.6	-	-
2008	108.1	17.7	161,700 / 42,100	6.2
2009	119.1	21.3	157,701 / 44,098	6.7
2010	137.8	29.8	190,464 / 50,084	8.3
2011	147	29.3	221,726 / 55,320	9.2
2012	166.6	27.7	235,868 / 60,495	10.7
2013	203.8	33.3	286,284 / 69,230	13.2
2014	183.7	35.4	319,208 / 70,398	13.6
2015	178.8	42.4	325,677 / 65,602	13.2
2016	179.9	45.6	308,745 / 62,546	13.2

Table 7. Case A’s sales, numbers of employees and R&D investments

Innovation phases of the firm

The company’s technological innovation started as soon it entered the DRAM business in 1983. The company widely adopted imitation and external acquisition as its catching-up innovation strategy. From this case study, the firm’s innovation phases are categorised into three phases: 1) a capability building phase when the company exploited external channels as a mean of developing its R&D capability for catching up; 2) a disruptive catching-up phase when the company carried out both new product (radical) innovation and manufacturing process (incremental) innovation through its ambidextrous structure of R&D; and 3) an transitional phase when the company moved up to the mainstream market level by employing its ambidextrous dynamic capability and was able to compete at the innovation frontier to maintain technological leadership.

Capability building phase

The capability building phase started when the company acquired H Semi-conductor Co. in 1974. Before the firm announced its entry into the semi-conductor business, it formed a team that was sent to the U.S. to analyse information, such as the industry environment, market situation and technological requirements. After the team analysed the feasibility of the business, the company faced two questions: 1) What product and technology it should develop – the target; and 2) how it should develop technologies that were related to setting up an innovation strategy. For the first question, the company decided to develop semi-conductor memory chips, instead of the non-memory chips that the company had been developing and using in its consumer electronics. This decision was informed by an in-depth analysis of the market, which revealed that the product lifecycle of non-memory chips had nearly reached its end and the growth of the semi-conductor industry was expected in the long-term. Furthermore, the fact that semi-conductor memory chips had a lower entry boundary in terms of technology, as they required applied technologies rather than basic scientific research innovations, contributed to the decision. Then, the company chose DRAM (Dynamic RAM) over SRAM (static RAM) because DRAM had a much bigger market size and was the leading technology in the 1980s. As soon as the managerial decision was made, the company developed 64K DRAM immediately, skipping the previous development stages of 1K, 4K and 16K DRAM[6].

In order to develop 64K DRAM, the company established a foreign R&D subsidiary in the Silicon Valley in the U.S. It employed Korean engineers and scientists who had been working in the industry in the U.S. The company's innovation strategy was focused on internal manufacturing and assembly process innovations which they were capable of accomplishing in-house, and acquiring licenses for or simply imitating design and fabrication innovation from the U.S. companies. The company acquired a final DRAM product from an American firm and learnt the technology by disassembling it. This is termed the 'reverse engineering' method. At the same time, the local headquarters in Korea focused on developing an assembly process through a basic level of knowledge that it had accumulated from IC transistor manufacturing. Through these dual-channel (in-house and out-of-the-house) innovations, the company launched 64K DRAM on November 1983, and this had taken only 6 months to develop. This implies that the company built up its technological capability for product design by exploiting external channels while the internal firm resources and capabilities were used for manufacturing.

In March 1984, the company moved on and started to develop 256K DRAM. The company adopted a similar ambidextrous strategy but ran both the local and foreign

[6] Lee and Lim (2001) studied this stage skipping catch-up innovation in their article, 'Technological regimes, catching-up and leapfrogging: findings from the Korean industries,' Research Policy, 2001.

R&D teams for the same radical product innovation. The difference here was that the local team developed 256K DRAM by acquiring the design technology from an American company, but the foreign team developed its own design technology. This parallel development by two teams played a key role in both reducing the development time and leveraging the risk of failure. The company then sent the local development team to the foreign subsidiary to learn the technology and tacit knowledge.

Until 256K DRAM, the company had followed the innovation trajectory and path of the advanced firms by imitating or formally acquiring technologies through joint ventures or licensing forms of inter-firm relationship. However, the company realised its own design technologies for later generation models were necessary. Advanced firms, which were its technological source, started to recognise the company as a competitor as its market share and technology advanced, and avoided technological sharing and licensing.

Disruptive catching-up phase

The concurrent parallel form of ambidexterity was emphasised when the company developed 1M DRAM. It is notable that the company decided to develop 1M DRAM internally by running both the local and the foreign team at the same time. This R&D structure had both advantages and disadvantages. One of the advantages was that it reduced the time of development as those two teams were pushed into internal competition. In addition, the risk of innovation failure was relatively reduced. One of the disadvantages was the cost and inefficiency of internal resources. While both teams were undertaking the radical innovation, the company expanded its manufacturing facilities and capabilities, such as the CAD system and wafer process, in order to be prepared for incremental innovation after their success. The local team developed 1M DRAM first in July 1986, within 11 months of development time. This confirmed that the R&D capability of the internal R&D team had increased, and prompted the top-level managers to plan an integrated R&D centre locally.

The following quote illustrates the disadvantages of having a foreign R&D subsidiary.

> *"In fact, having a [R&D] team in a far distant location is not beneficial. It simply costs more and is difficult to manage… a local team is much easier to manage and to control the innovations" [Senior manager in the R&D centre]*

Another informant pointed out the cost and management difficulty as the critical disadvantages in more detail.

> *"The [R&D] investment and cost were doubled. For example, the team in America has a lab that is full of expensive equipment. The local team has the same lab with the same equipment. So, it is simply a waste of money to buy the same thing. But the speed was much more important than the cost. [Senior manager in the R&D centre]*

As soon as the 1M DRAM development was finished, the company started the R&D for the next generation, 4M DRAM. The company used internal competition again, but it set a rule that 'the loser will leave the DRAM development'. The winner of the second competition was also the local team who developed it within only 7 months. This was an event in which the company restructured its competitive ambidextrous structure and turned it into an integrated R&D structure where the local team took radical innovation and the foreign team focused on incremental innovation in order to increase customer values. The company restructured its R&D even further in 1989 by building a centre in Giheung in Korea. The main objectives of this centre were to develop basic scientific technology, product design technology and manufacturing process technology.

Interviewees who worked in the local R&D team looked back at the situation at that time. The quote below illustrates an important point that while the foreign R&D subsidiary was collaborating with advanced firms for technological learning, the local R&D were relying on the reverse engineering of imitating existing products by analysing. The success of the imitation strategy over collaboration encouraged the top manager to consider the internalisation of technological developments.

> *"Everyone thought the team in the U.S. was better than us. We [the local team] showed that we were capable of making it on our own … I was an engineer on the local team at that time. The American team had many more advantages than us. They worked closely with other American firms while we had nothing. We worked almost 24 hours a day to analyse the chip that we got from the American and Japanese firms. Finally, we developed our own ones. [Formal R&D researcher of the local team]*

Another quote from the interview reveals why the company restructured its R&D and made it one local centre.

> *"The local team's win gave the group managers some confidence that the R&D ability of the local team had reached a somewhat competitive level. It also raised a question about even having a foreign team. Did we really need a foreign team when the cost was so expensive [operational]?" [Senior manager at the R&D centre]*

With its integrated R&D centre, the company maximised the use of its ambidextrous dynamic capability. The company rotated development teams so that they overlapped the innovation cycle. For example, when a team was developing 4M DRAM, another team started to develop the next generation, 16M DRAM. When the innovation cycle of 4M DRAM reached the final stage of commercialisation, that team moved on to 64M DRAM. Then, once again, when 16M DRAM reached the commercialisation stage, the team moved on to 256M. The figure 12 below[7] illustrates this innovation strategy.

An interviewee briefly described this concurrent development system with an example of CPU chips.

> *"A team develops a product, let's say, the 1st generation CPU chip. At the same time, B team develops another product, the 2nd generation CPU chip that has*

[7] The figure is a simple illustration of the structure. The specific teams and tasks change dynamically to deal with any upcoming issues or the product life cycle of the previous models. (e.g. the incremental team skipped the development of further generations of 64K DRAM as they rapidly moved on to 256K DRAM).

bigger capacity or processing speed. Then, A team moves onto the 3rd generation CPU chip as soon as they finish the 1st generation. Same for the B team. So, by the time that the [market for] 1st generation is dead, the 2nd generation is already ready for mass production. [Engineer at the R&D centre]

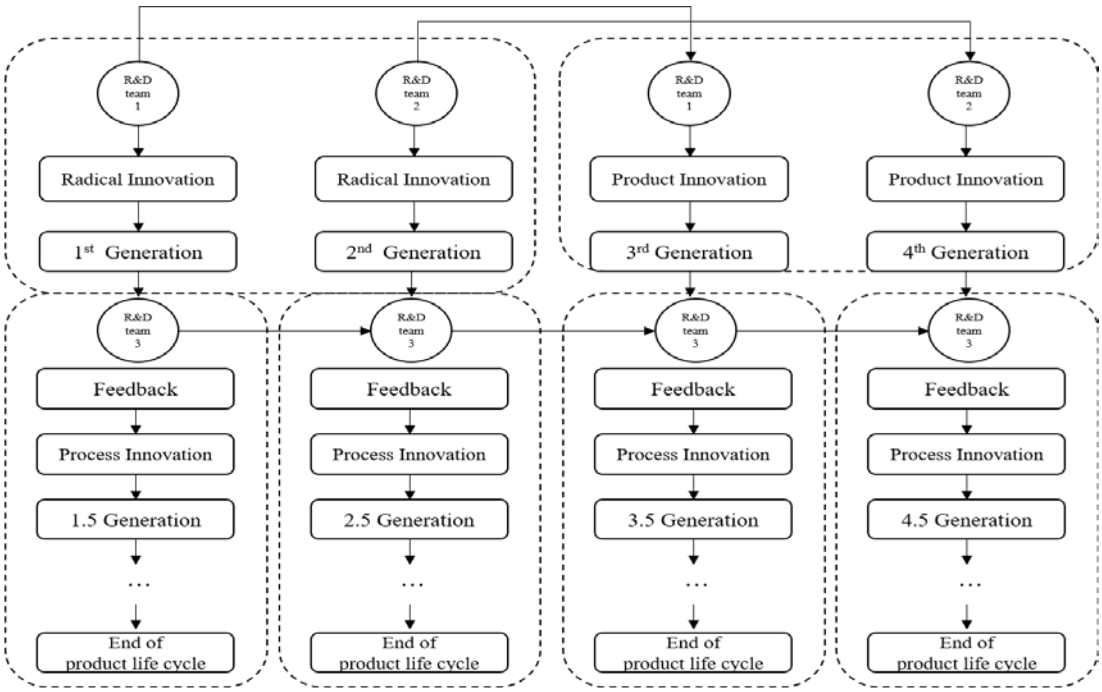

Figure 12. An example of concurrent product development system of the case A

Disruption occurred in 1991 when the company was able to move up to the mainstream market. Mainstream incumbents were preparing to move onto 4M DRAM production. However, the PC market and industry was expanding rapidly, which caused an increase in demand for a 1M DRAM that was cheaper and more reliable. The company saw this as an opportunity to increase its market share in DRAM.

Although the company's technological innovation had rapidly advanced, it was still operating in the low-end market where they set lower prices and used a lower capacity products strategy than their American or Japanese competitors. According to an informant, one of the reasons for this was that:

> *"I think we had good enough technology and quality [to compete against other advanced competitors]. But we didn't have the brand power. The market still preferred Japanese or American products to ours. So, we focused on selling one or a half old generation models at a cheaper price than that the other advanced competitors." [Senior manager in the firm's strategy department].*

The following quotes explain the market situation when this disruption occurred:

> *"It was lucky. Japanese firms almost stopped or were decreasing the 1M DRAM production. They wanted to produce more 4M DRAM, simply because it was more profitable." [Manager in the firm's strategy department]*

He continued:

> *"We were the biggest producer of 1M DRAM at that time. For example, Toshiba was one of the biggest manufacturers at that time. But Toshiba was not capable of supplying the sales demand because they turned all of their production to 4M DRAM. So, we became the first or second DRAM producer and a major company in the world." [Manager in the firm's strategy department]*

Together with the quote above, information from another interviewee points out that disruption turns out to an opportunity for latecomers. When disruption occurs, the under-valued low end market generates profitable values to latecomers.

> *"They [1M DRAM] were the cash cow. 1M DRAM was too profitable to just abandon. So we kept on developing the 1M DRAM manufacturing process, like developing advanced wafers and wires." [Manager in the firm's strategy department]*

Until the production of 16M DRAM the company was in a catching-up position. Since 1982, the company had successfully caught up with the incumbents within 7 years. The company then accelerated the speed of innovation by establishing a concurrent and parallel development system and structure. Accordingly, the company's innovation strategy focused on narrowing the technological gap by increasing the speed of radical innovation.

Transitional phase

After catching up so rapidly, the company had nearly reached the innovation frontier where they pioneered new technological innovation paths by exploiting the accumulated R&D capability. Unlike previous generations, 64M and 256M DRAM required internal capability and knowledge, as there was no advanced technology to follow. The company's innovation strategy during this phase was to moderate radical innovation while increasing incremental innovation.

It is important that the interviewees mentioned how they recognised and perceived R&D's role during the catch-up phase and how post catch-up the stage changed, as the company has become one of the technological leaders.

The following quote illustrates this point:

> *"There was no textbook any more. We were one of the leaders [in technology]. So we expanded our internal R&D to develop new technology and products. And the meaning of R&D became like finding new technology while developing existing products." [Former senior manager at the R&D centre]*

Another interviewee revealed an important point that when the company reached the innovation frontier, they recognised the limitation of the imitation strategy that had served them well. A new strategy to compete at the technological frontier and to secure the leadership was required.

> *"[During the catch-up] R&D was all about following others' technologies. For example, if we heard that a Japanese company was developing something like 64M, then we had to develop it. We knew what technologies were already in the market and in the hands of competitors. But when we became the leader, we had to change and find our own way to develop products. Nobody was pushing us when it came to catching up. We began to think about how we could secure profits and the leadership." [Senior manager in the R&D centre]*

As new-kind radical innovation is rarely born, the company adopted a strategy that explored new technological opportunities from the exploitation of existing products and technologies. The quote below depicts this:

> *"[During the catch up] We knew the technologies we needed to develop and what products… the game was all about increasing capacity, like 256K, then 1M and then 4M, and who made it first. Now the capacity does not really matter. When we became the leader, previous races became less important. Searching for new technologies became difficult because the DRAM technology is now mature. So we tried to find new technologies by developing existing technologies." [Senior manager in the R&D centre]*

The company started product innovations from process innovations, which was the opposite of the development process in the previous catching-up phase, where the radical technology of the product design was accomplished first and then the incremental process innovation developed to fit the manufacturing into the design. For example, the company developed technology that slimmed the width of the wires down to nanometres and developed new technology to increase the capacity that fits into the new wire size. The same method was adopted for 1G, 4G DRAM and the models currently being developed. New technology from incremental innovation also not only applied to existing previous generation models, but also to new products. For instance, 64M DRAM was made with 0.35nm wires when it was introduced in 1991, and then 0.25nm, 0.18nm and 0.13nm were later developed for 256M, 1G and 4G. The company still adopts this method when it releases new high-end products, such as

HBM DRAM, that stack up more modules on a smaller size wafer to increase the capacity and processing speed.

Innovation strategy and the structure of ambidexterity

The firm's innovation strategy and structure has evolved along with its innovation phases. The focus of the strategy during the capability building was on rapidly catching up the technological gap. It is notable that the company set up an ambidextrous organisational structure from the start of its business. The foreign R&D subsidiary was set up as the main channel of product innovation through the external exploitation of technology and product design. At the same time, the company focused on building its internal manufacturing capability and incremental innovation for the production process.

As the company's strategy was to place emphasis on the speed of the development, it formed a unique and radical structure of R&D: the concurrent parallel development. By running two R&D teams on the same project at the same time, but in different locations and with different methods (internal vs. external exploitation), the company was able to rapidly use R&D to develop the design technology for the next generation product.

The innovation strategy and structure of the firm changed when disruptive innovation happened in 1991. The new strategy was to focus on serving existing customers, and also develop its own design technologies for the long-term. Due to the increased demand there was from customers in the low-end market, the company set up another

R&D system to run incremental process innovation for existing 1M DRAM products. It also maintained radical product innovation but formed a different structure. As the company learned that parallel developments accelerated the development speed of radical innovation, the foreign subsidiary was integrated into the local R&D centre and reformed so that two teams were running product innovations. The different and unique feature was that they started developing two generations at the same time. This dual-generation development strategy allowed the firm to keep up its rapid development pace.

During the transitional phase, the company had to compete in the mainstream and high-end market, as well as at the innovation frontier. It adopted a reverse manufacturing process in which innovative knowledge comes from incremental process innovation, and the technology is applied to radical product innovation.

The technology strategies had been set up and improved to carry the set of innovation goals and tasks in each phase. During the catching up, the main focus of the technology strategy was on reducing the technological gap between the company and the advanced competitors such as American firms – until 1970s, and Japanese firms – until 1980-90s. After the company achieved successful catching up, new strategy was set up that promoted the development of the world's new technology in producing increased capacity DRAMs.

	Catching up	Transition		Leadership	
	Until 1992	1992-1998	1998-2014	2014 - 2016	Current
Technology Strategies	Catching up the technological gap between the company and American and Japanese incumbents	Developing the world's first new technology in capacity	Developing the world's first new nano technology	Maintaining the technological leadership - widening the gap with competitors	Leading at a higher level beyond comparison
Technology specification	64K, 256K, 1M, 4M, 16M and 64M DRAM	256M, 1G DRAM	120nm, 80nm, 50nm, 40nm 4G, 8G, 16G	20nm, 10nm 32G, 64G	7nm, 3nm
Innovation structure	Parellel in a remote location – two R&D teams on the same projects	Trio-system – multiple product and technology development teams plus incremental development teams		Trio-system – multiple product and technology development teams plus incremental development teams	
Main source of technology	External, imitation, in-house R&D	In-house R&D		In-house R&D	

Table 8. Case A's technology strategies

It is important here that when the company faced the limitation of technological advancement in capacity, they focused on the nano process technology to find the solution. The nano process technology enabled the company to develop larger capacity, but smaller size DRAM products. The technological strategy was then improved to secure the technological leadership by developing new technologies and new products at a rapid speed. The company recently promotes its strategy, 'leading at a higher level beyond comparison [with competitors] which portrays the company's eagerness to maintain the technological leadership.

Summary of case study A

In conclusion, it was found that this company was a textbook example of catching-up models that many previous pieces of research had studied. The company explored and exploited various external channels during the early phase to acquire technologies and manufacturing capabilities. Product design capability was initially developed by acquiring technology from advanced U.S. firms. The company's manufacturing and production capability were advanced by it being engaged in the OEM production of chips and transistors. The existing models theorised this catching up as being the assimilation of external technologies into internal capability. However, importantly, this case study found that the company adopted different forms of ambidexterity; not only during the catching up stage, but also when they reached the innovation frontier. It was observed that forms of ambidexterity could differ according to the firm's strategy of exploration, the exploitation of its innovation capability, and the firm's position on the innovation path. Disruptive innovation was also discovered. During the catching-up stage, the company served the low-end market. Whilst innovation leaders were competing in the next generation (high-end market), the company moved up from the low-end market, and challenged incumbents in the mainstream. When the company reached the innovation frontier, the production and process innovation process reversed. There will be further discussion of these findings in Chapter 6.

5.3 Case study B - Steel/Automobile company

The history of the company B's developments

1953-1970s

The company was launched as 'K heavy industry Corporation' on June 1953. It was established by the government to help the nation's recovery process after the Korean War by producing a series of plants, such as steel, a bloom/mid-sized rolling mill and a thin plate rolling mill for infrastructures. Due to a lack of resources and technology to build and run the steel milling facility, the company acquired the SL/RN process[8] and electric furnace facilities from 'Mannesman-Demag GmbH' and 'Lurgi GmbH' in West Germany. As part of the government's plan for national recovery, scientists, engineers and government officers were sent to West Germany to learn how to operate machines and production lines.

The following quote illustrates the situation that existed when the company was established as a government-owned public company after the war:

> *"It was just after the [Korean] War. There was nothing. Everything was just destroyed. The government and President Park set up a recovery programme. Steel industry was thought of as one of the important ones, and the company was a part of the plan." [Senior manager in the strategy department]*

[8] The "Stelco-Lurgi/Republic Steel-National Lead (SL/RN) process is a widely used coal-based DRI-making process which uses a rotary kiln. The process uses lump ore, pellets, beach sand or ilmenite ore and solid carbon to produce hot or cold DRI. The process operates at high temperature and atmospheric pressure." (IETD)

However, the company faced difficulties that led it to being privatised and merged with ‘I steel’ in 1970. The biggest problem was the company was incapable of producing hot metals from pig iron as the facility had been designed to only recycle steel materials that had been left over after the War. This process of recycling metal scraps through electric silos, the so-called pre-reduction steel recycling process, seemed to have more advantages than the blast furnace, as its construction costs and time, and operating costs are cheaper than the blast furnace/electric silo process. However, this process was new and had not been technologically and practically proven in advanced countries at that time. This experimental adoption caused several industrial accidents, even with experienced German engineers on the site. Five workers died in 1969 and ten workers in 1970 due to pipe and silo explosions (the company report, 1990, Dong-A news, 1969 and 1970).

The second problem was that the government’s plan for steel industrialisation had not been fully revised, even though many researchers and engineers were worried about the company’s profitability. Political pressure came from North Korea’s advanced industrialision, and from the financial aid from West Germany that helped with the construction of the facility (Song, 2002; the company report, 1990). The failure of the company made the government decide to privatise it and make another plan for an integrated steel company that would work with other companies and Japan later in the 1970s.

1980-1990s

In 1978, the company was acquired by the current owning group. The company found a way to survive and catch investments from the group, as the group's main business was construction and heavy industries, such as shipbuilding. In 1979, the company started upgrading its facilities and reformed its production line facilities in order to increase production efficiency. Investments had been made during the 1980s: a high-efficiency 50 tonnes electric furnace in 1984, a 70 tonnes furnace upgrade and other facilities, such as a cooling system and additional pressing facilities from 1984 to 1986. With the increased demand for H beams in the construction industry, the company improved its sales and profit in 1980s, as shown in table 9.

Year	**Sales revenue (KRW)**	**Margin profit (KRW)**
1980	118,471,000	-1,920,488
1981	151,729,923	157,995
1982	211,685,713	156,249
1983	246,667,495	4,119,013
1984	256,023,993	-1,557,297
1985	291,912,916	2,879,815
1986	340,269,681	5,098,485
1987	374,468,202	14,454,771
1988	422,762,530	27,406,670
1989	500,369,316	21,305,351

Table 9. Case B's sales revenue and profit flow from 1980 until 1989

2000-onwards

The company produced low-technological products until the 2000s. However, the construction industry faced a huge recession because of the financial crisis in the late 1990s, caused by the severe foreign exchange shortage when South Korea was on the brink of default in December 1997 and was bailed out by the IMF. Moreover, the company realised the need for an integrated blast furnaces and R&D centre due to limitations of the electric arc furnace that it can only produce low technology, low margin products. Thus, the company established its first R&D research centre in 2007 to develop technology and to expand its product portfolio.

However, the financial crisis was an opportunity for the company. In 2000 it merged with a domestic ‘K Industries’ and acquired another domestic ‘S Specialty Steel Co.’, which had gone bankrupt due to aggressive investments made during the crisis. This merger and acquisition enabled the company not only to reach its production capacity, nearing eight million tonnes, but also to take over 35% of the domestic market. The company rapidly expanded and became the second largest electric arc furnace producer in the world. The acquisition of ‘S Specialty Steel Co.’ enabled the company to produce specialty steel products, such as stainless steel or alloy steel that could be used in automobile components.

In 2001 the owner group was divided, because of the financial crisis of Korea and political pressure after the death of its founder subsequently. The group was then restructured by the founder’s sons. After this restructuring, the steel company was transferred under the motors group and changed its name to ‘I steel Co’. The automobile group set a long-term plan for the value and supply chain for its automobile business. M&A was the key strategy of the plan, which still continues. The company acquired ‘K heavy industry and automobile’ and ‘H.B. steel’ in 2004. The acquisition of H.B. enabled the company to have both a hot rolling process and hot pressing facilities and technologies. The company later finished tailoring its value and supply chain with the internal acquisition of ‘H Hysco’, which produces steel pipe for automobiles.

The group changed the company's name again to ‘H steel’ and planned to grow it as an integrated milling company in 2006, According to this plan, the company finished the construction of its first blast furnace and facilities in 2009 and expanded it so that it had three blast furnaces in 2013.

Years	**Annual sales (Billion USD)**	**Numbers of employees**	**R&D employees + external R&D employees[9]**	**R&D Investments (Million USD)**
2007	7.8	6,078	20	1.0
2008	9.36	6,686	167	1.8
2009	7.09	7,678	212+200	1.4
2010	9.08	8,268	320+400	2.5
2011	13.6	8,468	325+300	4.7
2012	12.6	8,957	325+300	6.0
2013	14.6	10,663	350+300	6.3
2014	17.3	10,753	500+300	6.9
2015	14.3	11,263	550+400	9.5
2016	14.8	11,134	550+400	10.85

Table 10. Case B’s sales, numbers of employees and R&D investments

[9] External R&D researchers from the customer and other affiliated companies.

Table 10 presents a summary of the company B's sales, numbers of employees and R&D employees, and R&D investments in the recent 10 years. It is notable that the annual sales have significantly increased since the company started producing automotive steel products from the blast furnace built in 2007. The number of R&D employees significantly increased since the company established a new R&D centre and system to develop automotive steel technologies since 2007. It is worth noting that external R&D expertise from the car company (the customer) and other affiliated companies such as H Hysco were involved in R&D developments and collaborated in the R&D centre under its new R&D system – called 'early vendor involvement (EVI)'. This EVI system is explained in the following section.

In summary, the company has a diverse business history. It started as a basic steel producer and continued in this business until the 1990s. After acquisition by the automobile group, the company has changed its business model and strategy. Three blast furnaces with an annual production capacity of 12 million tons enable the company to produce different types of steel products and more advanced technological products, such as automotive materials and special steel products.

Innovation phases of the firm

The company's technological innovation activities were not significant from the 1950s to 1990s, when the motors group acquired it. The company did not even have its own R&D centre and was not eagerly engaged in technological developments. The main reason for this was that there was no motivation for innovation. The company acquired silos and facilities from foreign sources and acquired some level of tacit knowledge by sending engineers, professionals and scientists to the technological source. In addition, the company invited technological personnel from the original source of the technology to initiate its facilities. However, as they failed to fully absorb the external technology, and the main business produced basic low technological steel products from back-end processes, it appears that the importance level of innovation was low.

The following quotes from interviewees illustrate why they were running the production passively without any motivation to innovate:

> *"[At that time] we brought the equipment and facilities from the West German companies. All we had to do was just learn the operation of the silo and facility with the manual and the supervision of engineers from Germany. We could not think of any innovation because we were busy enough learning how to run the silo." [Senior manager in the strategy department]*

An interviewee gave some insight as to why innovation was not effective before the 1990s with an explanation of the industrial and market situation at that time.

> *"In fact, there was nothing to R&D back in the 1970-90s.The steel industry at that time was all about reducing raw material costs and leveraging more profits. We entirely relied on the supply from Japan, but they were too expensive. Scrap metal was the only possible source for materials. Also, we had only electric arc furnaces, so were only producing limited construction*

materials, like H beams and pipes." [Senior manager in the strategy department]

Innovation became important for the firm from 2001 when it entered the automotive steel industry. Recently, the automotive steel industry has required a high level of technology to increase the strength and flexibility of the steel while also reducing the weight. As automotive design has become more complex and curvy, so the technology for producing high strength steel with appropriate features such as maintaining both high rigidity and high flexibility has also become key. New materials and chemical combinations, such as high strength aluminium or mixing aluminium with high strength steel, are also key technologies in the industry.

The company launched its first R&D centre in 1997. After being acquired by the motors group, this R&D centre began playing an important role in innovation and the firm's strategy. As the market for steel construction materials and shipbuilding was saturated and in recession after the crisis, there was a transition in the company's product lines from basic steels to automotive materials.

The innovation phases of the firm were organised into three phases: 1) a capability building phase when the firm set up an innovation strategy and invested in R&D capability while recognising a new innovation system to develop higher technological products that had higher profit values; 2) a disruption phase when the firm achieved rapid technological catch-up by restructuring its R&D into an ambidextrous structure; 3) a transitional phase when the company increased the quality of its disruptive products enough to reach mainstream market level and got close to the innovation frontier through its ambidextrous dynamic capability.

Capability building phase

The first phase began when the company started to plan an integrated steel producing system by building a blast furnace. The company set up a long-term strategic plan of “innovation, creation of value and system for technological knowledge”. As the first step of the plan, the company was engaged in three strategic M&As. The company firstly merged with K Industries, Co. which had coal mining and processing technologies. Then, it acquired S Special Steel Co., which had stainless steel technologies. From these two M&As in 2000, the company was able to immediately increase productivity and obtain technologies without further investments. In 2004, the company acquired H.B. Steel, which was producing molten iron from an electric furnace but had huge excess land within their site. This acquisition was important for the company enabling it to almost double the productivity of its electric arc and acquire land to build the new blast furnaces.

As soon as they finalised the M&As, the company attempted to move on to the manufacture of the automotive steel products for the group’s car. However, it did not have the technological capability to produce automotive parts. It is notable that the company developed everything in-house, instead of acquiring the relevant technologies from external sources. An interviewee revealed that the reason behind this was that it is difficult in practice to acquire technology if it is of a high level and related to products that are profitable in the industry. The following quotes strongly illustrate this point:

> *"We had to decide between, either 'Tech Make' or 'Tech Buy'. We tried to buy some technologies or at least have a collaborative relationship with advanced firms, like Thyssenkrupp (TKS), JFE or Bao. But it didn't go well." [Senior manager in the R&D centre]*

He continued:

> *"Because they don't share their technology with a potential rival. Realistically, we just had a few workshops with a German company to share some of the knowhow about running the blast furnace, but nothing about products and technology." [Senior manager in the R&D centre]*

Another interviewee confirmed that collaboration with the external channels was limited to a workshop where knowledge of the operational level production process was exchanged.

> *"We work with a few Japanese, Chinese and ThyssenKrupp in Germany [TKS AG]. We send our engineers to TKS for regular workshops to learn the operations of the blast furnace. But we are not getting anything more than that." [General manager in the R&D centre]*

Without acquiring external technologies, the company needed two competencies in order to develop the technology required for automotive steel products: an innovation strategy and R&D capability. For the innovation strategy, the company firstly clarified three points: 1) what to research, 2) who does the research and 3) how to do this research. For the first point, the company had a clear set of goals that flowed down from group level management through its vertical hierarchy. These were developing technologies of steel sheets for vehicle frames and exteriors and ultra-high strength steel [10] for automobiles (UHSS). Ultra-high strength steel is the most critical technology in the automotive steel industry (see the footnote below for a better understanding of the automotive steel and UHSS).

The following quote illustrates the clear innovation goal and strategy from group managerial level.

> *"The Chairman of the group came to us and told us "the R&D centre should develop all the technologies and be ready before the new blast furnace and steel mill opens in 2007. That was in 2004." [Senior manager in the R&D centre]*

For the second and third points, the group adopted 'early vendor involvement (EVI) system' in their R&D process. EVI, or ESI, is normally a form of vertical collaboration between supply chain partners and a manufacturer that suppliers are involved with at an early stage of new product development. Traditional EVI only considers the

[10] High strength steels are complex, sophisticated materials with carefully selected chemical compositions and multi-phase microstructures that result from precisely controlled heating and cooling processes. They are uniquely lightweight and engineered to meet the challenges of today's vehicles for stringent safety regulations, emissions reduction and solid performance. Advanced high strength steels yield strength levels that are in excess of 550 MPa. Ultra-high strength steels yield levels exceeding 780 MPa (Worldautosteel.org, 2017).

benefits that come from providing better quality and lower costs by ensuring supplier quality assurance (e.g. Weele, 2010). However, this case group formed a horizontal collaboration in which the R&D centre performed as a cluster between three different R&D centres of the group's affiliates. The company called this R&D centre the 'total solution centre'.

This horizontal EVI had some unique characteristics. Under this structure, the researchers from the cars, steel and special steel supplier[11] collaborated from the first stage of developing the cars to the feedback solution, which is even further than the last stage of the actual manufacturing process. In order to be actively involved in the process, researchers from each company had to learn each other's industry and technologies. Throughout this learning, the researchers from the steel company learned how automobile company made the car and what they needed in the design and product specification stage, while the researchers from the car company learned how the steel company made the steel and what they could actually create as a new product or do to improve existing ones, and vice versa. The knowledge and learning process was then applied from the design to the final manufacturing stage.

It is also important that this early vendor involvement innovation process contained continuous real-time feedback learning. The real-time feedback learning significantly reduces the time that is required between the product development stage, through the radical innovation and the product improvement stage, and right through to incremental innovation. Under a normal R&D and business structure, a supplier

[11] Merged with the steel company in 2015.

develops and provides a component [product] to the end manufacturer. Any feedback is obtained after an interval because the end manufacturer should first employ the component in its own final product production and then run prototype tests. It can take longer if the manufacturer collects feedback from the market and customers. Either way, it requires significant time to reflect on the feedback and learning and apply it to the incremental innovations for both the products and processes. In the early vendor involvement process, real-time feedback leads to continuous incremental innovation, as the supplier and manufacturer collaborate in all of the stages in both development and product processes.

The following quote illustrates how the early vendor involvement process works during the design phase:

> *"So we had to learn about cars. And the car company people had to learn about steels. And we shared more than just ideas. We now know how they design and make cars. So we actually suggest the design and specification of a new car, like we go and tell them: 'We can use our new aluminium pillers*[12] *to new models.' The car company people suggest new materials or specifications to us that they want to apply to the new cars."* [*Senior manager in the R&D centre]*

In addition to the sharing knowledge within the system, EVI generates a real-time learning process that encourages incremental innovations whilst performing radical innovations. The quote below highlights this:

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[12] A kind of mainframe component of cars (e.g. front A pillar, middle B pillar, rear C pillar).

> *"We got involved in the early stage of the design, even after the actual manufacturing of the car – this process is what we call 'the total solution'. We also provided feedback and trouble-shooting after we supplied our products to H cars. H cars also gave us feedback, then we fixed, modified or changed our products immediately."* [*Senior manager in the R&D centre]*

Even after the product design and commercialisation phases, EVI stimulates the incremental innovation of further product innovation and process innovation. Based on the information from continuous learning and incremental innovation, the company provides 'after care' and 'trouble-shooting' after they have supplied products to the car company.

The quote below illustrates this aftercare process, which they call 'the total solution system'.

> *"We got involved in the early stage from the design, and even after the actual manufacturing of the car – this process is what we call 'the total solution'. We also provided feedback and trouble-shooting after we supplied our products to H cars. H cars also gave us feedback and then we fixed, modified or changed our products immediately."* [*Senior manager in the R&D centre]*

Important information was provided by an interviewee that demonstrated that the total solution system is not a one-time activity. The critical feature is that it creates a continuous incremental innovation loop for future product development. The quote below gives an example of this loop process.

"Do you know car face lifting? Basically it is the car company that applies newly developed components and systems into existing lines [models]. The total solution system is important for this because we provide increased quality steels to the car company for their next generation models or other upcoming launching models." [Manager in the R&D centre]

This EVI innovation strategy provided a significant advantage for the company as the innovation was able to narrowly focus on specific technological requirements. In other words, the company was able to leverage and reduce the risk, cost and uncertainty of innovation. This innovation strategy and the total R&D centre became the source of the company's rapid catching up and its dynamic capability in the later phase.

Disruptive catching-up phase

The catch-up phase began when the company facilitated its EVI-based R&D system. In 2007, about 200 researchers from the three companies started developing technologies. Without any technological knowledge about automotive steel, the company's catching-up strategy was reverse engineering. This is an imitation process that is carried out by analysing the materials or technologies used in the commercialised final product of advanced producers. From the analysis of cars of advanced producers, such as German and Japanese cars, the researchers tested the recipes of different combinations that were suitable for the steel plates of the firm's own cars.

The quote from an interviewee revealed that they adopted the reversed engineering method as a way of traditional imitation to improve the catching-up innovation.

> *"We disassembled the medium range bestselling ones and the flagship cars from other leading companies, like German and Japanese cars. We used to disassemble 3-4 cars every year to analyse the components and materials of the plates." [R&D engineer in the R&D centre]*

Another interviewee also confirmed this:

> *"We tried to learn about what materials and technologies the other companies used in their steel products. But we did not fully imitate the technology and materials. We started thinking about our own methods and technologies from the analysis. That was the start." [R&D engineer in the R&D centre]*

After this analysis of materials, researchers in the joint team had to clarify to themselves what process they needed. In general, the innovator should consider three factors: 1) the R&D target – what to develop, 2) the cost and 3) the risk/uncertainty from the commercialisation – where to sell the final product and who to. However, this company already had the target, the customer and the market. As it was involved in EVI, it had a realistic set of targets and technological requirements, super-strength steel sheets and lightweight car steel plates for the motors' products. The risk was minimised to almost nothing. This can also be seen in the production of a low standardised, customised small batch, as the products were very customer specific.

The quote below provides a strong indication that there was a minimum level of risk and also that uncertainty was the key in encouraging the radical product innovation.

> *"The group CEO encouraged us to develop own products and technologies. He promised that everything we needed, money [financial support] and everything else would be supplied by the group. He also promised that the car would use most of our production." [Manager in the R&D/strategic department]*

Another interviewee also confirmed that the low risk and uncertainty reduced the speed of catching up innovation.

> *"The motors buy 98% of our production at the moment. So we did not need to think about the failure of commercialisation or the market for our products. I think that is one of the reasons we were able to develop 81 core technologies within only 3 years." [Senior manager in the R&D centre]*

In order to reduce the R&D cost, the company built an integrated mock test facility, which was a mini version of its steel milling factory and process. By using this test lab, the company were able to do experiments on a smaller scale and take feedback from the customer (the motors). Due to these advances, the R&D centre developed 81 core technologies to initiate the manufacturing of steel plates within only 3 years, compared to a timeframe of 10 years for their competitors. Those 81 technologies were all applied to the car company's products.

Initially, these 81 core technologies only applied to the low-lower medium range models, as the quality did not match the standard that was required for the medium and high-end flagship models. This was where disruptive innovation occurred by penetrating into the market with low-end products. It is notable that the company was able to raise the quality very rapidly through incremental innovations and the continuous feedback loop with the customer. By successfully developing high strength steel and then ultra-high strength steel products consecutively, the company moved up to the mainstream market and high-end market. The company also drew near to the technological frontier at this stage.

Transitional phase

At the same time, the company set up their R&D capability for incremental innovation for the outcomes of radical innovation, as they had to provide both feedback and modification of the new technology that was adopted. There are four systems within the R&D centre's system: 1) the research department, which does basic scientific research conducting deep analysis of new and existing materials; 2) the integrated development centre, which develops new high strength steel plates; 3) the iron and steel experiment centre, which focuses on improving the quality of existing product lines; and 4) the rolling experiment centre, which focuses on improving the process of the existing product lines. This is in line with the company's recognition and definition of R&D. Across all of the managerial levels in the firm, all managers had an understanding of R&D. They also understood the difference between radical and incremental innovations, even though they did not use these terms specifically.

The quotes from senior level interviewees show their own definitions of R&D and their understanding of the importance of radical and incremental innovations.

> *"We think that R&D is research for middle to long-term survival, exploring new materials. And development for short-term technological development that brings about the development of existing products – for example, the quality." [Head manager in the R&D centre]*

This quote strongly implies that radical innovations for new product developments are crucial in terms of long-term survival while incremental innovations for existing products are important to sustain competitive advantage in short term. In addition, another quote also implies that the company managers are fully aware of the difference between radical and incremental innovations.

> *"We clearly divided R&D into two steps. 'Research to make new things' and then 'development' after the actual production of it.' [Manager in the strategy department]*

An interesting finding is that the balance between radical and incremental innovations is dynamically changing depending on the stage of the product development.

> *"We equally value the importance of R&D in developing both new product, and process and quality innovation. I would say 50:50. But we sometimes put more focus on quality and performance improvements than we do new*

technology. Maybe 80:20. So it changes, depending on what we need at each point in time. Solving a problem or developing a new one." [Researcher in the R&D centre]

Information from another interviewee explains the reason behind the dynamics of the degree of radical and incremental innovations. As a car development process can be seen as a project of a highly customised product, the focus of innovation is dependent on the phases of a project.

"At the moment, we mainly focus on quality and process R&D, as we just developed new ultra-high strength steels. But we keep looking for opportunities for new products, such as AMP, QNP and TBF, for future car development projects." [Research engineer in the R&D centre]

The interviewees' quotes provide an important insight into how the ambidextrous dynamic capability is not always equally valued, but is employed dynamically, depending on the current situation of the firm. Specifically, incremental innovation was a higher priority than radical innovation after the company had succeeded in catching-up. Nevertheless, the company continued the radical innovation of new ultra-high strength steel (UHSS) for mainstream market products, such as medium and high-end range models.

It was observed that the industry's characteristics determine the degrees of radical and incremental innovation and the focus of the exploitation of dynamic ambidexterity. The velocity of the steel industry is relatively low. The exploration of radical research in a scientific sense is limited, and there is much more emphasis on the exploitation of incremental innovation of process and product performance.

An interviewee was quoted as saying:

> *"In the steel industry, there is no clear distinction between radical and incremental R&D because new ideas usually come out of incremental R&D that make existing ones better [performance and quality]. New ideas for new products come out while testing new combinations of chemical compound or materials." [Senior researcher in the R&D centre]*

Innovation strategy and the structure of ambidexterity

The firm's R&D strategy and the structure of R&D have also changed according to the phases. Before they entered into the automobile steel plates business, the firm's innovation strategy and the role of the R&D centre was focused on reducing the cost of production and increasing the quality of existing steel products. The R&D centre was structured and managed as a separate division.

After they entered into the new business, the firm recognised the importance of innovation capabilities in undertaking the radical innovation that develops products. The firm's strategy of "innovation, creation of value and system for technological knowledge" also reflects that a lot of emphasis was put on technological development. An important finding is that the company's technological strategy clearly states the vision and mission for each innovation phase. As shown in table 11, during the catching up, until 2012, the technology strategy focused on developing basic and relatively low quality steel technologies to initiate the production of automotive steel products. Once the company accomplished catching up by developing 81 technologies, the strategy accordingly changed to develop the technologies that the market demanded at that time.

	Catching up	**Transition**			
	Before 2012	**2012**	**2013**	**2014**	**2015-2016**
Technology Strategies	Basic grades for automotive steels	Basic grades for market needs	Customised steel with high vsalue	Specilised and strategic	Value creation for new demands (leading future market)
Technology specification	High strength steel for automobiles (81 technologies)	Ultra high strength steel (100-120kg) Hot rolled high strength steel (80kg)	High strength outer sheet (60kg, 35kg/SO) High-strength hot rolled alloy steel (60kg, 80kg)	Ultra high strength steel with high formability (120kg, 150kg) Next generation steel (high Mn steel, light weight)	Joint development of steel types using new technologies Developing module testing/interpretation technologies
Innovation structure	Ambidextrous - technological research team plus development team	Horizontal integration (EVI) – In-house R&D plus collaboration with external customers			
Main source of technology	External, In-house R&D	In-house R&D centre integrating customers in the development process			

Table 11. Case B's technology strategies

New strategies, then, were set up to produce more customer specific and customised products that have higher values while simultaneously developing incremental process innovations for existing product lines. The R&D structure was transformed radically and rapidly in order to support these technology strategies and the development of new automobile steel products. The EVI system, which is a form of ambidextrous innovation structure that involves the customer from the early design stage until even after the commercialisation of the product, allowed the firm to catch up on the relevant technologies at a rapid speed, within just 3 years. The prototypes – or the first-generation products – were applied in the lower market models until the quality caught up with the need of the mainstream models. The strategy of the firm also changed to incorporate this shift upmarket: "from the molten iron to the car".

The internal R&D centre provides the competitive internal innovation capabilities that are required to manage the continuous learning that occurs through real-time feedback and to undertake radical and incremental innovations continuously and simultaneously. The quotes below depict how the internal R&D centre supports this.

> *"We also have an integrated mock test facility, which is a mini version of our steel mill factory itself; we run experiments, analysis and feedback through it. So, for example, when we developed a UHSS steel plate for 'xxxx' model, the car company and we figured out what kind of UHSS plates we needed. Then, we developed prototypes and kept running the prototypes in our mock test facility until we had got the result. This reduced a lot of time and cost." [R&D engineer in the R&D centre]*

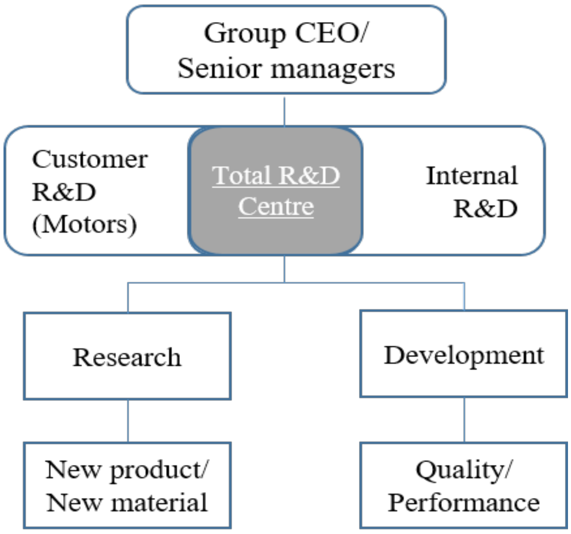

Figure 13. An example illustration of the EVI system

Another interviewee also spoke about the structure and role of each department in the R&D centre:

> *"Within the R&D centre, we have 4 teams [departments] – the Research department, Integrated development centre, Iron making experiment centre and rolling experiment centre. The research centre does the deep analysis of new/existing materials. The integrated centre develops new products like high strength steels. The iron making and rolling centres experiment new ways of doing the cold and hot rolling and pressing method. So they also do process and quality improvements, where we have the best experimental machines and facilities that are brand new." [Senior manager in the R&D centre]*

It can be concluded from this information that the innovation strategy has been set to aid the company's overall strategy of entering into the automotive steel industry and catching up with technologies in a very short period of time. In order to achieve this rapid process of catching up, the company set up a gigantic internal R&D centre that bridged two different industries, the company itself and the car company. This unique R&D strategy and structure was the main driver that led to rapid catching up and to the company's core competitive advantage that led to it moving into the mainstream market and reaching the technological frontier.

Summary of case B

Case B provides many important findings that help to explain how a firm's dynamic capabilities and ambidexterity can speed up the process of catching up and competing against advanced incumbents in the mainstream market. There were three phases in the firm's catching up process – capability building, disruptive catching up and the transitional phase. The management level's core activity during the capability building phase was to set the right innovation strategy, acquire production and R&D capabilities from external sources, and develop internal R&D capabilities to run innovation tasks. The firm developed a unique EVI system that integrated all participants, knowledge, sub-systems and internal and external capabilities that were involved within its R&D centre in order to deal with the innovation conditional factors (target, cost and uncertainty). The innovation process was also managed as a system that integrates everything, from the initial design to final commercialisation. The firm also partially confirmed the disruptive innovation theory that penetrated into the market by initially serving the low-end and then gradually moving up to the mainstream. This explains the market positioning of the latecomers, and yet the company has not reached the technological frontier, whilst other advanced firms, such as German or Japanese ones, have. Thus, it is hard to argue that a full disruption has occurred. Later, in Chapter 7, a full discussion of the case study and its application to the conceptual model will be developed and suggested.

5.4. Case study C – Construction company

The history of the company C's developments

1970s-1994

The company was established in 1994 by the internal merger of an engineering and a construction company that were both under the largest steel company in Korea. The engineering and construction companies took on the role of supporting the steel company. The engineering company was established in 1970 to support the engineering of the blast furnace. The construction company was also established in 1984 for a similar purpose, to supply the construction of the blast furnace of the steel company, as well as maintenance of the facilities.

The group decided the future course of those two companies after finishing the project of the integrated blast furnace in Gwangyang in Korea. At this time the group was facing new business opportunities provided by the integrated blast furnace. The group announced its new vision and goals, as well as the restructuring plan of its subsidiaries. The internal merger of engineering and construction built a strong subsidiary in plant engineering and construction in the global market, as the engineering company had accumulated knowledge in plant engineering and the construction company had accumulated knowledge in plant construction management. Thus, the company's main products were plant and civil engineering and construction until 1994.

1994 – onwards

The company started expanding its business area in the 1990s to include commercial and estates building construction and city development, as the plant construction industry was in recession due to the Korean IMF bailout of 1997[13]. After constructing its first estates building in 1997, the company launched its own apartment complex brand in 2002. In the early 2000s, the company considered city development as a new potential business for the future.

Years	Annual sales (Billion USD)	Number of employees	Number of R&D employees	R&D investments (Million USD)
2009	5.9	2,956	-	23.6
2010	5.5	3,111	-	31.3
2011	5.4	3,535	63	37.4
2012	6.3	4,177	64 / 15	44.1
2013	7.1	4,189	59 / 15	13.5
2014	6.7	5,394	54 / 15	38.9
2015	5.8	5,381	65 / 20	37.9
2016	4.9	5,381	70 /20	14.7

Table 12. Case C's sales, numbers of employees and R&D investments

[13] According to the company history report, the sales plant engineering dropped from 1.4 trillion KRW to 400 billion KRW in 1997 and 1998 (The company history report, 2015).

The table 12 presents the annual sales, numbers of employees and R&D employees and R&D investments of the company in the last 8 years. The fluctuations of the sales are because of the characteristic of the industry that the sector is hugely impacted by the economic situation. It is notable that the company increased R&D investment in 2011 and 2012 when Songdo project began.

Songdo, a city in Korea, was being newly developed at the time and the company decided to enter into the industry by taking part in the project. This project has been selected for a case study because of two reasons. First, this project was a strategic project that the company planned to develop it into a new business model in order to expand the company's business portfolio which previously consisted of three, plant, civil and estate construction. Second, this project was an explorative project that a new-kind-of-innovation project to the company. The project involved the latest technologies and components such as Green energy, IoT and engineering. The case study was designed to explore and examine how the company carried out all explanatory innovations and developed them into a product to transfer to its operation of the company.

Thus, the scope in this case study is the Songdo IBD project, a mega-city development project. Unlike the previous two cases, this company and the construction industry as a whole are project-based, which requires a different perspective and approach to the firm's innovation and capability building. The project is considered as a CoPS project with many different sub-projects, sub-systems and components within it. This was a

10-year project, which implies that the firm's innovation should be understood within the context of the project.

From this case study, the firm's innovation phases in the project can be categorised into three phases: 1) a capability building phase when the company explored external sources and channels for radical innovation and exploited the internal accumulated knowledge of the project; 2) a catching-up phase when the company integrated and applied learning and knowledge from external sources into their internal capabilities through its ambidextrous dynamic capability; 3) a disruptive innovation phase when the company created a new product and market.

Innovation phases of the firm

The innovation phases of the firm started as soon as the company was commissioned for the project. As the project was a breakthrough project, developing new city development technologies was the key issue.

Capability building phase

The capability building phase started when the company formed 'N LLC', a joint venture with Gale international for the Songdo IBD project. The city of Incheon and the government (the customer) requested that the project have some designated features: a compact city that contains all of the convenient facilities, is sustainable and eco-friendly and is an IoT[14]-based smart city. As the project is a new kind of 'vanguard'

[14] IoT- the internet of things

project, the company had to rely on external channels to bring radical innovative ideas and technologies into the project. N LLC assigned KPF, a New York-based architectural firm, to create the master plan. The KPF's preliminary plan included different sectoral sub-projects.

According to the master plan, the company identified which technologies and innovations were required in each of the sub-projects and sub-systems. As table 13 shows, the company had to rely heavily on external technologies to develop new products. It is notable that the company was engaged in inter-firm relationships through many joint ventures, but it did not formally acquire the technologies. Interviewees stated that it was crucial to manage the technology suppliers from the product development stage, due to the nature of the industry.

The quotes below from the interviewees below reveal their perspectives on R&D and the reliance on external sources for innovation in the construction industry.

> *"We are less motivated by doing internal R&D for technologies. But we want innovation, so we always seek potential technologies or partners." [Manager in the R&D department]*

This quote strongly implies that the internalisation of R&D is very weak in this construction company. The reason was found from information from another interviewee:

> *"If we see an [innovation] opportunity, we just find the one who has the technology and involve them in our supply chain. So, managing the technology*

suppliers was the key in the early stage [of planning]." [Senior manager in the R&D department]

A different interviewee also echoed this point by mentioning:

"In the construction industry, we focus on managing suppliers to get them involved in the right project, right place and right process. Unless it is a kind of architectural technologies, it is normally difficult to make or buy a technology." [Manager in the R&D department]

It can be understood that, due to the nature of the business and industry, that construction projects involve various sub-systems that require different technologies and that internal technological development is less attractive. Instead, external exploration and exploitation is the key to deliver the customer's demanding technology into the project.

For the Songdo project, information from the informants revealed that they exploited the external channels for radical innovations. The quote below explains how they set up the innovation target and external exploitation.

"For this Songdo project, the city authority and we set specific things like eco-technology, IT things etc. Cisco was selected because they had the right platform that we were looking for. We also agreed on MOU with universities, IT platform companies, architecture companies and environment technology companies etc" [Manager in the R&D department]

Sub-product type	Open innovation form	Partner
	A compact city facilities	
A leisure facility – a golf resort	Joint venture	Kitson & Partners, Jack Nicklaus
Retail mall complex	Joint venture	Taubman
Educational service sector	Joint venture	ISS (US educational service provider), Milton Academy, NYU, Yonsei Univ.
Hospital	JV/MOU	NY Presbyterian Hospital (MOU) Yonsei Univ. Hospital (JV)
Office sector	Joint venture	LIG, IBM, Samsung
Hotels and residentials	Joint venture	Daewoo construction, P
Landmark towers	Joint venture	Morgan Stanley,
	Sustainability & Eco-friendly	
The Central Park[15]	MOU	ARUP
Underground car parks	JV/MOU	Gale Int., KPF
The seawater canal/ water taxi service	MOU	ARUP
LEED[16] certificate from U.S. Green building council	MOU	USGBC, Hanjin Group, United Technologies Corporation
Low-energy consumption technologies	Joint venture	Cisco, GE, LG CNS, U-Life
	IoT – Smart city	
IT network infrastructure	JV/MOU	LG CNS, Microsoft, IBM, GE Korea, SK Telecom, Cisco

[15] Inspired by Central Park in New York City in US
[16] LEED – Leadership in Energy and Environmental Design.

Ubiquitous system infrastructure[17]	JV/MOU	LG CNS, SK Telecom, Posco IoTM U-Life, LLC.

Table 13. Sub-products and systems installed in the project and type of inter-firm partnerships

Another interviewee explains the process of external exploration.

> *"We identified what and who we needed for this and that. Then we collaborated with the best leading partners in their area. For things that we can do by ourselves, like [building] apartments, subway, waste plants and infrastructure, we have been doing that. For Smart city, IT, Eco-energy technologies – those things we cannot do ourselves – we collaborated with other companies." [Senior manager in the R&D department]*

This information from the interviewees implies that the project can be divided into two categories – the type of products and the sources of external technologies. For new products where radical innovations were required, the firm explored and exploited external channels. For existing products, the firm utilised its routinised current business base, where it had accumulated knowledge from experience. For example, the company built 19 apartment complexes in the city and each complex sector has more than 2500 households.

[17] Ubiquitous system for home application control, security, integrated traffic control, disaster management system etc.

Catching up phase

The catching up phase started when the company integrated the external technologies with its routinised business-based products. In order to implement and achieve one of the features of the city – the eco-green, sustainable and smart city – the company formed joint ventures with GE Korea and Cisco International to cooperate on the development of environmental friendly products, infrastructures and solutions. At city level, numerous new technologies were applied, such as a citywide pneumatic waste disposal system that does not need garbage collection trucks, a self-sustaining irrigation system in the Central Park and the technological infrastructure that linked all of the sub-systems of all the buildings in the city in order to measure and monitor energy consumption.

The firm later applied all of these external technologies into their existing business products, the residential apartments. For instance, all apartment buildings have eco-friendly features that are approved by LEED. By applying the pneumatic waste disposal system, all the apartment buildings have a central waste collection system. Once trash is disposed through a collection point on each floor, the vacuum pump blows it to the central waste collection facility that is 1.5-2 miles away from the apartment; each residence has an energy monitoring system that generates real-time consumption reports. Low U value windows are used in buildings, as well as LED lights, a water-cooled air conditioning system and solar energy, which reduces energy consumption in each building by 30%.

IoT technologies were also applied to the buildings. In order to set up a large city scale IoT infrastructure, the company set up a joint venture with Gale, LG CNS[18] and CISCO Int. Gale later agreed on a MOU contract with Microsoft. IBM and SK telecom[19] also participated in the smart city project. At the city level, they set up an integrated IT system that collects all of the city's information in the central controlling centre. For instance, real-time traffic controlling, emergency traffic accident control, city security service, public facilities management etc are all controlled by the central system. The company recently developed its own IoT products for its apartments that work on the Zigbee system that reduces energy consumption and transfers small amounts of information by using WiFi. By using these products, residents can control all of their energy consumption, door locks and home electronics on one switch.

The following quotes from interviewees revealed how the knowledge that had been learned from the project had been transferred into their existing products and business routines.

> *"We wanted to implement an eco-friendly idea, not only to the city, but also in our apartments and buildings. Our R&D centre played a key role in applying these technologies. Their job was to find one that could be applied to our apartments and figure out how we could implement it." [Senior employee in the R&D/strategic department]*

[18] One of LG's subsidiaries that provides IT, network and system integration solutions.
[19] The biggest network provider in Korea.

From this information it can be understood that the R&D centre was in charge of transferring the knowledge into the firm's existing business. In other words, project-level of technological learning turned over to firm-level of product developments. Another interviewee explained this with a detailed example:

> *"From what we learned from the project, we adopted and applied them in our apartments. We believe the IoT will be the important thing in the residential construction business in the near future. The IoT is now a unique feature of our brand [apartments]. For example, you can control everything in your home on your phone, like switching on and off, gas, lights, heating and anything." [Senior manager in the strategic department]*

This implies that when radical innovations were required for new technologies and products, the firm's capabilities were used to search an innovative opportunity through external channels. Internal capabilities were deployed to transfer knowledge that was learnt from the project into the firm's knowledge level. In other words, the company's catching-up phase was the process of internalising the knowledge gained from the project.

Disruptive and transitional innovation phase

A disruptive innovation phase was found where the firm created a new city planning business from the learning and knowledge gained from the project. From the experience of the Songdo IDB project, the company expanded the city development to a whole product package. Unlike other developers, who were involved in, or provide, a specific phase of the development, this package included a city-level development, the design of the master plan and a sub-project operational level that included the construction of apartments, commercial buildings and convenience facilities in the large-scale project.

The company is developing a new city called 'Splendora' in Vietnam as a joint venture with a local public construction company. The company designed the master plan and also built the apartments and villas. In order to meet the customer's requirements, the company modified some specifications of the existing products through incremental innovations. For example, a different type of material was used on the outer structure of buildings to prevent issues resulting from the humid climate.

Interviewees said that they had to modify some features of the city development plan in order to adopt the different requirements of the customer.

> *"The humid climate is one of the important issues for the Vietnam project. They have different cultures and weather, so we tested new materials for the apartments. Paints, floor materials, cement etc are developed for the project."*
> *[Manager in the R&D centre]*

From this quote, it is possible to find that the customer's specific demand is the most important determinant of technologies used in a project. However, the company was also achieving the economies of repetition (Davies and Brady, 2016) by applying standardised routines and re-use technological knowledge from the Songdo project. The quote below confirms this:

"We put in many similar things in Vietnam, just like we did in Songdo, like the park, educational sector, our branded apartments and retail complex. You can say the city looks pretty like Songdo." [Manager in R&D centre]

This implies that the company created a new product – a city development as a product package – by assimilating the learning, knowledge, technologies and experience from the vanguard project. In other words, a disruptive innovation occurred through routinising the non-routinised activities by learning from the vanguard project and including this into the firm's existing business base.

Innovation strategy and the structure of ambidexterity

The firm was seen to have a different approach towards innovation strategy and structure. Interviewees noted that the degree of innovation and the speed of technological advance was significantly low in the construction industry. Moreover, the technology is not the direct source of the firm's competitive advantage in construction. An interviewee identified the main role of the R&D department as:

"One of the tasks [in our R&D centre] is to find innovative opportunities. We do research into what new technologies are out there and how we can implement them in our future projects. I think innovation just means finding something new or a new way of doing something. Mostly new things come from suppliers. They suggest a different method of building, for example." [Senior employee in the R&D department]

It is notable that the interviewee's definition of innovation is largely inclined to the exploration of new innovation opportunities, rather than the internal – also external – exploitation.

This also explains why the firm's R&D structure has a high degree of externalisation and a low degree of internal R&D, as the locus of innovation is not in-house. Instead, the innovation capability is much more emphasised in the management of tacit knowledge and the learning and routinisation of non-routine activities that evolve during a project. Based on the information from the interviewees, it was possible to discover the main key role that the R&D centre plays in exploration of innovation opportunities was uncovered. As the company produces highly customised project-based products, it is important to meet the customer's specific requirements.

The technology strategy of the company reflects the innovation strategy. In the firm level perspective, the catching up phase started from 1994 when the company was established to support its owner group's main affiliated company, P steel. The focus of the firm activities and innovations was on developing plant and civil engineering technologies to build, operate and maintain the furnace facilities. Transitioning phase started from 1997 when the company moved into estate and civil construction business.

The technology strategy aimed to develop necessary architectural and construction technologies while developing plant engineering technologies for existing business. From 2001, the company planned to expand its business portfolio. City development projects were strategically chosen as a new drive for growth. Thus, new technology strategy was set up to carry out the Songdo project and combine new knowledge learned from the project with accumulated construction technologies in order to develop it into a product package.

	Catching up	Transition		
	1994 - 1997	**1997 - 2000**	**2001 – current Songdo project**	
Technology Strategies	Developing plant and civil engineering technologies	Developing plant and civil engineering technologies Developing estate and civil construction technologies	Developing city development technologies Developing process technologies in EPC and plant engineering	Developing city development technologies Developing city development as a new product
Technology specification	Civil engineering and construction technologies Plant (furnace) equipment and engineering technologies	FINEX, EPC (engineering, procurement, construction) plant technologies Architectural, structural and construction technologies	PEPCOM (project planning, engineering, procurement, construction, operation and maintenance)	City design and construction technologies Combining them with accmulated construction technologies
Innovation structure	External collaboration, In-house R&D	External collaboration, In-house R&D	External collaboration, In-house R&D	In-house R&D to internalisation of technology
Main source of technology	External collaboration	External collaboration	External collaboration	Project, in-house R&D

Table 14. Case C’s technology strategies

In the Songdo project, the smart city features, IoT, eco-friendly and sustainability, were all set as the target of radical innovation. In order to bring about these radical innovations, most of the innovative technologies came from external sources. Thus, during the project planning phases, the core activity of the R&D centre was finding the external partners or sources. The radical innovative technologies were later applied, with the core activity of the R&D centre being the assimilation of the technologies into the firm's existing business. By downsizing the technologies from large-scale project level to firm product level, the company was able to develop new sub-products and sub-components in their product lines. Figure 14 illustrates this structure and the process of the R&D centre.

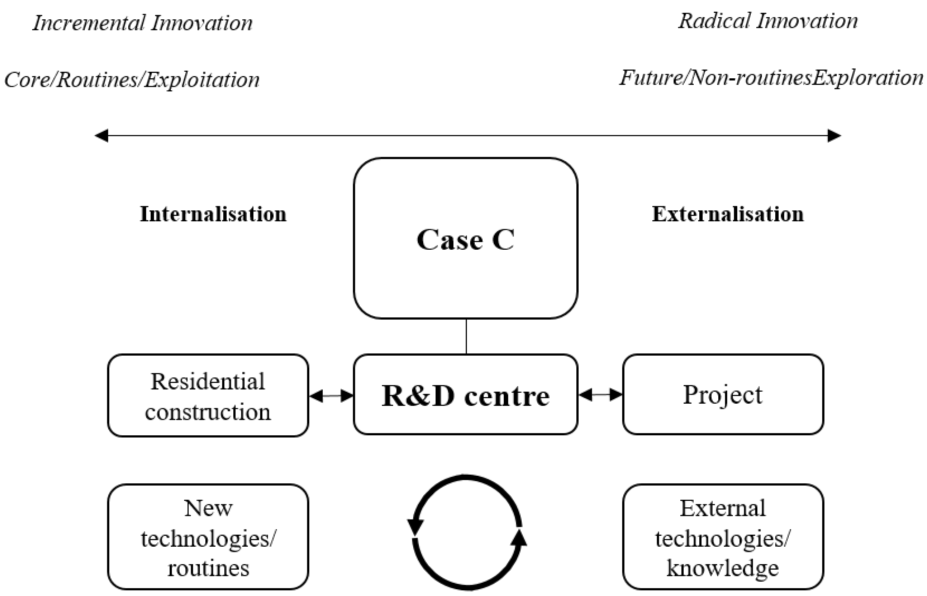

Figure 14. An example illustration of the project-firm level spanning system

Summary of case study C

In conclusion, the project studied in this case study was a large-scale city infrastructure project, a city development that consists of numerous sub-systems, sub-components, systems and stakeholders. The project was a new kind for the firm; thus, it was necessary to explore and exploit external technologies as the mean and source of radical innovations. The firm's internal capabilities were employed to manage those external suppliers. Later, the internal capabilities played a key role in the assimilation of the new technologies and knowledge from the project in the firm's existing routine base. Disruptive innovation was observed when the firm applied the new knowledge and reproduced an improved product along with incremental innovations to meet the requirements of the existing product. In the next chapter, a deeper analysis of how the firm employed its capabilities will be presented.

Chapter Summary

The case studies findings were reported. From the three cases, it must be recognised that case A and B have reached the leading phase and the innovation frontier, but case C has not reached this stage yet. This is due to the characteristic of construction industry that technology does not directly affect product and process developments. As clarified in the literature review in chapter 2, company C produces a CoPS product which contains different levels and various sub-systems and components inside and therefore required a slightly diverted approach compared to the other two cases. Specifically, a project of the company was studied, and the knowledge created and learned from the project was transferred to the firm level for the development of another projects.

It is also essential to recognise that the phases seem not to be strictly separated, but possibly can overlap depending on the current situation of business and environment.

In the next chapter these findings will be discussed and analysed further and reflected in the conceptual model that was presented previously in Chapter 3.

Chapter 6

Analysis of the case study findings

In this chapter, the analysis of the case study findings is presented. It begins with an analysis of individual cases. A cross-case analysis that compares the findings of the individual cases follows. The cross-case analysis offers an important insight into the determinants of latecomer's innovation and dynamic capabilities. Finally, these analyses are reflected and linked to elaborate the findings with previous literature and models.

6.1 Analysis and comparison

Three case studies were conducted in this research. These revealed that the catching-up innovation process is not so much about learning and assimilating advanced technologies and knowledge, but more about building up the firm's capability to develop, modify and sometimes create a new business model, innovation strategy, structure and system that is the most suitable to carry out both radical and incremental innovations. The first important finding from case A is that the assimilation of advanced technologies was the main driver during the early phase of catching-up innovation. This acquisition, assimilation and improvement concept was well addressed in the previous literature. Disruptive innovation was also discovered during this early phase. The low cost and low price strategy served well when the company operated in the low-end market. However, as the firm progressed along the product and business lifecycle, technology acquisition from external sources became complicated and difficult. This case has instead focused on building dynamic capabilities to speed up the catching-up process. The identified form of ambidexterity is a 'trio system' that runs two radical product innovations at the same time, while another team focuses on incremental innovations for the current line of products. When the firm had reached the innovation frontier, this ambidexterity became the firm's competitive advantage that enabled it to maintain technological leadership. This case study is the opposite of a common belief, which is that radical product innovation occurs because of the emergence of a totally new technology or process. Instead, it was found that a new innovative idea and opportunity comes from incremental innovations of existing products as the firm gets closer to the technological frontier (e.g. the technological development of design technology using nano process has enabled the firm to develop larger memory and higher density chips). Dynamic capabilities were the power source of disruption as they played an important role in moving up to the mainstream and high-end market.

Case study B did not follow the classic three stages. Instead, the firm successfully caught up by developing everything in-house through R&D. In order to reduce the time and cost, the company involved the customer in its R&D structure from an early stage. This suggests another form of ambidexterity, called the horizontal integration structure. The dynamic capabilities of this firm lie in its integrated R&D centre. A continuous feedback loop is generated by integrating the customer. Real-time learning from the feedback loop allows the company to undertake both incremental and radical innovations simultaneously. This ambidextrous innovation structure was also the source of disruptive innovation. Disruption occurred when the company produced low quality products for low range car models. The quality of the products increased rapidly through radical and incremental innovations, up to the level of medium range car models.

Case study C is an example of heavy engagement in inter-firm relationships for innovation leading to new radical innovations. The project considered in this research was the Songdo IBD project in Korea. As the company is project-based and a producer of highly customised products, the customer of the project, the government and the city authority, requested new specific features for the project. In order to bring in new technologies, the company engaged in inter-firm relationships, including joint ventures and memorandum of understandings (commonly termed as MOU) as any other CoPS. The dynamic capabilities were used to incorporate project level knowledge into the firm through learning. The R&D centre, which mainly was in charge of seeking innovation opportunities through external partners and channels, was at the centre of integrating the learning from the project into the firm's existing business. By scaling down the knowledge learned, the company achieved new product developments of IoT and smart residential apartments. Furthermore, it created a new business using this accumulated knowledge and the market for a city development as a package. As Davies and Brady (2000) suggest, this is an example of the economies of repetition. Dynamic capabilities were used to achieve the economies of repetition as the firm had to routinise new knowledge and processes that were related to the city development. This is also an example of learning by doing (Arrow, 1971). In order to maintain its existing business in building construction and generate a new business in city development, an ambidextrous structure was formed. This ambidexterity also played a key role in the firm's rapid catching up. Even though the project was a vanguard project – a totally new kind of project that the firm had never accomplished before – the learning and internalisation of project knowledge generated a new type of product for the firm. This was also where the disruption occurred. The disruption here refers to the creation of a new market and product that was different to the type referred to in cases A and B.

Cross-case analysis

Following Yin's (2009) guidelines to cross-case studies, this section provides a cross-case analysis that aggregates and compares the findings of the individual cases. Table 15 presents the factors of firm, innovation and dynamic capabilities.

One of the most important findings from the cross-case analysis was that the importance and degree of dynamic capability and ambidexterity increase, in proportion to the degree of environmental change. This finding echoes the literature in the contingency theory of uncertainty and complexity (Tidd, 2001) and the dynamic capability (Nelson and Winter, 1982, March, 1991, Teece et al., 1997, O'Reily and Tushman, 2008). As a firm is closer to the typical permanent organisation that produces highly standardised mass productive commodities, it faces low complexity.

If the degree of environmental change (uncertainty) is high while the degree of complexity is low, the firm tends to undertake all types of innovations within its internal R&D. Thus, both the size and importance of the internal R&D becomes bigger. The role of the internal R&D is critical as it is the firm's source of competitive advantage through technological advance. As almost every innovation activity is facilitated in-house, the firm should have the capability to deal with both incremental and radical innovation at the same time.

Thus, the importance of dynamic capability and ambidexterity is also high. However, if a firm is a project-based organisation that produces highly customised, unique products, the firm faces a high level of complexity as various sub-components and sub-systems are involved in meeting the requirements of a customer. If the degree of environment change (uncertainty) is low while the degree of complexity is high, the firm tends to engage in open innovation, which appreciates the exploration and exploitation of external channels and technological sources. Accordingly, the role of internal R&D is also focused on the learning of a new innovative idea or technology. The firm's innovation capability is applied to assimilate the new knowledge by transferring the project level innovation to the firm level innovation, or vice versa. It is a critical activity as it becomes the source of new radical innovation that generates a new market or product, a new firm routine and new business model.

Although the degree of dynamic capabilities in each case were slightly different, all the cases that have been studied in this research revealed the importance of ambidexterity in carrying out incremental innovations for existing base business areas and products, and radical innovations for new business markets and products.

		Case A	**Case B**	**Case C**
Firm level context factors	**Industry**	Semi-conductor	Steel/Automotive	Construction
	Type of the firm	Permanent	Permanent/project-based	Project-based
	Type of the firm's product	Standardised / Mass production	Low standardised / High batch production	Customised / Unique project
	Complexity of the firm's product	Low complexity	Fairly complexity	High complexity
Innovation context factors	**The main source of innovation**	Internal	Internal and External (Customer)	External
	The strategic importance of innovation to the firm	Extremely high	High	Low
	The source of competitive advantage	Internal R&D centre	Internal R&D centre/ external collaboration	Innovation supply chain (external collaboration)
	The dominant driver of innovation	Technology (Technology push)	Technology and customer need (Technology & market push)	Customer need (Market push)
Dynamic capability factors	**The degree of environment change**	Extremely High	Moderate-High	Low
	The degree of dynamic capability	Extremely High	High	Low
	The form of ambidexterity	Trio system	Horizontal integration	Spanning structure

Table 15. The cross-case analysis: the factors affect innovation and dynamic capabilities

O'Reily and Tushman (2008) argue that the key to successful ambidexterity is the organisation's alignment of a separate organisational structure for exploration and exploitation. Internalisation happens if a product has a low strategic importance but offers operational leverage.

The findings from the case studies counter their argument by showing that although a product is strategically important and offers benefits to a firm's existing resources and capabilities, it tends to be internalised within a massive internal R&D centre. Furthermore, the successful structure of an ambidextrous organisation is not restricted to separating the exploratory units. Alternatively, a massive R&D centre can form a bridge between exploration and exploitation – radical and incremental innovations.

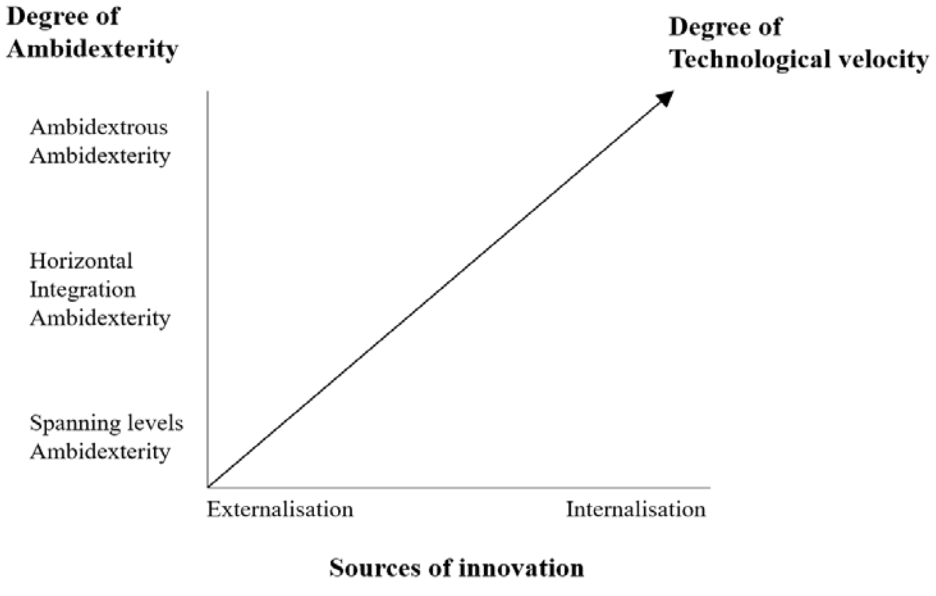

Figure 15. Degree of ambidexterity, technological velocity and sources of innovation

The structure of the R&D centre depends on the degree and importance of external technologies. For instance, case A has multiple internal R&D sub-units within the R&D centre for explorations and exploitation within the centre, while the R&D centre of case B involves its customer within its structure. The main role of the R&D centre of case C was to link project level innovation with firm level innovation. It was also responsible for the internalisation of external radical innovations. This implies that as much as the firm undertakes innovation at project level and is open to external sources, the dynamic capability should be capable of integrating the source in the internalisation process. Internalised knowledge is further developed and assimilated into the firm's routinised business, which generates radical innovation that improves existing products. A vanguard project creates a new business routine for the firm. Case company C created a new business model and product, the city development, from the vanguard project, Songdo project, and then commercialised it as a project level package, which can be viewed as a disruption.

The cross-analysis has important implications as it was found that the latecomer's innovation depended heavily on the determinants of innovation. The determinants of innovation strategy, type and structure discovered in this research were the velocity of the external environment and the degree of uncertainty and complexity. As defined earlier in Chapter 3, the velocity of environments can be measured by considering velocity in technology, product and market demand with industrial context and general product life cycle. In DRAM, the semi-conductor industry (case A), the core technology is the design and fabrication technology, also referred to as node or technology node, which is typically indicated in micro or nano meters. From 1970s till early 1990s, the development speed of these technology was generally between 3-4 years. From the mid-late 1990s, the speed of technological development has rapidly increased and has now reached an average of 1.5-2 years. The speed of new product development and product life cycle is also very short. In terms of demand velocity, as more electronic devices have advanced to offer complex functions, the demand for bigger capacity and smaller size of DRAM has also increased. Thus, the environmental velocity of this industry can be seen as high.

In the automotive steel industry (case B), the focus of the core technology was on the safety issue that became a concern from the 1960s in the U.S. This resulted in more applications of steel in the components of cars in order to meet legal requirements. The technology trend has shifted since the 1990s, which now stresses not only the strength but also the light weight of the steel, to meet the environmental regulations for pollution and the demand from the market for fuel efficiency. Although the importance of the technology for achieving strength and light weight is high, the technological shift from the 1st generation (mild steel) to the 2nd generation (high-strength steel) took almost 20 years (1980s to 2000s). The industry is facing an increasing speed of technological development from the 2nd generation to the 3rd generation (ultra-high strength steel) that is expected to be applied to products in 2020[20]. The demand velocity is relatively low as the safety and light weight are certainly one of the important factors when purchasing a car, but not the main priority

[20] Source: from interviews and a report from Korea Development Bank, ‘Weekly KDB report, 04/06/2018).

such as performance or price. Therefore, the environmental velocity of the automotive steel industry can be seen as medium/high.

In the construction industry (case C), although recently there is a trend of implementing green energy and IoT (internet of things) technologies into construction, the speed of change and development in terms of technology is low as product development is not based on the technological base. The demand for new technology or products are also relatively low as consumers consider other crucial factors such as price, location or tax over the technological feature of products. Thus, the environmental velocity of construction industry can be seen as low.

Under a rapidly changing environment with a high degree of uncertainty, the company tends to internalise its innovation activities, as they are the direct source of its competitive advantage. In contrast, external sources are more likely to be explored and exploited in an environment where technological change is slow and the degree of uncertainty is low. In industries where firms produce highly customised products, such as construction, external exploration and exploitation are crucial for innovation as those products exhibit a high degree of complexity. In other words, due to the fact that a highly complex project consists of various sub-components and sub-systems, a company should rely on external partners to bring about a new innovative idea. The structure of ambidexterity, a form of dynamic capabilities, is also determined by these factors. If a firm's competitive advantage is directly related to technology and its innovation outcome, it tends to have a big in-house R&D and allocate more resources to radical innovations. In this structure, the most critical thing is to operate both radical and incremental innovations simultaneously and continuously. If technology is not a direct source of competitive advantage, more resources are allocated into incremental innovation and organisational learning. A firm's dynamic capabilities enable it to carry this learning and apply the knowledge into the firm so as to develop existing products or routines, or create new products and routinise non-routines.

Linking the findings to the literature and model

Previous models in the literature had emphasised the acquisition of technologies from external sources as being the key activity during the early phase of catching up. However, the findings from case studies A and B suggest that the external acquisition of advanced technologies is challenging due to the fact that incumbents are pessimistic about sharing their technologies, especially if they are advanced and related to their core products. The case studies revealed that the companies acquired and assimilated external tacit knowledge, but it was strictly limited to process technologies, rather than a wide knowledge base that could be applied to product innovation. Due to this 'guarding behaviour', the importance and dependence of both external exploration and exploitation was significantly low. Instead, the companies decided to establish internal R&D capabilities to develop everything in-house. In contrast to existing models, this suggests that catching up innovation does not necessarily follow the linear three stages of importing external technologies and developing them internally in the later stages. In fact, case A and B adopted a reverse engineering strategy that allowed them to find out the technological specifications and detect the level of technology in the existing market. This can be seen as dynamic learning, ‘learning-by-searching’ because the company used the information about advanced technologies to learn the business and technological environment, rather than simply aim for an imitation by learning by doing. Internal technological development through in-house R&D was much more highly emphasised at the early stage.

By contrast, case study C revealed that the external exploration and exploitation of a new innovative idea is crucial in radical product development. When a project is a new type that creates a new business to the firm, external channels are a valuable source of innovation. This can be explained in terms of competitive advantage. Recalling the competitive advantage and resource-based view, knowledge and technologies can be understood as a firm’s peculiar asset and a resource that generates a competitive advantage. In industries where technology is directly related to products, such as the semi-conductor industry in cases A and B, the competitive advantage comes from the firm’s inimitable product and innovative capabilities. The ‘guarding behaviour’ by other advanced incumbents in the market means that latecomers need to possess internal R&D capabilities to develop their own products through radical innovations, and increase the quality and improve the process of the products through incremental innovations. In some industries, where the velocity of technology and changes in the environment are slow, such as construction, innovation and technological development are not the primary source of competitive advantage until the firm generates a new product by integrating new learning with its existing product base.

Rather, the firm's capability of accumulating knowledge and integrating the innovation supply chain becomes the source of its competitive advantage.

There are four common findings across all of the case studies. First, the early phase of catching-up innovation can be understood as a dynamic capability building process. The dynamic capability comes from effective R&D structuring into an ambidextrous firm and the exploration of innovation opportunities. In order to increase internal R&D capability, the companies were engaged in strategic M&As. These M&As were made using a strategic approach to absorb the production capabilities that were required for the core business products. For cases A and B, the R&D centre played a key role in building up the internal R&D capability for radical product innovation, incremental quality and process innovation, in addition to these absorbed capabilities. The R&D centre in company C was not significantly engaged during this phase, but they did help the design phase of each sub-component and system in the project.

Second, the speed of catching up was increased by solving the 'innovator's dilemma' about the risk, cost and commercialisation of innovation. In case A, the R&D centre reduced the risk of innovation failure by running the same radical innovation project with two different teams at two different locations: the parallel system. Despite the fact that this innovation strategy and process increased the cost of the development, it did successfully achieve the firm's managerial strategy that was focused on speed. This also implies that development speed is critical because of the high velocity of the technological change in computer industry, which is one of the characteristics of the industrial velocity[21]. The commercialisation of innovation was solved by having low-end market products. In case B, the R&D centre provided the solution by reducing both the risk and cost of radical innovation through the horizontal integration of two different industries – the EVI. The EVI system allowed the firm to develop new technologies under conditions where their innovation was almost certain. This also reduced the risk of commercialisation as the supplier and customer developed together from the start of the automobile design stage to actual production. In both case C and the project, the risk was leveraged by open innovation. By setting up the joint venture with Gale and the other technology providers, the company was able to significantly reduce the risk and cost of radical innovations.

Third, in the later transitional phase, it was found that dynamic capability was employed and exploited to increase the quality of products through incremental innovation. For case A, the firm reformed the parallel development system into a 'two generations' system that develops further generations simultaneously. Whilst running radical innovations, the firm also ran incremental innovations to raise the profit margins and quality of existing products lines (e.g. increased capacity, low energy consumption and size minimisation). For case B, the immediate feedback loop system under the EVI system enabled the firm to undertake incremental innovation and radical innovation for future product lines. Company C employed the dynamic capability to assimilate the knowledge learned from the project into its existing products. The R&D

[21] The racing to make new next generation computer is not uncommon. A book written by Tracy Kiddler in 1981, called 'The soul of a new machine' also portrayed a turf war between two computer design engineering teams being pushed for designing a next generation computer at a rapid pace under pressure.

centre was in charge of the role of downsizing city-level technologies to building-level ones. In other words, the scale of the technology was decreased from large- scale project level to sub-project level.

Fourth, disruptive innovation occurred when the companies entered into the low-end market by commercialising products with technologies that were developed at the catching-up stage. Then, the quality caught up to mainstream products level during the transitional phase. Thus, the R&D centre was the source of the ambidextrous dynamic capability and disruptive innovation. Company C showed a different type of disruptive innovation that creates a new market with a new product. With the accumulated knowledge they gained from the Songdo IBD project, the company was able to provide a full package of city development from the design service to the construction of residential buildings in Vietnam.

These common findings from the case studies suggest that there are important contrasting facts against the existing theories and models.

1. **The catching-up innovation of latecomers not only follows the simple lifecycle model, but also depends on firm level capability building.**

The linear reversed process model by Kim (1997) and Lee et al. (1988) captured how latecomers employ external channels to accomplish catching up from an almost zero base of technological knowledge. However, the model is ambiguous in the sense that it does not explain how latecomers develop their own products from the in-house development process. It might be impossible to repeat and repeat again the 'acquisition-assimilation-improvement' process when a firm develops a new product. The case studies in this thesis found that firms facilitate learning in order to build their internal capabilities. This also confirmed '*Proposition 1. The catching-up process is also a dynamic capability building process,'* that was made in the conceptual model.

2. **Open innovation is not always the answer for latecomers.**

The open innovation model by Chesbrough (2003) and the corresponding literature (e.g. Enkel et al., 2009, Dahlander and Gann, 2010, Gassmann et al., 2010) argue that the externalisation of R&D is the key in generating value from innovations, and an internal R&D capability is needed to absorb the knowledge (Cohen and Levinthal, 1989). As the open innovation model points out, the case study firms severely exploited external channels to acquire technologies, such as licensing and joint venture, during the early stage. However, it is notable that companies A and B only relied on external technology in incremental innovations and they had a lack of tacit knowledge about manufacturing operations. This thesis argues that the higher the velocity of technological changes and environmental changes, the more firms tend to show 'guarding behaviour' in order to protect their competitive advantage, as they come from a technologically dominant position. In order to decrease external dependency, the companies have built up an internal R&D centre to increase their internal R&D capabilities. Company C, however, was the case that supported open innovation. It is argued that due to the nature of the industrial characteristics of construction, a CoPS project has numerous sub-components and systems, and that sharing technologies for each sub-component is common as they are engaged under formal contracts or inter-firm relationships in the technological supply chain. The internal R&D capability was much emphasised instead and employed in both the learning process and internal product development.

This difference in industrial characteristics implies that the external exploration/exploitation of innovation is useful if the importance of technology in the product, process and velocity of the environment and technological change is low. Accordingly, the importance of the dynamic capability is also low because selective learning occurs when a radical innovative idea is assimilated into the firm’s products. If the importance of technology in the product/process and the velocity of environment and technological change is high, the importance of the dynamic capability is also high as it is directly related to the creation of a competitive advantage.

3. **The form of ambidexterity can vary, depending on the focus of the innovation strategy.**

The case studies support propositions 2, 3 and 4 that:

Proposition 2. Once they possess the capabilities to develop and produce their own products/services, they will transform themselves into an ambidextrous organisation.

Proposition 3. Ambidexterity plays an important role in overcoming 'an innovation dilemma'.

Proposition 4. Firms who successfully exercise dynamic capabilities get into the transitional phase where they compete against incumbents in the mainstream market.

From the case studies, it is clear that ambidexterity is crucial if the firm is to maintain the pace of radical innovation, and also undertake incremental innovation to preserve its performance in the existing market. However, contrary to the argument of Tushman and O'Reilly (1997) and O'Reilly and Tushman (2008), the case studies provide an interesting insight that ambidexterity should not necessarily be limited to having independent teams for each radical and incremental innovation task. Each case study in this thesis developed its own unique form of ambidexterity, depending on the innovation strategy. Regardless of the structure, continuous real-time learning between radical and incremental innovation was at the core of their ambidexterity, and was done simultaneously to make sure that new innovative knowledge was implemented into the final product.

The dynamic capability of ambidexterity can be solved by the innovation dilemma. Specifically, critical counter-evidence against the argument of Hobday, Bessant and Rush (2004) was found. Although Hobday et al. (2004) identified the latecomers' tendency to step back when they reached the innovation frontier and repeat the strategy of following the incumbent's path, the case studies presented here revealed that firms compete against advanced competitors at the frontier. If the latecomers hesitate to operate at the technological frontier and keep the existing strategy of low-price and low-quality imitation, they will either lose their share in the market or fail because of the dynamic market and technological environment and changing customer needs. Thus, in order to survive in the market, latecomers should set up a new strategy to approach the frontier. Indeed, the cases in this thesis suggest that latecomers who successfully reach the frontier search for opportunities for innovation by using incremental innovations. Although it can reasoned that latecomers do not compete at the front frontier, as they have not yet introduced 'a completely new to the market' type of product, this thesis argues that the paradigm shift is extremely rare. For instance, the dominant design of the smartphone has not significantly changed since the first PDA was introduced by IBM in 1994. In particular, case B supports this argument as new process technologies were employed in the development of new radical product innovations.

Chapter Summary

This chapter has provided an analysis of the findings from the case studies. The analysis has revealed three critical elements of latecomers' journey beyond the catching up. First, latecomers' catching up innovation activities can be seen as a dynamic capability building process. The catching up from imitation to improvement serves latecomers well during the initial technological development stage. They subsequently develop dynamic capabilities to trigger low-end market disruption to enter into higher and mass production market segment. Second, in contrast to the concept and model of open innovation and externalisation of innovation, the internalisation of knowledge through its R&D centre is critical. Third, ambidextrous organisational structure is required. The form of ambidexterity varies, depending on the firm’s strategy to deal with the internalisation process and cope with external environments in the industry. The next chapter discusses these in greater depth to revise and develop the conceptual model presented in chapter 3 into a model.

Chapter 7

Discussion and conclusion

This chapter provides a further discussion of the case study findings. Based on evidence from the case studies, it can be argued that latecomers follow four phases of capability building, catching-up, transitional and leading phases, and progress towards the innovation frontier. Nevertheless it was found that transformational innovation capabilities may also be required to progress from catching up status to technological leadership. Thereafter, a summary of the thesis pointing out the key findings is presented and its theoretical contribution and managerial implications are discussed. The chapter , and also this thesis, ends with a discussion of the limitations of this research, and recommendations for future research in the area of latecomer's innovation and mainstream innovation.

7.1 Transformational Innovation Capability model

From the in-depth analysis of the cases in Chapter 6, this research presents the Transformational Innovation Capabilities model which is a revisal of the conceptual model proposed in Chapter 3. In Figure 16, the transformational innovation capability model is recalled from Chapter 3 to enable the reader to understand and visualise the model.

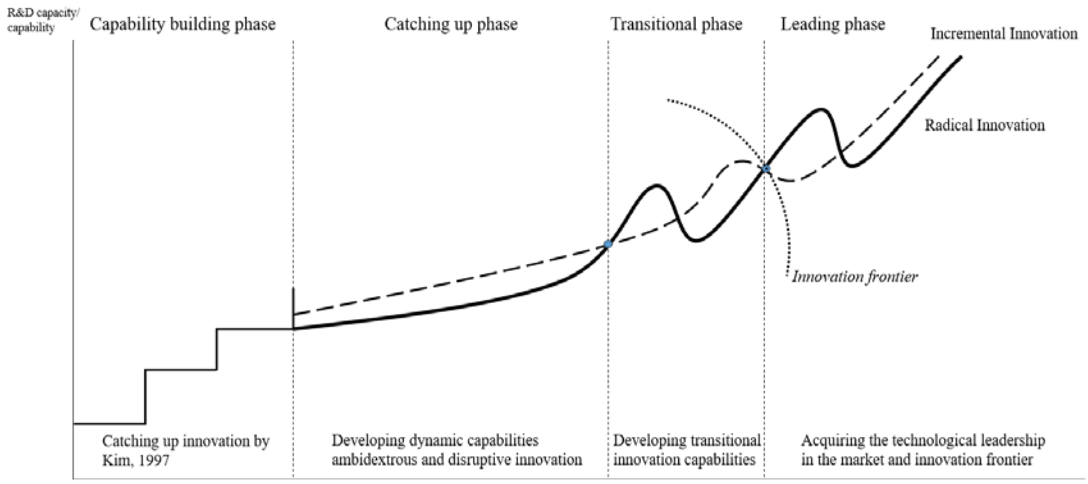

Figure 16. Transformational innovation capability model

Capability building phase

First, latecomers can initially build their own firm capabilities, including R&D, operational (production and process) and project capabilities during the capability building phase by exploring the external channels or exploiting internal resources, or both. This degree of externality or internality depends heavily on an individual firm's choice in accordance with the characteristic and contingency of its industry and environment. The key activity here is the initial set up of an innovation strategy and an appropriate structure for the strategy.

Catching up phase

Once they successfully possess firm capabilities, then radical product innovation and incremental process innovation tend to occur simultaneously. It is notable that the rate of incremental innovation is higher and radical innovation is lower, which is the reverse of the PLC model of Utterback and Abernathy (1975). Over time, the rate of radical innovation has gradually increased. The outcome is the firm's own new product is introduced to the market. This is also where the disruptive innovation occurs as this type of product is produced from low-end technologies and therefore is low priced and low quality for the low-end market. This catching up phase is primarily in the same vein with previous NIC catching up models.

Transitional phase

After achieving successful technological catch-up, latecomers face an intricate dilemma that puts them into a question 'how they can survive along the innovation frontier'.

Findings from the case studies suggest that successful latecomers are required to generate critical 'transformational capabilities' to overcome this dilemma during the transitional phase. The transformational capabilities consist of three core dimensions: successful catch up, disruptive market positioning and ambidexterity. First, successful catching up refers to the process that the previous models established and it has been confirmed with the case studies in this thesis. The catching up process is required to reduce the technological gap between the advanced firms and latecomers. Second, disruptive market positioning is one of the key components of the transformational capabilities. As explained in the previous chapter, disruption occurs by serving low price products to overlooked customers in the low-end market. This disruptive market positioning is important because as the more the latecomer reduce the technological gap, they start moving up to the mass volume market to generate more profits. Third, ambidexterity is at the core of the capability for latecomers to progress towards the high-end market, where profit margins are the highest, and for sustainable advantages in order to compete at the innovation frontier. During this transitional phase, the rate of incremental innovation increases again in order to raise quality so that it is of a high

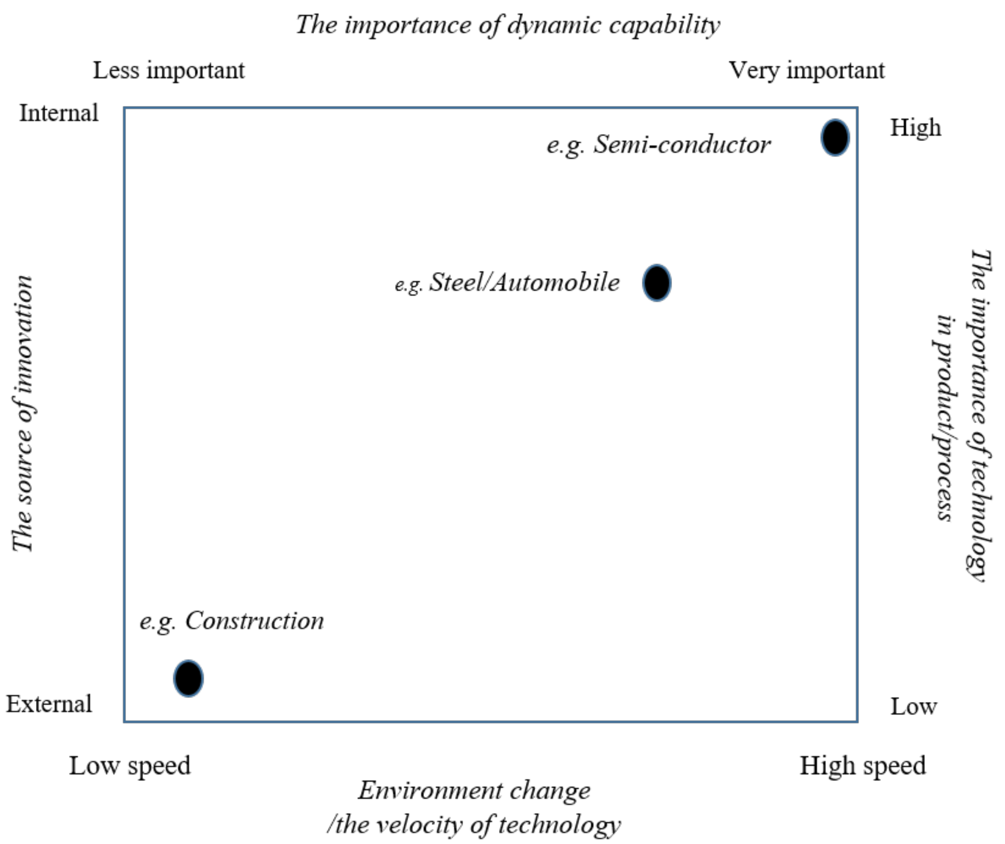

Figure 17. The determinant dimensions of ambidexterity

enough level for the upper markets. In the meantime, radical innovation is also undertaken for the next generation product. Ambidexterity and the dynamic capability should be strategically and effectively employed to cope with both of these higher rates of radical and incremental innovations. It is an important finding that the type and form is determined by the external environment and the velocity of technological development of the industry. In contrast to the spin-off unit structure that was suggested as the ideal structure of ambidextrous organisations by O'Reilly and Tushman (2008), various types of the organisational structure can be employed depending on the environmental velocity. If an industry has high environmental velocity and the importance of technology in product and process is high, the importance of dynamic capability is accordingly high. This may prompt a firm to shape high degree of ambidextrous organisational structure, in order to undertake in-house technological R&D at a blistering pace. If an industry has medium-high velocity and the source of innovation is from both internal and external, a company may have an ambidextrous structure which can involve its customer into its technological development. If an industry has low environmental velocity, the source of innovation is merely from external and work as project-based, the structure of ambidexterity should be able to transfer project level innovations to firm level innovations. Figure 17 shows the determinants of ambidexterity structures. Three types of ambidexterity were found from the case studies: horizontal integration, trio-system and spanning structure. The trio-system, as illustrated in Figure 18, is effective when a firm's reliance is contingent on the rate of technological change and competitiveness of the environment. Especially in certain industries such as IT and computer electronics, radical product innovations should be conducted to cope with the high velocity, competitiveness and uncertainty of technology and the market environment. Moreover, in those industries, technology tends to become the critical source of product and process innovations. By employing two ambidextrous radical innovation systems within the ambidextrous structure, it enables a firm to follow up advanced technologies and generates sustainable competitive advantages to compete at the innovation frontier.

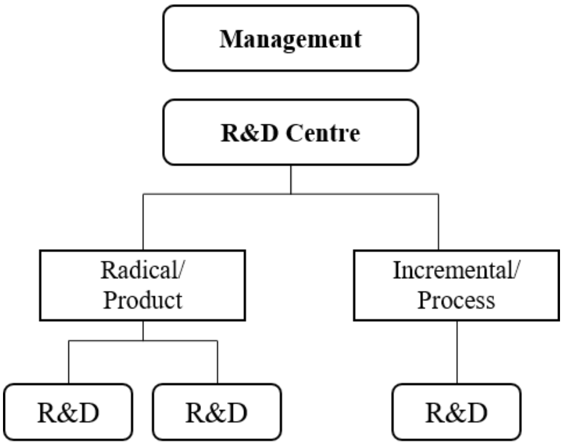

Figure 18. An example of the trio-system structure

The horizontal integration structure is able to cope with a moderate technological and market environment in which the rate of technological change and competitiveness of the environment is relatively high, but the importance of technology in product and process innovations is only moderately high. The main feature of this structure is that it promotes the engagement of external parties (customers or suppliers) within a firm's R&D. By having the customer involved in all stages in innovation activities, a firm is able to facilitate a rapid problem solving arising at any stage in both new product/technology and process innovations. It is also beneficial to provide incremental process innovations after the commercialisation of the technology and product developed from previous radical innovations, as it gathers real time feedback from the customer. Sustainable competitive advantages are generated throughout the whole process of technology co-creation.

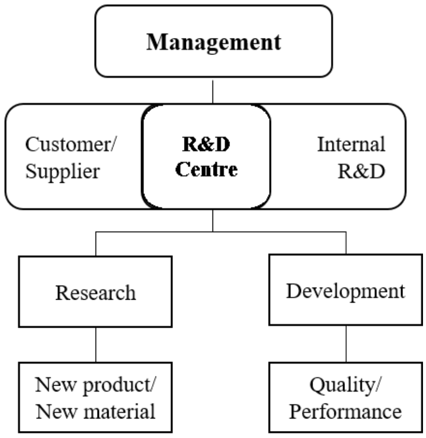

Figure 19. An example of the horizontal integration structure

The spanning structure is suitable for project-based organisations in which innovations happen in projects. In some industries such as construction, innovation tends to occur by learning from projects. As discussed earlier, the concern in innovation in project management is merely on how firms build project capabilities to deliver new technology from project level to firm level (Brady and Davies, 2004, Davies and Brady, 2016). Thus, innovation focuses on developing new process or project routines from new technologies or routines that are learned from projects. Thus, the role of internal R&D is spanning the project level technologies to firm level product developments.

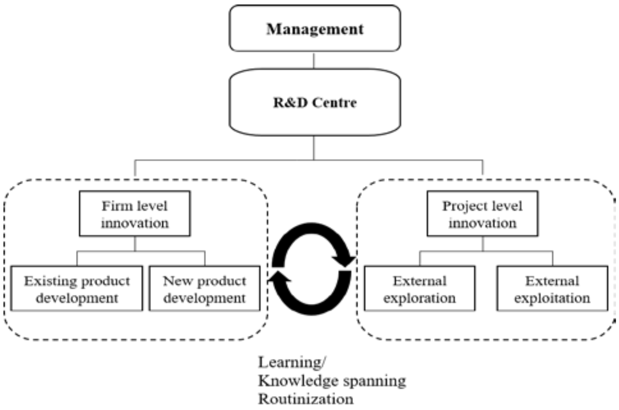

Figure 20. An example of the spanning structure

Leading phase

Once latecomers move through these phases and possess the transformational capabilities, they are no longer catching-up firms; they compete at the innovation frontier as one of the technological leaders. The transformational capabilities which had been generating competitive advantages now become the source of sustainable advantages that allow latecomers to compete at the innovation frontier. Successful latecomers in this stage are one of the technological leaders.

In summary, this dynamic capability model explains how catching-up firms accomplish their rapid technological catch up and are able to compete as one of the players in the mainstream and high-end market. It suggests an interesting insight that dynamic capability building is the most critical factor in catching up innovation, which is something that previous models neglect to consider.

A latecomer's catch-up innovation can be carried out both externally and internally if a company meets two conditional innovation settings. These are: 1) setting up an integrated internal R&D structure that is capable of solving 'the innovator's dilemma'; 2) dynamic capabilities that can hold radical and incremental innovation concurrently through a real-time feedback loop system. The cases also support the idea of disruptive innovation, in terms of explaining how ambidexterity helps disruptors to move into the mainstream market.

7.2 Conclusion

Overview of the thesis

The main objective of this research was to revitalise innovation theory in the context of NICs, as stated in the introductory chapter. The research started after the author became deeply inspired by key literature about NIC-based innovation (Lee et al., 1988, Kim, 1997, Hobday, 2005 and Hobday, Bessant and Rush, 2004). Interestingly, NIC-based innovation has not proliferated, even though this literature was introduced two decades ago. Considering that the business, technology and innovation environment is now much more complex and dynamic than it was, and the latecomers studied in the literature have begun performing in the mainstream market and competing against incumbents that they have caught up. In order to address this purpose, the research question that guided this thesis is 'how latecomers become leaders'. In order to answer this question, the abductive mode of research was employed with the aim of departing from what is missing in the existing literature and the existing innovation models. A conceptual model was conducted with a set of assumptions and propositions made, based on the literature review and modern perspectives in strategic innovation, dynamic capabilities view of the firm and disruptive innovation. Then, empirical data – three case studies with a semi-conductor, an automotive steel and a construction company – have been analysed. From the findings of these case studies, the conceptual model has been revised in order to suggest a new way of thinking about NIC-based catching up innovation. Key findings of the case studies are summarised in the following section.

Summary of key findings

What the case study findings show is that latecomer's catching-up innovation is not merely about reducing the technological gap. Indeed, the catching-up innovation process should be considered in a broader perspective. All three cases show that ambidexterity, a form of dynamic capability, is the critical driving factor in catch-up innovation. However, the catching-up innovation processes were significantly different because of the determinant factors. Case study A shows that catching-up innovation depends heavily on the velocity of environmental changes. As the industry is mainly driven by technology, the key factor is the speed of innovation. In order to achieve this speed, the firm set up an ambidextrous structure of R&D that undertook radical and incremental innovations simultaneously and continuously. This unique structure of ambidexterity, which runs two radical product developments concurrently, helped the firm to reduce the gap rapidly, and later it became the source of the firm's competitive advantage when it reached the innovation frontier. Case B shows that the speed of catching up can be accelerated by involving the customer in the early phase of innovations. This form of R&D was the key factor in developing dynamic capability as it created a continuous feedback loop for radical and incremental innovations. Case C relies heavily on external sources for radical innovations. The dynamic capabilities are applied so as to transfer new innovative knowledge into the existing business, and also to create a new business area that provides a city development and construction as a package.

The cross-analysis of the cases suggests that there are various factors and determinants in latecomers' innovation. The type of firm and its product are related to the degree of uncertainty and complexity there is. The degree of uncertainty and complexity also determines the technological source of the innovation. Depending on the internal or external dependency, the form of ambidexterity and the degree of dynamic capabilities vary from a centralised and radical innovation focus to a decentralised and learning span focus.

These findings challenge the core idea and concepts of the existing models and previous literature and also the simple dimensional perspective of latecomer innovation. The next section explains the theoretical contributions that this research provides.

Theoretical contributions

This thesis makes contributions to three main areas of innovation. First, it suggests a new theoretical framework that will increase our understanding of NIC-based, latecomers' innovation models. The most important references were selected among a large volume of literature and were made the focus. Lee et al. (1988) and Kim (1997) introduced an insightful model which states that catching-up innovation occurs as a reversed process of the product lifecycle model. By catching up through acquisition, assimilation and improvement phases, latecomers can reduce the technological gap. Hobday (1995, 2005) confirmed this model with findings from the Korean cases and those of other East Asian firms. Hobday, Bessant and Rush (2004) then expanded the idea, arguing the latecomer's innovation dilemma by examining the Korean firms' approach towards the innovation frontier. Although the literature provided a valid and powerful theoretical lens, its focus and locus did not seem appropriate for recent environments where the velocity of technological change and the uncertainty of market conditions are higher than in 1990s, or even the early 2000s. Under these dynamic conditions, the simple approach of 'from imitation to innovation' lacked explanatory power. Moreover, there has been an increased level of competition between market push firms to achieve sustainable competitive advantages. Thus, successful latecomers do not seem to hesitate in competing against incumbents in the mainstream market and at the innovation frontier. This thesis argues that the dynamic capabilities view of the firm is a more appropriate approach as the catching-up innovation process has become more complex and complicated. However, even the literature about ambidexterity and ambidextrous organisations do not discuss possible structures and forms that successfully address both radical and incremental innovations. This is the thesis's second area of contribution.

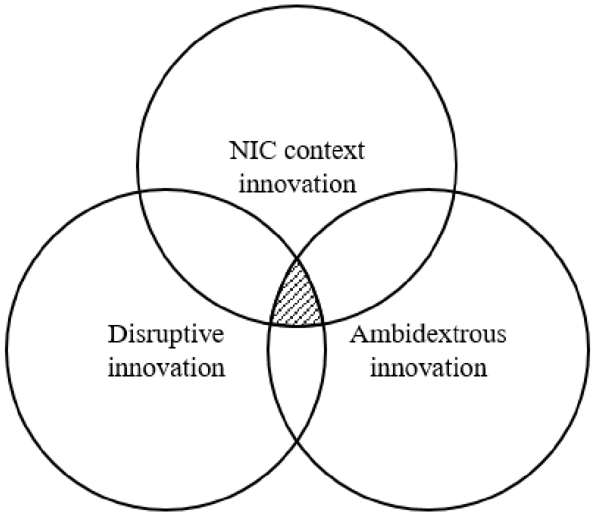

Figure 21. Theoretical contributions

As mentioned in the literature review, O'Reilly and Tushman (2008) suggested a form of ambidexterity where another unit was just separated to undertake radical innovations that deal with dynamic environment changes. However, this thesis argues that there can be many different forms of ambidexterity as a result of the firm's innovation strategy and contingencies from the dynamic environment. Three ambidextrous structures were discovered and suggested in this thesis.

The third and last theoretical area where this thesis makes a contribution is the theory of disruptive innovation. As discussed in the literature review, the concept of disruption has been mainly used to address the entrepreneur behaviour of creating a new market and value network that eventually displaces existing incumbents and their products by disrupting an existing market and value network (Christensen, 1997). Another usage of the concept is 'low-end disruption', where a disruptor begins by serving customers in the low-end market. By gradually improving the quality and performance of the product, the disruptor can gain a foothold in the mainstream and enter into the high-end market to improve its profit margin (Christensen, 1997, Christensen et al., 2015). This thesis has applied the disruptive innovation theory to explain the market positioning of latecomers. Although Christensen and his colleagues viewed a disruptor as an opportunistic entrepreneur who focuses on the under-valued segment of a market, this thesis argues that latecomers naturally serve the low-end market due to their lack of technologies, and their strategy of low cost, price and quality. Once the latecomer successfully serves the segment, it seeks higher profit margins. In order to move up to the mainstream and high-end markets, where profit margins are much higher, innovation becomes the key activity for the latecomer, as this will enable it to raise the quality of its products up to the level that customers demand. Thus, successful latecomers are disruptors who successfully gain a foothold in the market and compete against incumbents – advanced firms. This new method of approach and perspective widens up the applicability of disruptive innovation theory.

Limitations and recommendations for future research

The last section of this chapter and the thesis addresses the limitations to this research and suggests recommendations for the future research. First, a weakness and limitation of this research is that the case studies were conducted with only Korean companies. It might be argued that this is a serious disadvantage that impacts on the generalisability of the proposed model that has been developed from the study’s findings, as it cannot necessarily be applied to other country settings. Indeed, there is a concern that Korea is a very unique and successful case of rapid catching up among developing countries. As the studies on Latin America represent, successful catching up and innovation transformation does not merely depend upon firm-level factors, but also significantly affected by institutional frameworks, policies and socio- and economic-technological factors. Hobday, Rush and Bessant (2004) pointed out this concern earlier. Hence, there is no recent distinctive role model that other latecomers might be inspired to follow, both academically and in practice. This research was undertaken to push the theoretical frontier of NIC's catching-up innovation, with the hope of suggesting a role model for other latecomers. Thus, generalisability is a low priority in this research. If further research is conducted, it could take into account different national contexts and different histories, strategies, cultures and national level of settings, including government policies, social factors and industrial characteristics.

Second, another limitation concerns the fact that the research analysis was directed content analysis that used concepts developed by existing theories. This might raise issues of bias and reliability. In fact, the rise of the grounded theory or mixed methodology was meant to deal with the validity, bias and reliability of the theory-laden methodology. This limitation was countered by the fact that the key departing literature was widely cited and peer-reviewed by top-level journal publications, which provides some strength to its credibility. Furthermore, the same companies that the pieces of research studied were also studied in this thesis. Therefore, this way of replicating the case studies has offset the weakness of potential bias and unreliability.

Third, the research has only focused on the managerial level of perspective in the case studies. In fact, innovation activities include factors at various levels such as organisational structure, characteristic, strategy, systems and finance at macro level, and finance, human resource, management, leadership, behaviour and social network at micro level. Furthermore, the research did not consider statistical or econometric factors in-depth. Although they are prominent factors in innovation studies, as Hobday (2007) warned, conventional indicators do not adequately capture the dynamics of change in latecomer firms strive to move beyond their existing capability levels. The research also has not tackled the other factors to examine if they play a role or affect in the different stages during transition and transformational innovation capability building. It was not possible to trace back all the information about innovation activities, people involved in each activity, detailed financial data (e.g. R&D spending) and other organisational factors for each case for almost 10 years of period. Thus, the level of the case studies and analysis in this thesis was designed to provide a top level/managerial and strategic insight in conceptualising the dynamic process and the dominant direction of the transformation from latecomer to leader positions. Future research should conduct deeper and wider lower levels studies to find the micro mechanism of the transitional process and analyse different levels of factors.

Fourth, the model's flexibility should be acknowledged. The model has been developed with three cases in each industry. Therefore, it might have certain limitations if it is to be applied to other firms in the same industry or different industries. Further, the factors that drive the market environment of each industry were not considered in this research due to the scope of the research. The case C, the construction company, represents a case that a project based firm can facilitate innovation at the project level, and transfer the knowledge to the operational level in the firm. However, this research could not reach to a conclusion that the product developed from a project can be produced repeatedly after its first project in Vietnam, as Brady and Davies called 'the economies of repetition'. To enhance the solidity of the model, it would be prudent to gather and receive more data from more samples in each sector and across different industries.

This thesis has proposed a new perspective on NIC-based innovation models by arguing that latecomers can hold competitive positions when they reach the innovation frontier through catching up innovation and transformational capability building. It is hoped that it has encouraged a new shifting way of thinking that latecomers can be viewed as breaking out disruptors from bottom to up markets. In both mainstream innovation research and NIC innovation research, it would be important to study the model presented in this thesis in another countries or industries settings to enhance the understandings. Although this thesis set the scope and context as NIC, and specifically Korea, future works could be extended to even developed countries-based context to examine if latecomers in developed economies can follow the phases and adapt the transformational capabilities to reach the frontier.

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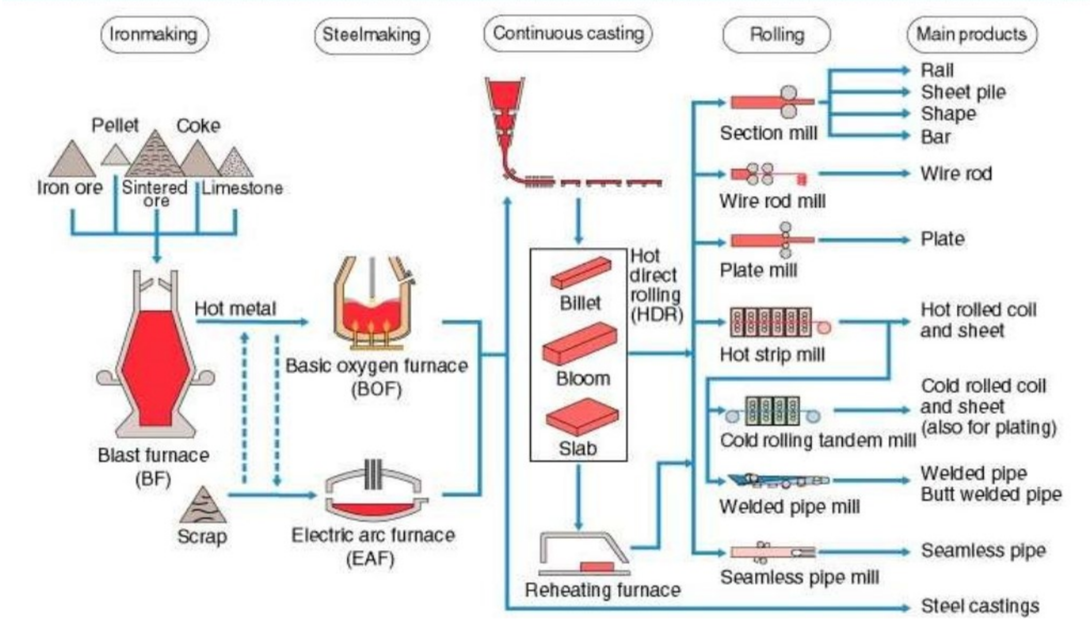
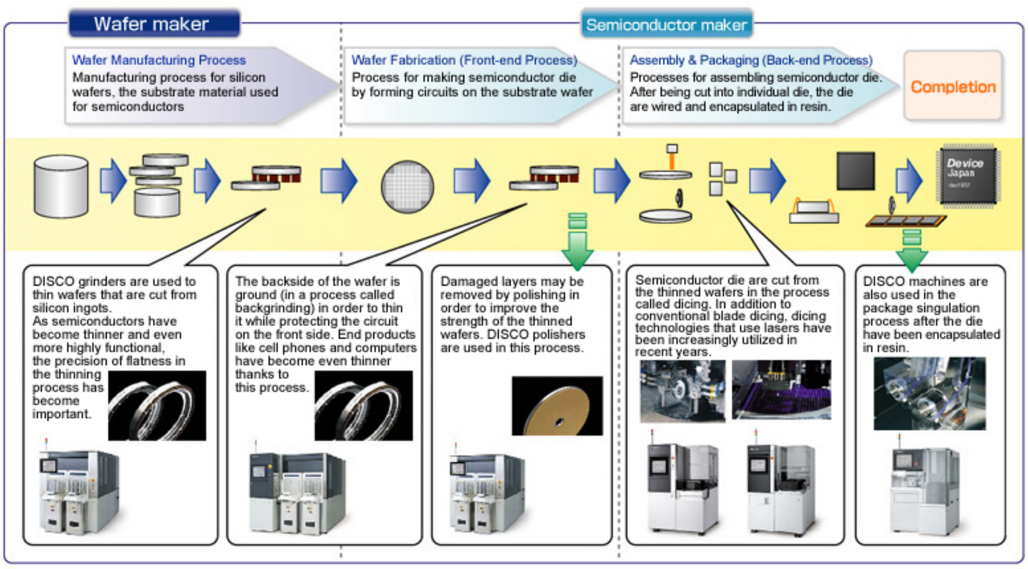
Appendix 1



The manufacturing process of iron and steel to help the understandings.

(Image found from google)



The manufacturing process of semi-conductor to help the understandings.

(Image found from google)

A picture of Songdo IBD, the case project of the case study C