The birth, growth, and dynamics of innovation systems in less-favoured regions: A case study on the Optics Valley of China, Wuhan

By

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DECLARATION

I, Tian MIAO, 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.

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ABSTRACT

Science parks (SPs) have been gaining momentum worldwide in the new century as a concrete way of promoting high-tech industries. In China, industrial and science parks of various kinds have become an important device not only to boost innovation but also to alleviate the severe regional disparities. Nevertheless, due to defective political auditing and data constraints, the birth, growth, and dynamics of these cultivated clusters, as well as their present contributions, are still little understood.

This PhD thesis develops the theoretical and empirical understanding of SPs as instruments of innovation promotion and regional development in less-favoured countries/regions from the standpoint of innovation system theory. It argues that the existing theoretical foundation underpinning SPs needs revision by a framework that takes account of historic evolution and relationship patterns, and that the existing empirical studies need to be moved beyond political evaluations which neglect temporal and spatial differences and the multi-dimensions of these SPs. The outcome of this thesis is an eclectic four-quadrant model for analysing the dynamics of SPs, which is employed in an original case study on the Optics Valley of China, Wuhan (OVC).

The thesis focuses on one particular high-tech industry, optoelectronics, in OVC. Original data are obtained through an extensive face-to-face questionnaire survey of 138 companies, as well as 55 interviews with representatives of public institutions and private agencies on different levels. Qualitative analysis reveals a rich growth history of this potential innovation system, which is accompanied by profound power redistributions between different domains and a strong government intervention. Quantitative analysis investigates the influence of companies' entrepreneurship, internal resources, and external environment on their general and innovation performance. The results reveal the multiple dimensions of companies' entrepreneurship and the diverse factors that influence companies' economic and innovation achievements.

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Chapter 1 Introduction

1.1 Research background

Local and regional development has long been a global issue. Notwithstanding the long-lasting debates on the convergent or divergent spatial development results (Myrdal 1957; Gerschenkron 1962; Hirschman 1970; Barro et al. 1991; Chatterji 1992), it is increasingly accepted that acute inequalities between different territories have deepened (Pike et al. 2006b). How to counter and reduce this imbalance has been one of the main targets for governments ever since the early 1930s, and was widely accepted shortly after World War II (Hall 2007). Early practices during the 1960s and 1970s were mainly concerned with allocating loans and grants to firms located in under-developed areas, restricting further congestion in the established urban centres, or providing 'tax holidays', rent relief and subsidies in order to attract inward investment to assisted regions (Hall 1999). However, many of these efforts have left behind some 'branch economies' (Phelps 2009), because the high value-added jobs, such as management, design, and R & D, remain concentrating within the metropolitan centres (Hall 1999). The severe economic depression and profound social and institutional reorganization from the late 1970s and early 1980s called into question 'the old verities concerning the pattern, causes, and cures of the regional problem' (Townroe & Martin 1992).

Several bodies of literature are worth noting for their plausible explanations to the patterns of regional development. On the micro-level, the early exploration on firms' location choices was dominated by econometric calculations of such factors like transport cost and weight of inputs (Isard 1956), whose sustaining influence would still be found in the so-called New Economic Geography School (Krugman 1993; Fujita & Thisse 1996; Krugman 1998). However, the quickly emerging information technologies not only improve the efficiency of communication and transportation, but also give prominence to human capital and creative ideas – the most mobile input on a company's production lines. Therefore, this simplified econometric analysis of a region's attraction is incomplete, if not misleading, to account for its industrial patterns. On the community level, the existence of agglomeration economies, which are external to any single company but internal to the whole community, was elaborated by Marshall (1961) as early as 1890, and continuously being refined (Hoover 1937; Jacobs 1970; Moseley 1974; Storper & Christopherson 1987). However, what this Marshallian school fails to explain is the birth of a vibrant cluster in the first place (Braunerhjelm & Feldman 2006), as well as the fluctuations of an agglomeration over time. When the worldwide economy slowed down in the 1980s and more recently since 2008, it was arguably the third strand of literature – the cyclical theory – that attracted the greatest interest (see Freeman et al. 1982; Hall & Preston 1988). Scholars refer to Kondratieff's long wave theory, and especially Schumpeter's (1934; 1939) 'creative destruction' explanations, to explain the dramatic technological, social, and economic changes in different times and spaces. At the core of Schumpeter's theory is the entrepreneurship, which accelerates the innovation rate at times of crisis, and eases the product-consumption imbalance inherent to capitalism. To many observers (Castells 1996; Freeman & Louca 2001), the emerging information technology is the most suitable candidate as the next 'carrier wave'.

The strongest evidence supporting these scholars' beliefs is arguably the enabling capability of the information technology (IT). This is to say that IT can be seen as a general-purpose technology, whose application in many industries would significantly improve the productivity of the whole industrial chain. Nevertheless, different sectors may benefit differentially from the IT revolution, resulting in a widening gap between their growth rates: the resource-based extractive industries, such as coal-mining, are less likely to shift their manufacturing mode because of the IT industry. It is arguably the innovation intensive and creative intensive sectors, such as the biotechnology industry and the creative industries (Florida 2003; Markusen et al. 2008), that gain the greatest momentum from this revolution. Therefore what the information technology brings to our daily life is not only the electronic products per se, but also the rapid transformation, emergence, and expansion of a collection of industrial sectors, whose fundamental inputs are knowledge, ideas, and innovations. These knowledge-intensive sectors, in turn, are becoming the most strategic wealth generators for many countries and regions.

It is therefore not surprising to find that IT and its enabled high-tech sectors have attracted increasing attentions from scholars and governments. However, the unsolved yet crucial questions, are where the next high-tech cluster will be, and whether we can build one wherever and whenever we want from scratch. No easy answers have yet been offered because of the concurrent process of globalization and agglomeration. On one hand, the IT revolution is bringing forward a ‘globalized society’, in which financial, human capital, and production flows are increasingly organised on a global scale by the multinational corporations (MNCs), whose activities have noticeably blurred the territorial boundaries between states (Amin & Thrift 1994; Pike et al. 2006c). On the other hand, the location choices of these MNCs are increasingly determined by the ‘top hierarchical’ resources in specific regions or cities (Michael 1998), which in turn implies that the spatial agglomeration of these international players would be reinforced in some regions while diluted in others.

Nevertheless, the theoretical importance and political temptation of these two questions still motivate a steady stream of studies. To the first question, both theoretical and empirical explorations seem to point to two distinct types of spatial layouts: the first nurturing environment for high-tech industries, as convincingly illustrated by such famous scholars like Jacobs (1970; 1985) and Hall (1994b; 1996; 1998), is the well-established metropolitan areas such as New York, Paris, and London. These advanced urban agglomerations are not only melting pots with diversified economies and cultures, but also function as the most important nodes on the global value chain and information networks (Hall & Pain 2006). In contrast, the second geographical environment that proves popular with the high-tech industries could be profiled as the landscape with limited history of urbanization and industrialization. According to Hall (1985) and many others (Scott 1993; Castells & Hall 1994b; Feldman & Braunerhjelm 2006), the reasons for the popularity of these greenfield areas could be attributed to their weak union organizations, less-formalized industrial regulations, and lack of established power hierarchy, all of which are attractive to free-minded entrepreneurs and rule-breakers.

Among the above two spatial profiles, it is arguably the second type that triggers the most vigorous political imagination and enthusiasm – because contrary to the limited number of metropolitan centres, the greenfield areas within a territory boundary are widely available, especially in the less-favoured regions. Combined with the tremendous growth promise brought by the high-tech sectors, it is not surprising to find corresponding changes in government policies. On the national level, power decentralization to regional or local levels is highly noticeable, with the latter now taking more responsibilities for their indigenous development (Hall & Mark 2011). On the local level, the regional and local governments are now closely monitoring and studying the prototypes of the world's leading high-tech clusters with a modest start, hoping that one day they would become the next high-tech star. One seemingly common feature among the leading clusters, such as Silicon Valley in the US and Cambridge in the UK, stands out prominently, i.e., the existence of purposely developed facilities that catering for innovation activates, incubating small and medium enterprises (SMEs), and cross-fertilizing the knowledge institutes and private sector (Moore & Spires 1983; Glasson et al. 1988).

These knowledge facilities differ significantly from each other in practice regarding their names, scales, and structures, but their fundamental appeal, as summarised by the International Association of Science Parks (IASP 2002), is to promote regional and local economic development and competitiveness through nourishing a culture of innovation, providing a habitat for innovation activities, and setting up a platform for knowledge circulation and cooperation. The general name of '*Science Park*' is adopted in this study while acknowledging the diversified terms used in their real-life practices. As an institutional innovation (Stankiewicz 1998), the diffusion and adoption of the science park model also exhibit a noticeable geographical pattern (Phillimore & Joseph 2003), starting from the US then diffused to UK and the continental Europe. Now the Asia Pacific regions have gradually become the main experimental field of the science parks since the new century.

China, in particular, has relied on the science park model heavily to promote industrialization, urbanization, and modernization. Moreover, the decentralized management responsibility of science parks also makes them a promising way of relieving regional disparities. However, besides the 'good intentions' of the public sectors shared between China and many other countries, the science park practice in this country bears many unique features worthy of closer study. First and foremost, China is still the largest transitional economy in the world. The Chinese science parks in particular were conceived in a trial-and-error manner at the conjunction of this dramatic transformation era. As a result, the profiles and operations of these science parks have been left with a clear impression of China's dual-track economy pattern, which provides a fascinating case study in its own right. This evolving and transforming background has further affected the power adjustments and reallocations on different spaces and places, and thus to a great extent determines other characteristics of China's science parks. Second, the genesis and growth of China's high-tech clusters lack the spontaneity and dynamics observed in the west, which in turn is mainly derived from the fact that China's market foundation and institutional architectures are still taking shape. As a result, most of the noteworthy high-tech agglomerations in China overlap spatially with its science parks, the latter of which are essentially cultivated by the governments on different levels. Therefore, any study on China's high-tech industries and science parks requires sufficient attention to its government policies and interventions, a task that is normally regarded as of secondary importance in the western literatures. The related third feature of China's science parks is derived from the power relocations in the political domain. While China has followed the global trend in allocating more responsibilities to the local level, the sustained power struggles between central and local governments, between different industrial sectors, and between different regions are still prevalent. The regional and local governments not only have to compete intensely for favours from Beijing and from MNCs, but also have a long way to go before they master the art of incorporative governance (Pike et al. 2006a). The result is the existence of numerous *embryonic* local and regional innovation systems, on which the science parks are being constructed. This feature nevertheless offers a much needed contemporary case study for tracing the genesis of a potentially innovation-productive system.

All these distinctive features of China's science parks merit further exploration and discussion. However, the poor data availability, defective political auditing, and even linguistic obstacles have made China one of the least studied cases in the science park literature. What is more, the limited English publications on this matter almost exclusively focused on the flagship projects in the coastal regions, such as Z-Park in Beijing (see for example Cao 2004; Dai & Liu 2009) and Zhanjiang in Shanghai (see Wang & Zeng 2006), whose favourable metropolitan positions, histories, and locations make them the exception rather than the rule, and are difficult to duplicate in the hinterland. Therefore the urgent questions to be answered are how a potential innovation-productive system would emerge and grow in the less-favoured inland regions of China, and how it would interact and contribute to the wider regional development and regional parity. These are the fundamental questions that motivate and inspire this PhD study.

1.2 Disciplinary origins and existing work

Any review of the existing literature on the geography of innovation must start with the work of Joseph Schumpeter, who led the first research strand on innovation that focuses on entrepreneurs and entrepreneurship. For Schumpeter, innovation is 'setting up of a new production function…it breaks off any physical return 'curve' and replaces it by another' (Schumpeter 1939, p84). Entrepreneurs are important carriers in both radical and incremental innovations: They look for and seize market and/or technological opportunities quickly and bravely by bringing applicable inventions to the commercialization stage (Schumpeter 1939; Freeman, Clark, & Soete 1982). Although Schumpeter did not provide a clear answer to such fundamental questions like how and where entrepreneurship would emerge, his followers nevertheless have provided some tentative answers. Feldman and his colleagues (2001; 2005; 2007), for example, referred to the so-called 'entrepreneurship opportunity cost' – the expected cost for a potential entrepreneur to start his own company – to explain the entrepreneurial spark that later framed the biotech cluster in the Washington DC area. Geographically, this traditional Schumpeterian school assumes that the potential entrepreneurs are equally distributed throughout the regions as a proportion of their total population (Feldman & Francis 2003); unique shocks and historical events in a region will break the risk-reward balance for these inert entrepreneurs. However, relying on the irregular shocks to account for the entrepreneurial sparks arguably makes things unpredictable, and leaves little space for public intervention.

The second and arguably most influential research strand by now tries to understand companies' innovation activities through organisational analysis. Statistically, researchers in this school are concerned with identifying and evaluating both internal and external factors that would influence a company's innovation decisions and outcomes. Age, size, technological segmentation, and R & D activities are the widely-cited internal factors (Cohen 1995; Freeman & Soete 1997; Bottazzi et al. 2005), while market sophistication, input-output linkage, and agglomeration effect are prominent explanatory variables from companies' external environment (Audretsch & Feldman 1996b; Carter 2007). Dynamically, this organisational innovation school stands out most promisingly in its account of companies' life cycles. According to the resource-based view of the company (Wernerfelt 1984; Conner 1991; Conner & Prahalad 1996; Alvarez & Busenitz 2001), different innovation strategies are perused by firms at different stages of the product and the industry. This diversity and dynamic in turn needs to be complemented by different knowledge and skills, many of which are sourced from outside the companies. This out-sourcing process, implied by Schumpeter and explicitly advocated by Vannevar Bush (1945), was assumed to follow a linear process: starting with basic research, followed by applied research and development, and ending with production and diffusion (Godin 2006). However, the 'learning-by-doing' (Arrow 1962; Romer 1990) and 'learning-by-using' (Rosenberg 1982) proposals uncovered the chain-linked, interactive nature of innovation process (Kline & Rosenberg 1986). Nevertheless, companies are the dominant concerns of this school, which are usually regarded as self-sustained and independent from each other. Relatedly, the intangible social fabrics, such as norms, culture, behavior codes, and trust, are mostly left untouched because they are difficult to incorporate into standard economic analysis.

The third analytic approach is rooted within a much broader literature base – evolutionary institutional theory. Students in this school argue for a 'relational return' to the innovation analysis in space and place (Sunley 2008), and they pay much more attention to the intangible assets within a company as well as the interdependences between the innovation actors (Harrison 1992; Valentin 2002; Yeung 2002; Belussi 2006). An innovation network, composed of private and public sectors, is one of the key concepts in evolutionary thinking (Dacin et al. 2002). Moreover, an interactive and co-evolutionary path creation, path development, and path reformation process is deemed as crucial in understanding the dynamics of any local industry (Martin 2010), which implies that a region's unique institutional characteristics and development trajectory merit a close analysis.

Within this research strand, one quickly emerging literature is innovation system (IS) theory, proposed almost synchronously by Nelson and Winter (1982), Freeman (1987), and Lundvall (1985) in the mid-1980s. Scholars in this branch argue that in order to understand the development, diffusion, and utilization of innovations, more attentions should be paid to the institutional factors and their co-evolutionary with the economic activities (Edquist 2005). The compatibility and networks between the innovation components within a system in turn determine the efficiency of knowledge circulation. Evolving with time, this knowledge sharing and networking will gradually nourish a thick systematic synergy (Castells & Hall 1994b) and place the whole innovation system on a competitive position. While this theory is attributed as one of the most comprehensive explanations regarding the innovation process and its dynamic characteristic (Mothe and Paquet 1998), it is still silent on many crucial questions, such as how an innovation system could gradually take shape. Expanding and improving the IS theory is therefore necessary to make it widely applicable.

The science park model is argued in this study as a practical way of building an IS from scratch, which is also a more concrete planning concept compared with the flexible term of 'innovation system'. Therefore, a close monitoring of the genesis and growth of a science park could shed light on the dynamics of an IS, although the former may not necessarily be the most efficient way of constructing it (Grayson 1993; Felsenstein 1994; Castells & Hall 1994b). In comparison, studies on science parks have been lagging behind those on innovations, resulting mainly from their limited visibility in the 1960s and 1970s. Since the 1980s, however, there have been at least three waves of studies on science parks. These debates and refining, in turn, have significantly enriched the science park literature in scope and scale. Nevertheless, some crucial gaps still remain to be filled, especially in the context of developing/transitional countries. Chapter two will review these progresses and limitations in detail.

1.3 Research aim and research questions

Set against the wider research rationale on exploring the geography of potential high-tech clusters, and the limitations of existing research on science parks, the aim of this study is to analyse the system building dynamics brought by science parks against the backdrops of developing/transitional regions. One case study on the so-called Optics Valley of China (OVC), a national-level science park in Central China, will be conducted from the standpoint of innovation system theory, which requires an explicit consideration of the institutional factors and the innovation networks. However, the deficiencies of the IS theory need to be overcome first. By doing so, this research seeks to add to the innovation system theory and science park literature on the characters and dynamics of the top-down genesis mode of science parks characterized in Asia and other developing/transitional countries.

In order to reach this research aim, four questions will be addressed. <u>First, how was OVC conceived and generated in the first place?</u> Within this broad question, the author will seek to explore the international, national and regional backgrounds underpinning OVC's genesis, and to identify the decisive factors leading to its birth, if there were any. <u>Second, what did OVC's growth trajectory look like?</u> The sub-questions include what were the crucial moments along its history, and how did the relationships between the various components look like and change along its growth. <u>Third, what were the interactions and power (re)distributions like between the different layers of ISs as OVC developed?</u> Especially, what were the parallel relationships between different local innovation systems in China? And how did the interactions present themselves vertically across the political layers? Against the historical background and institutional settings, <u>the last enquiry asks what is the current performance of OVC?</u> The author will look into the profiles of on-park companies, their knowledge seeking and learning activities; the constitution and functions of OVC's institutional environment; and the interactions between the various system components.

1.4 Methodology

This study utilises both deductive and inductive methods by moving between theoretical construction and empirical study. Given the contemporary and explorative nature of this research, the method of case study is most plausible (Yin 1994; 2006). More specially, one case study based on Optics Valley of China (OVC) was adopted, in order to explore the dynamic of a science park and the co-evolution of the components within an IS that located in a less-favoured region of China. Within this general research methodology, two broad approaches comprising of both qualitative and quantitative methods will be applied. The first one is collecting secondary data through reviewing previous studies and relevant documents. However, this method could not contribute to the current research significantly because of the paucity of studies on OVC – actually the author could only find one PhD thesis published in English (Wang 2009) that had a short section devoted to OVC. The second but most important method is collecting original data through questionnaire survey of the optoelectronic companies, as well as interviewing the managers of companies, government officers on different levels, and public institutes. The information gained in turn provides the main data source for quantitative analysis. The statistical analysis software of SPSS 15.0 is utilised on arranging and analyzing the vast database, whereas Atlas.ti will be relied on to organise and analyse the interview and secondary data.

1.5 Summary: structure of the thesis

This PhD research aims at tapping into the genesis and dynamic of an on-going system construction process in Central China. Bearing in mind this research aim, the whole thesis is divided into nine chapters besides this introduction. Each chapter will focus on a different explanatory concern, but all hold together by the fundamental research target of this study.

Chapter two will embark on developing a conceptual framework for assessing the dynamics of science parks. After reviewing a large amount of available literature on science parks, the author is able to identify several urgent research gaps in the existing studies. Among these limitations, the author believes that the unrealistic theoretical assumption cast on science parks, namely the linear view of the innovation process, is the one that needs to be updated most urgently, and that science parks should be treated as an organic system instead of just being a container of economic activities. It is this aspiration that directs the author to adopt the emerging innovation system theory, as the latter pays attention to the whole forest instead of a single tree. Chapter two thus starts with a detailed review of the innovation system literature, trying to identify both its merits and limitations, as well as to find the junction between this theory and the science park practices. A four-quadrant dynamic conceptual model is constructed in this chapter as the main achievement of the above efforts. As will be illustrated in detail later, this four-quadrant model incorporates the virtues of the resource-based view of the firm and the entrepreneurship study to counter the weak explanatory power of the innovation system at the micro level.

Chapter three will bring this theoretical exploration one step further by giving it a contemporary taste. More specifically, this chapter will concentrate on reviewing and comparing some famous science parks in the world, which not only provides a preliminary test for the four-quadrant conceptual model, but also places OVC within a wider context. Five representative science parks are chosen from the US, UK, France, India, and Taiwan respectively. Furthermore, three factors are deemed as influential in their diversified growth trajectories: 1) the leader(s) of the innovation system; 2) the growth engine for its dynamic and; 3) the relative efficiency of this system to promote innovation and strengthen its competitiveness. Before comparing these features with the flagship science park in mainland China, however, the wider reform history of China is summarised first, with the aim to provide the backdrop of the national and regional innovation systems of China in general, and its science park practices in particular. Based on this wider setting, the Z-Park in Beijing is briefly reviewed. A tentative taxonomy of science parks is reached at the end of this chapter by comparing the six science parks. Although noticeable diversifications would be identified in practice between these different types of science parks, the four-quadrant conceptual analysis model generally works well and lives up to its explanation power. Therefore it has the promise in exploring the Optics Valley of China.

The four-quadrant conceptual model proposed in chapter two and the science park taxonomy elaborated in chapter three, on the other hand, is highly abstract and simplified. As a result, how to test this model and to apply it in reality needs to be solved before starting the empirical work. Chapter four is dedicated to this task. In this chapter, detailed information on the methodologies utilised in this study will be provided and justified; the specific industrial and geographical boundaries will be defined. Moreover, the readers will be introduced to the difficulties of accessing to the secondary information in China, let alone obtaining primary data. The importance of personal relationship is highlighted here.

Departing from chapter five, the focus will be on the genesis, growth, and performance of a concrete science park (OVC) in Central China. Chapter five to chapter seven will reconstruct the history of OVC mainly assisted by secondary data, starting from its genesis in the late 1980s (chapter five), to the slow departure during the 1990s (chapter six), and then its recent leap-forward since the new century (chapter seven). The focus of chapter five is to address the first research question on the birth of a cultivated science park in Central China, while chapters six and seven are concerned with the growth and dynamics of this local innovation system. The relationship between different layers' innovation systems, raised by question three, will also be the main concern of these three chapters. Here, the history-friendly approach adopted by the author has the potential of exposing a much richer story on the dynamic of a local innovation system in a less-favoured region. Furthermore, the evolutionary trajectory of OVC will convincingly justify the author's earlier argument, i.e., science parks cannot be evaluated from their static performance and contributions per se, but have to be put into the course of history and their embedded environment for a better understanding.

It is against these wider social and institutional backgrounds that chapters eight and nine start to examine the performance of the on-park optoelectronic companies, and the interactions between companies and their institutional environment. The focus of chapter eight is to shed light on the fourth research question, i.e., the general profiles of the optoelectronic companies located on OVC. Moreover, it is also in this chapter that some conventional wisdom will be challenged. Chapter nine takes the foregoing quantitative analysis one-step further by statistically testing the four-quadrant model. The general economic and innovation performance of the surveyed companies will be tentatively explained by: 1) their internal resources, 2) their entrepreneurship levels, and 3) the institutional environment and the systematic networks.

By now, the four research questions raised before have been duly addressed. It is time therefore, for chapter ten to review the main conclusions, and to summarise the lessons learnt from this study. Plausible political recommendations from this research and possible future work will also be elaborated there. Figure 1-1 below signposts the structure of the whole thesis.

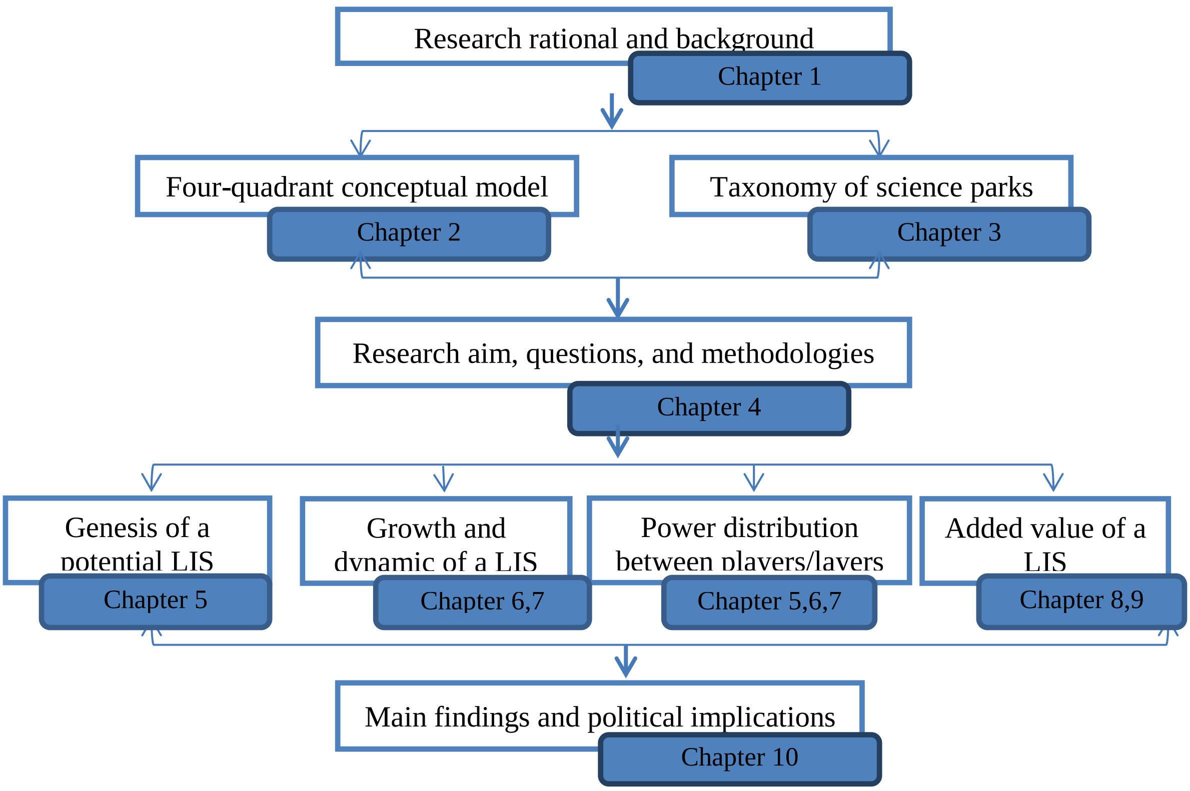

Figure 1-1 Structure of this thesis

Source: the author

Chapter 2 Innovation system, the four-quadrant model, and science park phenomenon

The concept of the innovation system (IS) was first proposed in the 1980s by Bengt-Åke Lundvall (1985), Christopher Freeman (1988) and Richard Nelson (1988). Since then it has been steadily emerging as a catch-word both in the academic and the politics world. Sitting at the intersection of institutional economics and evolutionary economics, the theory of innovation system emphasizes the role of institutions and their interactions with economic actors in the process of technology development. Moreover, it also embeds the framework of institutions within the historical development of a state and its regions, instead of taking a snapshot of the established institutional architecture. The definitions of the IS vary on different geographical and sectorial levels. However, the key ideas shared by most researchers in this school are the importance of knowledge, learning, and networking. By focusing on knowledge accumulation and circulation, the IS theory manages to link together the various actors in the process of knowledge production, diffusion, and utilization. A harmonious relationship and co-evolution between these actors and their environment are crucial for achieving long-term competitive advantages.

By adopting an organic viewpoint on technology change, IS theory holds a high potential to depict a relatively complete picture of the science park phenomenon. In saying that, the deficiencies of this theory need to be supplemented in order to fulfill its explanatory capability. This chapter aims to explore this emerging theory, and more importantly, to develop a conceptual framework that develops the current IS theory. In what follows, the background and definition of the IS will be introduced first. Then it will focus on the three key concepts underpinning the IS theory, and its weaknesses that remain to be improved. Section three will present a four-quadrant framework that builds on the IS theory. The potential of this four-quadrant model in evaluating the science park phenomenon is the theme of the last section, which also links up the theoretical and the empirical analyses of this thesis.

2.1 Theoretical background and definition of innovation system

As acknowledged by the forerunners of innovation system theory (Lundvall 1992a;Nelson 1993;Freeman 1995;Freeman & Soete 1997; 2002), Friedrich List is the ancestor of the original idea of IS. In his book *The National System of Political Economy* (List 1856), List criticized Adam Smith's narrow definition of national wealth, and pointed out that 'the property of a nation does not depend…on the quantity of riches and of exchangeable values it possesses, but upon the degree in which the productive power is developed' (List 1856, p222-3). This 'productive power', if expressed in today's language, is the solidified knowledge stored in the techno-institutional spheres and a nation's continuous learning capabilities. It derives from the overall productivity of a nation's industrial systems, which in turn are mutually dependent on each other (List 1856, p77). What is more important, this 'productive power' is influenced by the broader institutional environment, which in turn is dynamic and accumulative. So List had implicitly suggested many essentials of the modern IS theory, such as the distinction between the economic structure and the institutional environment (Lundvall 1992a); the importance of treating the economy as a whole; the value of state and its unique culture, language, political and civil status (Freeman 1995); the continuity of the wealth production process (Siegel et al. 2003b), and the necessary to marriage manufacturing with sciences and arts (Hall 1998).

However, List's idea was largely forgotten or ignored by the mainstream economists, because institutional factors were difficult to include into formal economic models. It was until the beginning of the 1980s that several researchers begun to realize the silence of institutions within these simplistic economic assumptions. Later on, other specifications on IS also emerged. For example, Breschi with colleagues (1997) developed the idea of 'sectorial innovation systems', while Carlsson et al. (1995) proposed the concept of 'technological systems'. On the geographical level, the regional innovation system (RIS) has developed quickly since the mid-1990s (Lundvall 2007c, p100). Cooke (2004; 2004; 2005; 2007), Asheim and Gertler (2005), and Maskell and Malmberg (1997) are the pioneers in the regional innovation system (RIS) school.

Literally, there is no universally accepted definition of innovation systems even today (OECD 1997). Nevertheless, a closer inspection of the existing studies could identify some consensus regarding the critical questions of 'who', 'what', and 'how' for any theory construction (Whetten 1989;Maskell and Kebir 2006). 'Who' should be included in the system depends on whether a 'narrow sense' or a 'broad sense' of analysis is taken (Lundvall 1992a). In the narrow definition of IS, only the institutions directly involved in producing, diffusing, and using knowledge are regarded as relevant. In the broader sense, however, even the above institutions are considered 'embedding in a much wider socio-economic system in which political and cultural influences as well as economic policies help to determine the scale, direction and relative success of all innovative activities' (Freeman 2002, p194). Now this broad definition is gaining in popularity, because it provides more space for scholars to take into consideration the specific context of their target studies. Lundvall (1992a, p13) even argued that 'a definition of the system of innovation must, to a certain degree, be kept open and flexible regarding which sub-systems should be included and which processes should be studied'.

Regarding the 'what' question, researchers generally agree that the main functions of the IS include producing and diffusing economically useful knowledge (Lundvall 1992c), promoting learning (Freeman 1987;Patel and Pavitt 1994), leveraging the innovation performance of the firms (Nelson 1993;Edquist 2005), and thus contributing to the local or national economic welfare (Lundvall 2007b). Knowledge is regarded as the most important resource contributing to firms' competitive advantage, and learning has substituted rational choice making as the most important activities for firms to improve their market status (Lundvall 1992a). 'How' to achieve these functions largely depends on the interactions and complementarity among various actors that are either directly or indirectly involved in the innovation process, as the knowledge and resources required in the innovation process have far exceeded the capability of any individual firm. The term 'innovation system' used in this study builds on earlier contributions, especially Metcalfe's (1995, p462) definition, and refers to *firms and the relative institutions within specific geographical boundaries, whose interactions with each other or linkages with actors outside the boundaries contribute to the product, store, diffuse, and use of economically useful* *knowledge, provide innovation incentives and opportunities, and thus promote both the firms' and the whole areas' innovation performance.*

2.2 Key concepts within innovation system theory

Like many emerging theories, the concept of innovation system is still being defined and polished through debate. This section will focus on three concepts that are central to the IS theory, namely: the structure of the IS, its functions, and its dynamics.

2.2.1 Systematical structure and the innovation process

According to Schumpeter (1939, p80), there are five types of innovations, including new product, new process, new market, new sources of supply, and new forms of organization. Lundvall (2007b, p13), however, disagreed with this classification, arguing that a division between technological and institutional innovation is enough and important, because 'the distinction makes it possible to link technical innovation to economic performance'. This simpler dichotomy is viewed by the author as a step forward compared with the Schumpeterian school's heroic entrepreneurs (Hansen 1972), because it takes the institutional environment into consideration.

Following this dichotomy, Lundvall (1992c) further suggested two spheres of the innovation system: one is the prevailing economic structure and the other is the institutional architecture. The economic structure is deemed as the core of any IS, which comprises all the firms and the institutions that directly relate to knowledge circulation. The wider institutional setting, on the other hand, is regarded as the supporting infrastructures, based on which the core is constructed and fertilized (Lundvall 2007b). Government and the financial sector, for example, are considered as important institutional factors (Lundvall 1992a;Edquist & Johnson 1997;Nelson 2000;Cooke et al. 2004). Moreover, to make this system 'organic', the mere existence of these actors is far less important than their networks and interactions (DeBresson & Amesse 1991;Ernst 2002;Bathelt et al. 2004;Fagerberg et al. 2005;Breschi & Malerba 2005). The linear model of either 'technology push' or 'market pull' is eliminated here. What emerges is 'a process of systems integration and networking', or the so-called 'fifth generation innovation process' (Rothwell 1994, p13, 15).

While Lundvall's (1992c) distinction between the core and the supporting actors within an innovation system is useful, two limitations are worth noting here. First, both firms and the institutions that directly contribute to innovation are labeled equally as the core of the system. While this classification highlights the importance of some organizations, such as the higher education institutions (HEIs) and research institutes (RIs), it nevertheless underestimates the fundamental divergences between private and public sectors regarding their objectives and operations (Freeman 1992; Valentin 2002; Link & Scott 2003; Lofsten & Lindelof 2005). Furthermore, this dichotomy also blurs the boundary between firms and industries on one hand, and the institutional environment on the other, which is firmly rooted in the evolutionary economics (Nelson & Winter 1982; Freeman & Perez 1988; Nelson 1994; Witt 2008a). Therefore, it is argued here that the core of the IS should only include the private sector, while leaving all the other institutions as the supporting factors. A noticeable advantage of placing firms in the central position is the ease at bridging the mainstream economics with the IS theory, especially when the analysis toolkit on the micro-level is relatively mature (empirical research focused on firm-level data to analyse innovation system can be found in OECD 1997; Cooke 2000; Smith 2000; Rantisi 2002; Hendry et al. 2003; Asheim & Coenen 2005). For example, it would be easier to include the resource-based view of the firm into innovation system analysis, which will be articulated later.

Second, the claim that all firms should be included in the innovation system is also problematic. Lundvall (2007b, p29) simply states that he will 'assume that every firm has a potential for developing, absorbing or using new technology….and they more or less are 'sites of learning' where employees may renew their competences while working'. However, this simplification overlooks the multiple dimensions involved in firms' decision making process. According to the resource-based view of the firm (Penrose 1959; Wernerfelt 1984; Barney 1991) and strategic management theory (Porter 1990; Freeman & Soete 1997), firms are unique combinations of resources and strategy preferences. On one hand, firms tend to choose their innovation strategies through the trade-off between the estimated value of external opportunities and self-confidence in their internal resources (Feldman et al. 2005). Therefore, a minimal level of internal resources or knowledge stock is arguably a precondition for firms to appreciate the opportunities and to absorb the new technologies (Cohen & Levinthal 1990; Mei & Nie 2007). On the other hand, a company's innovation strategy also reflects the preference of its 'collective entrepreneurs' (Reich 1999; Sharma & Chrisman 2007) as well as the market condition. The traditional-strategy-based firm, as classified by Freeman and Soete (1997, p281), for example, 'sees no reason to change its product because the market does not demand a change, and the competition does not compel it to do so'. Therefore it seems that a minimal level of entrepreneurship is also required for a company to be innovative. All in all, it is compelling to add some restrictions on a firm before it can be recognized as the core of the innovation system. This idea will be developed further in the conceptual framework proposed in section three.

2.2.2 Functions of innovation systems: innovation, knowledge, and learning

Some scholars argue for a function-centered instead of an actor-centered approach to analyse IS, because it is hard to decide what to include and what to exclude from this system (Edquist 2005). However, these debates do not imply that a common ground between the structuralism and the functionalism is missing. On the contrary, a shared belief in innovation, knowledge, and learning indicates the conceptual connection between these two viewpoints (see Lundvall & Johnson 1994; Acs 2000; Brefano & Lissoni 2001; Asheim & Gertler 2005; Cooke 2007).

The importance of innovation has been elaborated by Schumpeter more than half a century ago. Although endogenous growth theory (Roberts 1988; Lucas 1988; Romer 1990; Chatterji 1992; Romer 1999) has started to incorporate this factor into account, the wider socio-cultural aspect of innovation is still largely disregarded. This is why the IS theory, by shifting its focus to knowledge accumulation and learning, is regarded as a promising theoretical breakthrough (Miettinen 2002; Cooke et al. 2004). Regarding the nature of knowledge, it is useful to distinguish between codified and tacit knowledge (Nelson & Winter 1982; Senker 1995; Peri

2002; Asheim & Gertler 2005): While the former refers to relatively mature knowledge (information) that can be transferred over long distance, the latter means something that is 'in the air' (Marshall 1961), something that is stored in human capital and hard to articulate. More importantly, the classification between codified and tacit knowledge provides a 'window' through which the economic geographers have a say in the innovation system theory, because geographical proximity is regarded as important for diffusing tacit knowledge (Jaffe et al. 1993; Storper & Venables 2005; Hall & Pain 2006).

Regarding the term 'learning', it refers to the interactive process of acquiring something new, something that will increase the knowledge storage and impose influence on the behaviors of the subject(s). This learning process takes place in a specific socio-cultural setting and is directed by previous knowledge about institutions (such as norms, habits, and conventions) and organizations (such as governments and universities) (Johnson 1992; Hassink & Largendijk 2001; Lundvall 2007b). This socio-cultural environment in turn is inert and inflexible, which has at least three influences on firms' learning activities. First of all, the institutionalized rules and regulations could reduce uncertainties and thus make predictions possible, which in turn ease companies' decision making process (Rosenberg 1982; Johnson 1992). Secondly, the cumulative process in formalizing the institutional architecture would help solidify a specific technology trajectory and industrial structure within a geography boundary (Martin & Sunley 2006). This process would gradually cultivate Marshallian externalities such as specialized knowledge storage, cooperative supplier-user relationships, and skilled labor force (Phelps 1992), which, balanced with diversity and openness, would be a competitive advantage for local firms and meet their special learning requirements. Last but not least, the institutional setting of firms serves as the 'selection environment' of their innovations (Abramovitz 1986; Dosi & Nelson 1994; Saviotti 1996; Fagerberg 2003; Witt 2008b). Therefore within a given time period and space, the established institutions would strongly influence firms' decisions on 'what to learn', 'how to learn', and 'when to learn'. On the other hand, the continuous technology change and highly dynamic private sector could also exert pressure on the institutions, which in turn provides the most important channel through which institution changes happen and new regional paths emerge (Martin 2010).

Focusing on knowledge acquisition and interactive learning, the empirical studies on innovation systems not surprisingly concentrate on identifying the very existence and the contribution of *outside* linkages on firms' innovation achievement (Cooke 2000; Asheim & Coenen 2005; Chen & Kenney 2007; Saxenian 2007). While the importance of external networking is acknowledged here, some fundamental questions regarding the micro-level activities remain unsolved by the innovation system theory. For example, what are the incentives for firms' learning activities, how are the decisions made? Why do firms diversify regarding their learning competencies? And do they follow the same logic in 'internal learning' and 'external learning'?

To answer the above questions, it would be useful to distinguish between firms' internal and external learning activities. 'Internal learning' in this study refers to the process a firm getting familiar with its own resources (Romer 1999), identifying its competitive advantages (Porter 1990), and mobilizing these resources to achieve its goals. This is an interactive process between a firm's entrepreneurship and its internal resources (Shane & Venkataraman 2000; Blanchflower et al. 2001; Nouira et al. 2005), which will be elaborated later. Japanese firms, for example, are usually highly competitive in internal learning activities (Malecki 2000) by emphasizing 'integration and parallel development' (Rothwell 1994, p12). 'External learning', in comparison, is the outsourcing process. By establishing linkages with outside agencies, firms can cross their boundaries and acquire resources that they lack. The relationship between a firm's internal and external learning is summarised by Nooteboom's (1999, p132,3) learning cycle model: internal learning helps firms to receive ('accommodate') and absorb ('consolidate' and 'generalize') the external knowledge. External learning, on the other hand, exposes the diversified context, in which firms can make comparisons ('differentiation') and adapt the advanced practice ('reciprocation'). Companies' entrepreneurship is arguably one of the most determinant factors influencing their internal and external learning processes.

2.2.3 Dynamics of innovation systems: discontinuity and stabilization

Weick and Westley (1996, p440) pointed out that the expression, 'organisational learning', is an 'oxymoron', because 'to learn is to disorganize and increase variety, while to organize is to forget and reduce variety'. This flexibility-stability dilemma (Zaltman et al. 1973), on the other hand, also exists in the IS theory (Heidenreich 2004). Lundvall (2007c, p7) argued that the contradiction between changing brought by 'innovation' and stabilization emphasized by 'system' could be explained by the mutual influence and co-evolution between these two process, and one of the capabilities of an innovation system lies in dealing with this dilemma on 'spatial, social, material, and temporal dimensions' (Heidenreich 2004, p368).

However, up to now IS theory has not yet made much progress on dealing with this dynamic dilemma. More specifically, it is particularly weak in explaining the following three issues. The first one relates to the changes in institutional domain. To date, the IS school has either explicitly or implicitly posited the institutional structure as merely a passive environment for firms. Theoretically, the source of institutional changes is assumed to be pushed by technological advance (Nelson & Winter 1982; Freeman & Perez 1988; Acs & Mothe 2000). Empirically, the changing cultural and social environment often serves as the background of the innovative firms (Cooke 2000; Chen & Kenney 2007; Radosevic 2007). This explanatory weakness of IS theory directly results in its ambiguity in relation to the second issue, which is the bidirectional influences between the changes in techno-economics domain and changes in socio-institutional domain. Fuzzy concepts like 'interactions' or 'mutual influences' between these two domains are frequently used to skirt such crucial questions like how established institutions get the signal of firms' new interests, and how firms perceive and react to the changing institutional environments (Radosevic 2007). The implicit assumption of 'institutions as derived entities' (Coriat & Dosi 2000, p352) and the vagueness on the interaction mechanisms between the system components further leads to its biased view in connection to the third issue, which is the role of the state and governments. The criticism on 'government failure' (McKean 1965) is especially strong in the branch of regional and local innovation systems. For these two sub-branches, the interventions of government are constraints on technology advance and local development due to their inert nature (Segal Quince Wicksteed 2000), the contradictory interests (Lin 1997; Batisse & Poncet 2004), and the 'one-size-fits-all' principle (Shiro 2004). This perspective is clearly expressed in Cooke (2004, p4-5):

> 'Though many regional governances…proved to be smarter than the market, their executives were ill-attuned to innovation support, being under-trained, risk-averse and used to facilitating 'rent-seeking' by grant-hungry businesses rather than more innovative financial packages.'

In order to explore the sources of dynamics in the institutional domain, it is useful to borrow ideas from the recent research on institutional development, which replaces the traditional emphasis on the inert nature of institutions with a dynamic perspective (Barley & Tolbert 1997; Clemens & Cook 1999), and views the institutions as composite entities that can be layered-on, converted, and recombined (Martin 2010, p14). Following the structural distinction of an IS adopted in this study, the concept of 'institution' here refers to its broad definition (Coriat & Dosi 2000), including the *formal organizations* that are directly or indirectly related to the innovation process, such as HEIs and governments; and '*the rules of the game*' (North 1990) commonly shared by actors, which help to shape the interactions during the innovation process (Lundvall 2007b). Depending on the sources of the changes, two possible channels of institutional dynamics can be identified here, which are *self-reflecting* and *external-reacting*.

Self-reflecting originates from the internal conflicts within and between organizations and roles. The established roles, scripts or cultural variants are themselves mutable, multiple, and internally controversial (Clemens & Cook 1999, p448). The loosely defined law articles, incomplete regulation system, and the relatively low compulsory status could all lessen the determinate nature of institutions while increase the heterogeneity of the reactions. For example, the undefined institutional statement is especially prominent in China (Crawford & Ostrom 1995) as a result of its 'experimental reform strategy', which means the regulation loopholes are left purposely and temporarily for market units to explore, and once these hybrid forms at grassroots level are successfully tested, the government would then ratify the practices (McMillan & Naughton 1992; Qian & Xu 1993). During this process, however, different interpretations of the rules among the multi-layered organizations may lead to discordant behaviours. What is more, the misaligned interests of these organizations, such as the mismatched targets between the central and local governments, are also sources of conflicts and changes (Shiro 2004; Batisse & Poncet 2004).

External-reacting, on the other hand, stems from the interactions between institutions and firms. This kind of interaction explains the bulk of institutional changes, and thus is the main form of institutional learning. There are already many studies on this source of institutional changes from the IS school (see Lundvall 1985; Andersen 1992; OECD 1997; Edquist 1997; Nelson 2000; Cooke 2000). But the drawbacks, as stated before, lie in the limited concern on the feedback channels between institutional learning and firms' changes, as well as the lack of attention on the role of firms' entrepreneurship in this process. The conceptual model proposed in what follows can be seen as an initial attempt to counter these drawbacks.

These institutional discontinuities, in turn, could become opportunities for entrepreneurs (Radosevic 2007). Feldman et al. (2001; 2003; 2004; 2005; 2005; 2006; 2007) for example, analysed the transformation of the US capital region from a political center to an innovative bio-cluster. The policy changes, such as downsizing of federal employment and increasing the federal procurement on high-tech products between 1970 and 1990, were cited as the decisive triggers for the following entrepreneurial boom. The contribution of Feldman et al.'s studies, however, is arguably undermined by their failing to realize the connections between institutional changes and firms' entrepreneurship, as the authors simply attributed these institutional adjustments as 'exogenous shocks'. Radosevic (2007), on the other hand, treated entrepreneurship as a function of an innovation system (ibid. p11). For him, entrepreneurship derives from the matching between technological, market, and institutional opportunities (ibid. p22). The author has adopted and extended Radosevic's (2007) idea on systematic entrepreneurship in this study, as it offers a bridge linking the micro-level economic activities and the macro-level institutional learning.

2.2.4 Weakness of the innovation system theory

The above sections analysed the structure, the function, and the sources of dynamics that underpin the IS theory. The discontinuity and stabilization dilemma, in particular, has been given more attention to because it stands out most prominently in the system construction process, and has yet been fully explored by the IS study (Koschatzky 2004). As pointed out before, the development of IS theory is mainly based on the historical review of the established and most advanced systems in the world, trying to identify their common features, such as a supporting institutional structure (Nelson 2000) and a learning culture (Koschatzky 2004). However, trying to summarise the characteristics of a successful innovation system cannot help to solve the urgent questions of how these features emerge in the first place for developing/transitional countries. As Lundvall (2007a, p29) acknowledged, one of the main limitations of innovation system theories is that 'the system of innovation approach has not, to the same extent, been applied to system building'. Nevertheless, Lundvall (2007a) also rightly pointed out that more attention should be allocated to policies and institutional environment if system construction and system promotion are the foci.

Besides the paucity of study on the dynamics of an innovation system, the second and related weakness of the IS theory lies in its limited attention paid to the power relationship and adjustment between diversified actors within the system (Lundvall 2007a). This problem might become more severe against developing/transitional countries' background, where the construction of innovation systems is still an on-going project, and thus is unavoidably accompanied by power struggles. Sometimes these power struggles would even be decisive for the system constructing process (Shiro 2004), as will be illustrated by the Bangalore case in India and the Z-Park in China in chapter three. The third shortcoming of the IS theory would be found in the segmented studies on the national, regional, and local levels (Lundvall 2007a). Last, the IS theory lacks of explanatory power on micro-level. As discussed before, the growth of IS theory has followed the wider theoretical methodology of evolutionary economics (Nelson & Nelson 2002; Lundvall 2007c), which in turn is mainly concerned with long-term, macro-level development in order to grasp the common patterns and trajectories. Furthermore, the over-emphasis of IS theory on the linkages *among* firms and *between* firms and institutions (Capello & Faggian 2005) weakens its depth of investigation on what is going on *inside* the firms and the institutions. Therefore in what follows, a generic four-quadrant conceptual model will be proposed as a preliminary extension of IS theory. Retaining the latter's emphasis on interactions and learning, the four-quadrant framework proposed here further incorporates two micro-level theories, namely the resource-based view of the firm (RBV) and entrepreneurship studies, which not only complements the weakness of IS theory on explaining firms' behaviors, but also makes the dynamic of an IS easier to handle.

2.3 The four-quadrant model of innovation system

Figure 2-1 below exhibits the linkages between IS theory, RBV, and entrepreneurship theories within a four-quadrant model. In a sketch, quadrants I and III illustrate the core of the innovation system (innovative firms) and the institutional environment (innovation related institutions) respectively. Quadrant II shows the bidirectional learning processes between firms and institutions in a relatively stable environment. Quadrant IV, on the other hand, illustrates the opportunity recognizing and reacting process under changing environment.

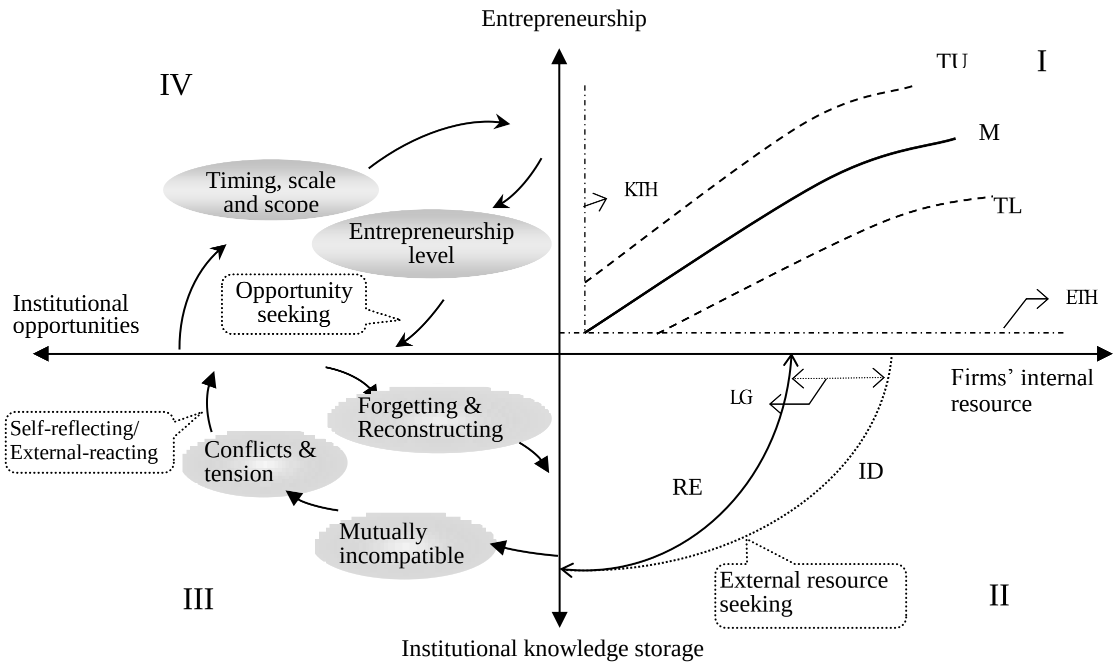

Figure 2-1 The four-quadrant system model

Source: the author

2.3.1 Quadrant I, the micro-foundation of innovation system

Quadrant I explains companies' innovation behaviors on the micro-level. The resource-based view of the firm (RBV) is chosen as the theoretical foundation here, because it not only uncovers firms' decision-making rules, but also bridges this process with firms' external environment (Eun et al. 2006). According to this theory (Penrose 1959; Richardson 1972; Wernerfelt 1984; Barney 1986; Conner 1991; Conner & Prahalad 1996; Oliver 1997), organizations are collections of unique resources and capabilities. These internal resources have the potential to generate sustained competitive advantages if they are rare, valuable, difficult to imitate and without equivalent substitutes (Barney 1991, p99). Asymmetries in privately held knowledge are arguably becoming the primary source of competitive advantages in this knowledge-based development era (Conner & Prahalad 1996). Furthermore, these diversifications and specializations in firms' resources will in turn lead firms into different markets. Based on this observation, Richardson (1972) argued that firms tend to choose 'similar activities' to do inside the organization, while out-sourcing for complementary resources. Lofsten and Lindelof (2005), for example, found that RBV was useful to explain the different performance of new technology-based firms established respectively by academic and corporate. Similarly, Dai and Liu (2009) found that SMEs operated by returnees in Z-Park of China performed better compared with those run by local entrepreneurs, as a result of the formers' superior technological and commercial knowledge, as well as their international business networks.

Recently, the theory of RBV is significantly improved by recognizing the importance of leading entrepreneurs or the entrepreneur team as a unique strategic resource for the companies (Alvarez & Busenitz 2001). Kamm et al. (1990) and Nouira et al. (2005) showed that the capabilities of the entrepreneur team to seek out unique resources are crucial for the firm's development. Actually, the entrepreneur team, by evaluating its own capabilities, exploring its knowledge stock, neutralizing external threats, and avoiding internal weakness (Barney 1991), would increase the efficiency of using all the other resources (Romer 1999; Barringer & Jones 2004; Carayannis et al. 2006). Therefore 'in a resource-based view, discerning appropriate inputs is ultimately a matter of entrepreneurial vision and intuition' (Conner 1991, p121).

However, In order to better integrate the entrepreneurship theory with RVB, the connotation of entrepreneurship should be extended beyond the neo-Schumpeterian school's focus on individual level and/or the new start-ups (Feldman & Francis 2003; Feldman 2007). In this research, the term 'entrepreneurship' is defined as *the above-average capabilities of firms in two dimensions: the first one is their efficiency in utilizing and mobilizing internal-resource; and the other is their sensitivity and reaction-time to external opportunities, which is also influenced by the compatibility of opportunities and the innovation system they are embedded in.* Regarding the relationships between a firm's internal resources and its entrepreneurship, there is arguably a bilateral linkage: on the one hand, a firm's entrepreneurship level (or its strategy choice) determines how well it explores the external contexts and exploits its internal resources (Nooteboom 1999); on the other hand, the stock of a firm's resources, both tangible and intangible, will impose constrains on its entrepreneurship level and strategy choice. A static model based on RVB and the entrepreneurship theory is summarised in figure 2-2.

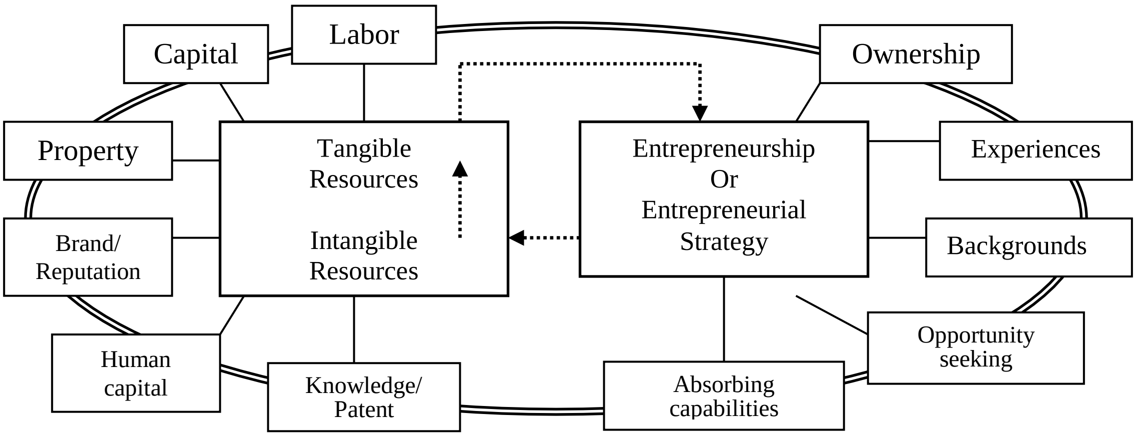

Figure 2-2 The static resource-based view of firm

Note: 1. Firm boundary (not closed for external linkages); Relationships;
2. Source: the author

Based on the above discussions, the logic of quadrant I becomes clear: Statically, a firm's decision on innovation (whether or not), the form it takes (individually or collectively), and the results of its innovation effort are mutually influenced by its internal resources and its entrepreneurship level, although it is acknowledged here that the external conditions, such as the market conditions (Acs 2002), technology uncertainties (Freeman & Soete 1997), local culture (Saxenian 2000), and international environments (Zhou & Xin 2003) would also make a difference. Moreover, a minimal stock of internal resources is required for a firm to conduct innovation activities, as has been discussed before. Among these resources, firms' specific knowledge and R & D activities are becoming increasingly important for them to 'absorb' external resources (Cohen & Levinthal 1990; Nelson 1993; Porter 2000). In the same vein, a minimal level of innovation willingness is also the precondition for a firm to react to external opportunities (Freeman & Soete 1997; Lofsten & Lindelof 2003; Eun et al. 2006; Watkins-Mathys & Foster 2006). In quadrant I, these requirements are expressed by the dotted lines named KTH (knowledge threshold) and ETH (entrepreneurship threshold) respectively.

Moreover, the mutually dependent relationship between a firm's internal resources and its entrepreneurship implies that there might be a 'matching' point between these two factors, represented by the solid line 'M'. Figures 2-1 and 2-3 below illustrate one possible relationship – the positive correlation – between these two factors. Nevertheless, a perfect matching is rare and temporary if it really exists, as both firm's resources and innovation strategies are constantly co-evolving with external environments. So around the matching line, there should be some 'tolerance area' (the area between tolerance upper line 'TU' and tolerance lower line 'TL'), which stands for the weak Pareto Optimum situations: either the opportunities are not fully recognized and realized by the firms, or the internal resources are not utilised to their maximum. A firm may locate itself on any position within quadrant I, based on the combination of these two factors. Freeman and Soete (1997, p267), for example, suggested six levels of entrepreneurship, which are: offensive ('OF'), defensive ('DE'), imitative ('IM'), dependent ('DP'), traditional ('TR'), and opportunist ('OP'). These six types of firms can be conveniently illustrated in quadrant I. Figure 2-3 zooms in on this quadrant and shows their distributions.

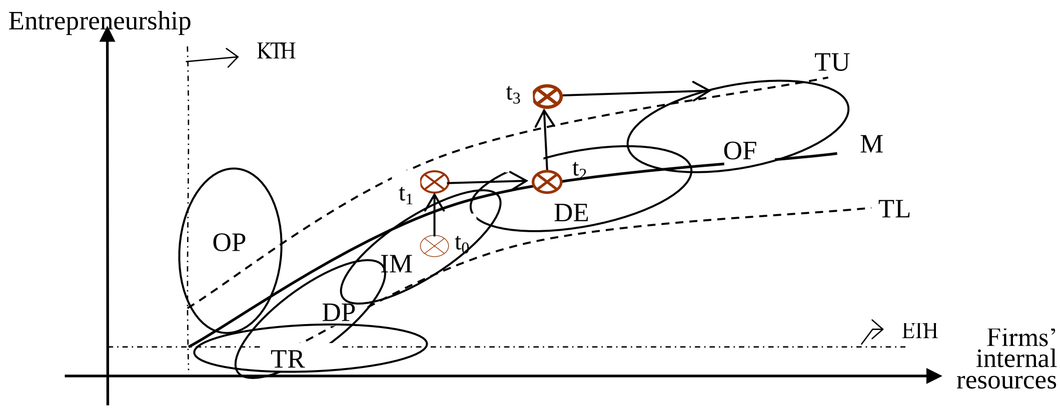

Figure 2-3 The dynamic of resource-based view of firm
Source: the author

However, this positive correlation between companies' entrepreneurship levels and internal resources is only one among some other possible relationships. Figure 2-4 exhibits other two possibilities. The one on the left shows a negative correlation between companies' entrepreneurship levels and internal resources. This relationship is plausible given that, small and medium high-tech companies are often found more willing to take risks compared to large companies' risk-alerting nature. The one on the right profiles a U-shaped correlation between these two variables. The underpinned rationale is companies' life cycle theory. According to the latter, young companies are competitive on emerging/niche market, and are proactive in innovations. As a company grows bigger and occupies a stable market share, however, the motivation for it to initialise any significant improvement and innovation will reduce accordingly. If this situation persists, a company is doomed to face the decrease of its market share, especially when new replacement products are available. Forced by market competition, a well-established, and usually large company, will have to reinvest in innovation and become entrepreneurial again. All three hypotheses could find their justifications in reality, and the empirical study presented in chapter 9 will test them against OVC's context.

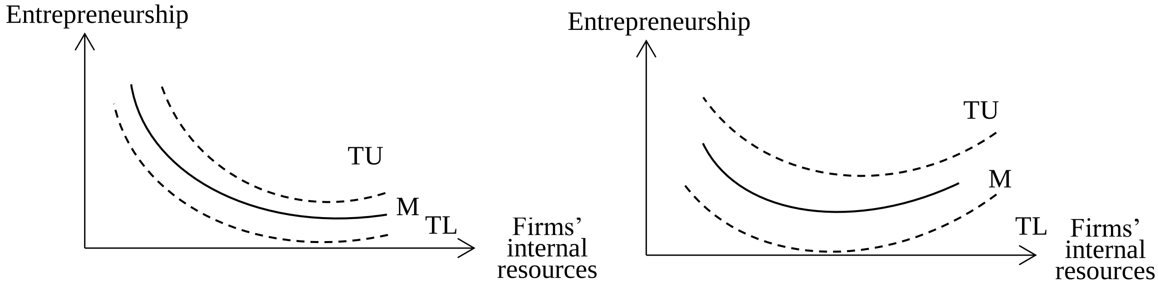

Figure 2-4 Possible relationships between companies' internal resources and entrepreneurship
Source: the author

Furthermore, a firm's position on this quadrant is anything but fixed. Adjustment and learning are necessary but not sufficient prerequisites for a firm to upgrade itself. This continuity of changing would in turn active this model. One channel for a firm to upgrade itself would take the following route: assuming this firm adopts the imitative strategy at the beginning (t_0). Then changes in the institutional environment provide conceivable opportunities to this firm, which in turn boost its entrepreneurship (t_1). In order to grasp these opportunities, the firm may exploit its internal resources, out-source/co-operate with external partners, or a combination of these two methods. The knowledge and experiences obtained in these internal and external learning processes would very likely increase the firm's knowledge storage and management skills, which is the foundation of a higher level entrepreneurship (t_2). When both the firm's internal resources and entrepreneurship get improved, it also upgrades from imitative to defensive category. Ideally, this whole process of changing, conceiving opportunities, and learning is a continuous process in a functioning innovation system, which may eventually lead the firm onto the offensive class.

As it is clear from the above discussion, what is important for the model's dynamic is arguably the existence of a trigger – being it either internal to the companies or external in the institutional environment. A trigger might be found along the production chain – Porter (1990)'s 'demanding users' are relevant here; or parallel to it – such as strategy shift in government policies (Hall et al. 1987; Etzkowitz 2006). Nurturing these triggers is arguably much more important in developing countries, because 'most firms in the developing countries are imitative, depend or traditional' (Freeman & Soete 1997, p275), therefore need a boost to upgrade themselves. What is emphasized in this study is the promise of the complementary external resources and the alluring opportunities as the dynamic triggers, which is illustrated by quadrant II and IV, and will be discussed below.

2.3.2 Quadrant II: firms' external resource-seeking process

Quadrant II offers a very simplified interpretation of firms' external resource seeking activities. Nevertheless, this quadrant profiles one of the two channels that triggers institutional changes, namely the ‘external reacting’ process. As discussed in the last section, when facing a tempting opportunity, a firm may choose to jump out of its ‘comfort zone’ and out-source for complementary or better resources to grasp this opportunity. Ideally, firms should be able to absorb all these resources during the interacting and learning process, which is represented in figure 2-1 by the dotted quarter circle ‘ID’. However, the reality is that firms’ limited absorptive capabilities (Cohen & Levinthal 1990), inter-organisational cultural distances (Baxter & Tyler 2007; Gertler 2007), and unequal power relationships (Young & Lan 1997) all restrict the amount of transferrable resources, which is represented by the contracted curve ‘RE’. The difference between the ideal amount and the real transferred amount is labeled here as the ‘learning gap’ (LG), a concept that is arguably broader than Cohen and Levinthal’s (1990) ‘absorptive capability’. A company’s learning gap is co-influenced by at least three broad factors, which is summarised in table 2-1.

Table 2-1 Influential factors on companies' learning gap

A. Geographical factor	**B Firms’ internal resources**	**C. Social-institutional factor**
a_1 Agglomeration economy	b_1 Industrial sector	c_1 Local culture
a_2 Openness vs. Closure	b_2 R & D	c_2 Policy
a_3 Local industrial structure	b_3 Power relationship	c_3 Institutional knowledge storage

Source: the author

First, firms’ learning gap is geographically sensitive. Geography can exert influence through at least three channels: First of all, the agglomeration economy. This may come in Alfred Marshall’s (1961,[1890]) original format, or Parr’s (2002) scope, scale, and interactive economy. The second channel is the inward and outward connections of a particular place. In order to avoid the ‘Upas tree’ effect (Checkland, 1975, quoted in Hall 1985, p9), the innovation practice should adopt the ‘open innovation’ model for heterogeneous knowledge (Chesbrough 2003; Chesbrough et al. 2006); while the organisational structure should be ‘flexible specialization’ in order to quicken the knowledge circulation (Scott 1988). The last influential factor is the established industrial structure (Martin & Sunley 2006; Phelps 2009). This factor in turn influences the local labor division (Feldman & Francis 2003), infrastructure (Hall & Preston 1988), specialized suppliers (Dyer 1996), and users’ expectations (Lundvall 1985). It also intertwines with the local institutional knowledge storage as will be shown later.

Second, this learning gap is related to firms' internal resources. What industrial sector the firm belongs to would exert influence in the first place. Breschi and Malerba (1997, p136), for example, argued that sectors will differ in the properties of a firm's knowledge in two dimensions: the nature of the knowledge and the methods of knowledge transmission. Even within the same sectors, however, companies' learning gaps tend to diversify, because of their different R & D activities on one hand, and the asymmetrical power relationship between the knowledge sender and receiver (Dosi 1995; Wank 1995). Lundvall (1992b, p54), when analysed the interactions between producers and users, pointed out that 'asymmetrical power relationships between users and producers may result in biased technical change'.

Third, the socio-institutional factor could also make a difference on companies' learning gap. The different performance between Silicon Valley and Route 128 (Saxenian 1994), and the 'third Italy' model (Alberti 2007, p1) have drawn people's attention to the 'relational turn' in economic geography (Yeung 2002; Capello & Faggian 2005; Sunley 2008). The advocators for 'institutional thickness' (Amin & Thrift 1994; Henry & Pinch 2001), 'social embeddedness' (Park 1996; Zhou et al. 2003; Porter et al. 2005), 'innovation milieu' (Maillat 1998; Hall 1998; Camagni 2005) and the 'learning region' (Florida 2000) all point out the importance of the local socio-institutional environment for firms' learning and innovation activities. Moreover, public policies can also influence the transmission of knowledge between the innovation partners directly or indirectly. The direct influence can be found in patent policy (Cohen et al. 2002), science and technology projects (Baxter & Tyler 2007; Bach et al. 2008), and R & D support (Breznitz 2004); while the indirect influence can be identified in such areas like infrastructure, finance, trade policies, and the legal system (Nelson 2000). The third sub-factor is the institutional knowledge storage. This is a term coined by the author to represent the established local knowledge pattern and specialization, which are partly shaped by its established industrial structure and partly influenced by the local knowledge institutions and learning culture.

2.3.3 Quadrant III: institutional learning and dynamic

Quadrant III is a simplified visualization on the dilemma between institutional stabilization and discontinuity discussed in the last section. Seo and Creed (2002, p225) proposed a four-stage model on institutional change, including: 1) social construction; 2) totality; 3) contradiction and; 4) praxis (fig. 2-5). Adopting their terminology in this research, the established institutional knowledge storage can be seen as the result of institutionalization. This relatively stabilized institutional environment is contained within the tolerance zone of the multiple players involved, but incompatibility and conflicts between established rules and organizations cannot be erased completed. In order to compromise these contradictions, the institutional environment could either be 'self-reflecting', readjusting the various power relations within itself, or 'external reacting' through interactions with the private sectors.

(Figure has been removed as third party copyright material)

Figure 2-5 Institutionalization and institutional change: process from dialectical perspective
Source: Seo and Creed (2002, p225)

Therefore, the bidirectional interaction between companies and the institutional knowledge storage in quadrant II could trigger changes in quadrant III: on one hand, companies' out-sourcing activities would inform organizations of their changing needs; on the other hand, the rules of processing these interactions could also be tested or tensioned along the interactions. The two processes of self-reflecting and external-reacting will gradually disclose these tensions and finally result in institutional transformation and change. Moreover, Schumpeter's (1934) 'creative destruction' is also applicable in the situation of institutional changes, because 'the enormous power of habits of thought in the economy constitutes a permanent risk for blocking potentially fertile learning processes' (Johnson 1992, p29). Therefore through the phase of forgetting, or 'praxis' in Seo and Creed's (2002) words, a more compatible institutional structure will be built up, upon which a new and more smooth round of knowledge accumulation and interactions will begin.

2.3.4 Quadrant IV: firms' opportunity seeking activities

Another possible result of institutional change, either intentionally or unintentionally, is the emerging of the entrepreneurial opportunities, which is shown in quadrant IV. Moreover, there is a two-way feedback loop between institutional opportunities and firms' entrepreneurship. On one end, the heterogeneity of firms' entrepreneurship will lead to different reactions even when firms face the same opportunity (Casson 1999). On the other end, the timing, the level of compatibility, and the scope of the institutional changes would produce different incentives to companies, as illustrated in figure 2-6 below.

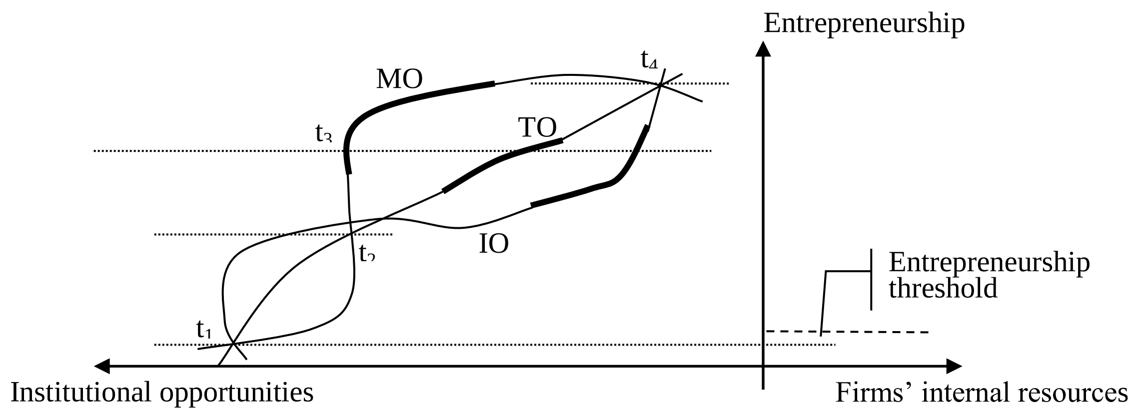

Figure 2-6 Opportunities and companies' entrepreneurship

Note: 1. MO: Market opportunity; TO: Technological opportunity; IO: Institutional opportunity.

2. Size of the lines refers to the significance of the opportunities.

3. Source: the author

Timing is a crucial factor on two dimensions: first of all, the emerging opportunities could only be perceived by companies with at least a minimal level of entrepreneurship. Secondly, the emerging time of the three main types of opportunities identified by Radosevic (2007, p22), namely the market opportunity (MO), the technological opportunity (TO), and the institutional opportunity (IO), should be reciprocal, or ideally, concurrent. These twin temporal dimensions of entrepreneurship are illustrated in figure 2-6 by t_1 and t_2 respectively. T_1 shows a time when the three types of opportunities are coexistent, but it occurs before a company accumulates a minimal level of entrepreneurship. T_2, on the other hand, shows a time when the company has surpassed the threshold level of entrepreneurship, but unfortunately, not all three types of opportunities are compatible at this point. An example to illustrate the above argument could be found in China's staged reform approach. Compared with the 'big bang' strategy used in East Europe (Hoff & Stiglitz 1994), China's reform is often cited as a successful case for transforming the economy (McMillan & Naughton 1992; Wei 1997). Referring to the explanation here, this smooth could be partly explained by the gradually released reforms and changes, which leave enough time for entrepreneurs to get familiar, feel confident, and at last grasp these opportunities brought about by institutional change (Liu & White 2001; Tan 2006). Furthermore, the almost synchronously processed reforms in the economic, social, and science & technology domains have secured a reciprocal relation between the different types of opportunities, which will be reviewed in the next chapter.

The second important consideration is the level of compatibility. Radosevic (2007), for example, implicitly argued that a 'perfect match' between the market, technological, and institutional opportunities is necessary for triggering entrepreneurship. However, the argument of the author is that a tolerance area should be allowed for the compatibilities between different kinds of opportunities. In figure 2-6, the points labeled t_2, t_3, and t_4 illustrate this idea. T_4 shows a perfect matching between the three types of opportunities, which might trigger companies' entrepreneurship most strongly. T_2, as discussed before, lacks such a high level of reciprocity. However, compared with t_3, when the three types of opportunities are far away from each other, t_2 is still a relatively promising moment on boosting companies' entrepreneurship.

The last but not least factor that deserves notice is the scope of changes occurring. In other words, whether it is incremental or dramatic change in the social-institutional sphere will make a difference in companies' reactions. In figure 2-6, the size of the lines represents the significance of changes, so in point t_3, even though there is little compatibility between the different kinds of opportunities, the mere significance of changes in any individual type of opportunity merits the power of triggering companies' entrepreneurship. In reality, this point would be illustrated again with China's example. When China has gradually transformed from a planned economy to market economy, the mode of incremental institutional adjustment may prove incapable of providing enough incentives to firms (Watkins-Mathys & Foster 2006; Altenburg et al. 2008), or slow in reaction to firms' needs (Jefferson & Rawski 1994; Goodall & Warner 1997; Demurger et al. 2002; Cao 2004).

2.3.5 Merits of the four-quadrant model

In summary, the proposed four-quadrant conceptual model in figure 2-1 is an attempt to bring dynamics into an innovation system, and to clearly address the behaviors of firms and institutions as well as the relationship between them. More specifically, this four-quadrant framework has the potential of adding to the IS theory on four dimensions: 1) the dynamic of an innovation system; 2) the system building process; 3) the micro-foundations of the system and; 4) the power relationships shaped by the system and its evolution.

The dynamics of the IS can proceed in the following stages (fig.2-7): External opportunities in the market, technological, and institutional domains emerge and are perceived by firms. By comparing their potential values and the effort needed to realize these values, firms' entrepreneurial teams will then make a decision based on their international resources, which is also confined by their entrepreneurial culture. If the firms' entrepreneurship is boosted modestly, or their internal resources are sufficient, the companies very likely will exploit and mobilise their internal resources to grasp them. If the opportunities raise firms' entrepreneurships significantly and also require great effort, the firms then have higher motivation to out-source complementary resources and co-operate with other agents. Companies' external resource-seeking process, however, is not smooth because of the existence of learning gap, which is space-sensitive. Nevertheless, the local institutional environment will learn companies' needs during this process. Through self-reflecting and external-reacting, the hidden incompatibilities within the institutional environment and between the established institutions and firms' changing needs will reveal themselves, get intensified, and finally lead to institutional adjustments. These adjustments and changes in institutional domain, under favorable timing, compatibility, and scope, will be perceived by firms and become their entrepreneurial opportunities again, which then starts a new round of dynamic interaction process. In this sense, both the economic landscape and its micro foundation become a complex system, coordinately manifested through the self-organising process of the innovation system (Martin & Sunley 2007). Furthermore, three factors are noteworthy during this dynamic process, namely the leader(s) of the innovation system; the growth engine; and the efficiency of the system to adjust itself and reach its designed goal. Based on reviewing the science park practices in the world, these factors will be discussed in detail in chapter three.

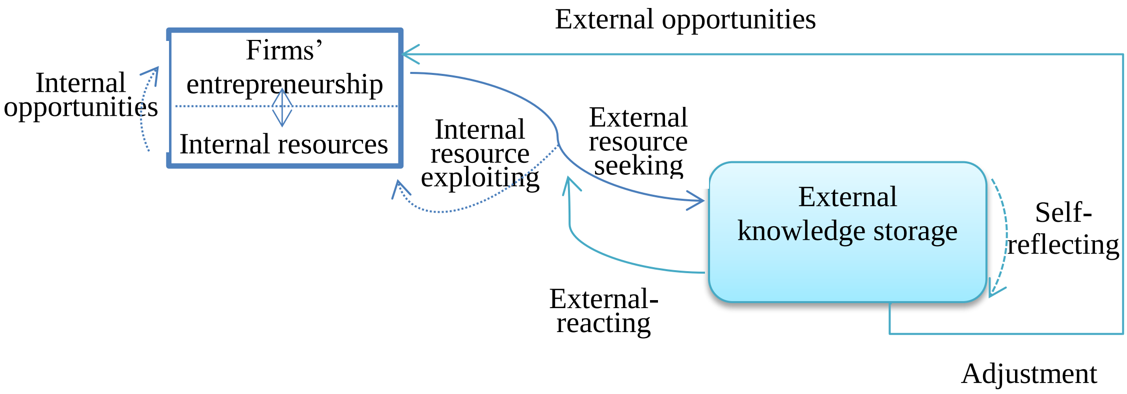

Figure 2-7 Dynamic stage model of the four-quadrant model

Source: the author

Regarding the system building process, some crucial questions stand out for developing/transitional economies. First, how to trigger firms' initiative, or to put it in another way, how to make firms the core of an innovation system? Although many authors argue that the private agents should be the engine of the innovation process, and their early engagement in the system building process is crucial (Cooke 2001; Rantisi 2002; Carlsson & Jacobsson 2004; Muscio 2006; Wolfe & Gertler 2006; Lundvall 2007c), the reality in some regions, particularly in the Asia Pacific region, however, might prove difficult to count solely on the private sector. The widely existed 'strong government but weak enterprises' in these areas means the government is still heavily engaged or directly participating in economic activities (The World Bank 1997). Second, where is the balancing point between institutional stability and discontinuity? Institutional stability, as discussed before, is necessary for knowledge accumulation, market prediction, and investment confidence (Freeman & Perez 1988), but it may also result in 'similar thinking' and system 'lock-in'. Institutional discontinuity, on the other hand, weeds the obsolete away and provides valuable entrepreneurship opportunities (Feldman 2005; Radosevic 2007). However, frequent changes and instability might lead to economic turmoil and social disorder, which are also undesirable. Therefore the capability to find and keep this balance also needs to be acquired during the system building process. Third, how could the interactions between the core of an innovation system and its supporting environment be increased? This mutual reciprocal relationship (Castells & Hall 1994b; Cooke 2001) is arguably easier to cultivate in an endogenous grown system than in the 'branch plant' economy (Phelps 2009). Therefore no matter how an innovation system is born, being it 'bottom-up' or 'top-down', cultivating the 'untraded interdependence' (Storper 1997) among its components is one of the key requirements for keeping 'sticky' places in 'slippery' space' (Markusen 1996, p293).

The extended four-quadrant model is particularly strong at micro-level analysis compared with the existing innovation system theory. Firms' innovation behaviors are hypothesized to be decided by their internal resources and the levels of their entrepreneurship, which are also mutually influential towards each other. Furthermore, firms' internal resources and entrepreneurship are also linked with their supporting environment through resource-seeking and opportunity-seeking, which solves the 'incentive' problem identified within the innovation system theory earlier. Power asymmetry and redistribution also become prominent features in this interaction process.

2.4 Geography of innovation system

An important determinant on the dynamic and power distribution of an innovation system is the geographical factor. Although the idea of innovation system was first conceived and applied on the national level in the 1980s (Freeman 1995; Nelson 2000; Lundvall 2007c), studies on regional or local levels also emerged quickly in the 1990s (Cooke, Heidenreich, & Braczyk 2004; 2004; 2005; 2007). This section will compare these different branches of innovation system on national (NIS), regional (RIS), and local level (LIS), with special attention paid to: 1) what are the crucial factors identified in these sub-branches; 2) how these factors are related; and 3) why they are important and linked in a particular way.

2.4.1 Innovation system on national level (NIS)

Inspired by the institutional theory and evolutionary economics, the idea of IS was developed originally on the national level out of the dissatisfaction with neo-classical economic theory. For NIS, firms and institutions are ‘what’ should be considered, but they have to be located within the boundary of a nation and directly or indirectly involved in the innovation processes (OECD 1997). Firms in NIS are the carriers of technology innovations and diffusions. They are the catalysts of economic growth. The institutions, on the other hand, provide skilled labor (education sector), capital (financial sector), infrastructure, home market advantages, and a generally supportive environment (Lundvall 1992a; Nelson 2000). Learning and knowledge seeking are ‘how’ these factors link with each other. ‘Why’ NISs evolve and differ in performance is explained by the different ‘matching’ levels between firms and institutions (Nelson 1994). Therefore interaction and co-evolution between these two factors are crucial for a NIS to forge ahead or catch up (Abramovitz 1986; Perez & Soete 1988; Freeman 2002; Fagerberg & Godinho 2005).

2.4.2 Innovation system on regional/local level (RIS/LIS)

The idea of RIS/LIS gains its popularity mainly through the effort of economic geographers. Although its answers to the ‘what’, ‘how’, and ‘why’ questions are very similar to NIS, the theoretical root of this sub-branch however, is arguably derived from economic geography and regional science. Therefore it is easy to detect the theoretical linkages between RIS/LIS and Marshall’s (1961) industrial districts, Perroux’s (1950) growth pole, and the more recent relational economic geography (Yeung 2002; Sunley 2008) and the geography of knowledge and innovation (Audretsch & Feldman 1996b; Asheim & Gertler 2005; Polenske 2007). By focusing on the spatial dimension of innovation activities, RIS/LIS builds on NIS by revising the latter’s ‘flat surface’ assumption within a nation (Yeung 2009, P210).

Firms and institutions are still regarded as the main factors in RIS/LIS, but this time, the region or sub-region defines its analysis boundary. According to Cooke et al. (2000b, p2), regions are 'meso-level entities operating, in political and administrative terms, between local and national governments with varying degrees of influence over innovation policy'. Learning and knowledge seeking also answers the question of 'how' these factors are linked with each other. Nevertheless, the invisible interdependence in a particular space, such as the social tie, cooperative tradition, and a tolerance for failure, are all intangible elements that link these actors together (Saxenian 2000; Breschi & Malerba 2005). Regarding the question of 'why' innovation systems differ in performance, RIS/LIS pays more attention to the spatial dimension as well. Regions differ in their industrial structures and institutional architectures, both of which would influence the profiles of their RIS/LIS (Cooke 1992; 2004).

2.4.3 Relationship between NIS and RIS/LIS

The development of RIS/LIS theory, to some degree, can be seen as built up from critique of the NIS. Mothe and Paquet (2000, p30), for example, argued that the concept of NIS 'suffers in so far as it is itself not so much an explanatory variable as a dependent variable', and that the notion of NIS will 'almost inevitably lead to compulsive centralization and misguided approaches' (Acs et al. 2000, p37). The logics that underpin these criticisms including: 1) The rapid globalizing process and the changing technological conditions compel firms to become 'footloose' (Phelps 2008) and to form more flexible networks with other agents both locally and internationally (Scott 1988). This expanding business network thus blurs the boundaries between states. 2) The MNCs, by mobilizing labor, capital, and resources worldwide, are substituting the nation-state to become the carriers of innovation (Mothe & Paquet 2000). 3) Advances in transport and communication have decreased the importance of traded interdependencies, while increased the weight of intangible resources such as knowledge and social relationships (Storper 1997). 4) These untraded interdependencies not only take time to accumulate, but also are 'space sensitive' (Andersson & Karlsson 2004). The most effective way for firms to tap into this network is by actually 'being there' (Gertler 2003).

In comparison, the scholars in NIS are more open to the idea of RIS/LIS, while affirming the influence of state and the central government. Lundvall (2007a; 2007b) for example, suggested that RIS/LIS is not replacing but complementing NIS, because a better understanding of innovation on regional and local levels would make it easier to compare innovation performance across countries. The author takes an eclectic attitude towards the IS theory, and argues that all the national, regional, and local factors have a say in firms' innovation performance (fig. 2-8).

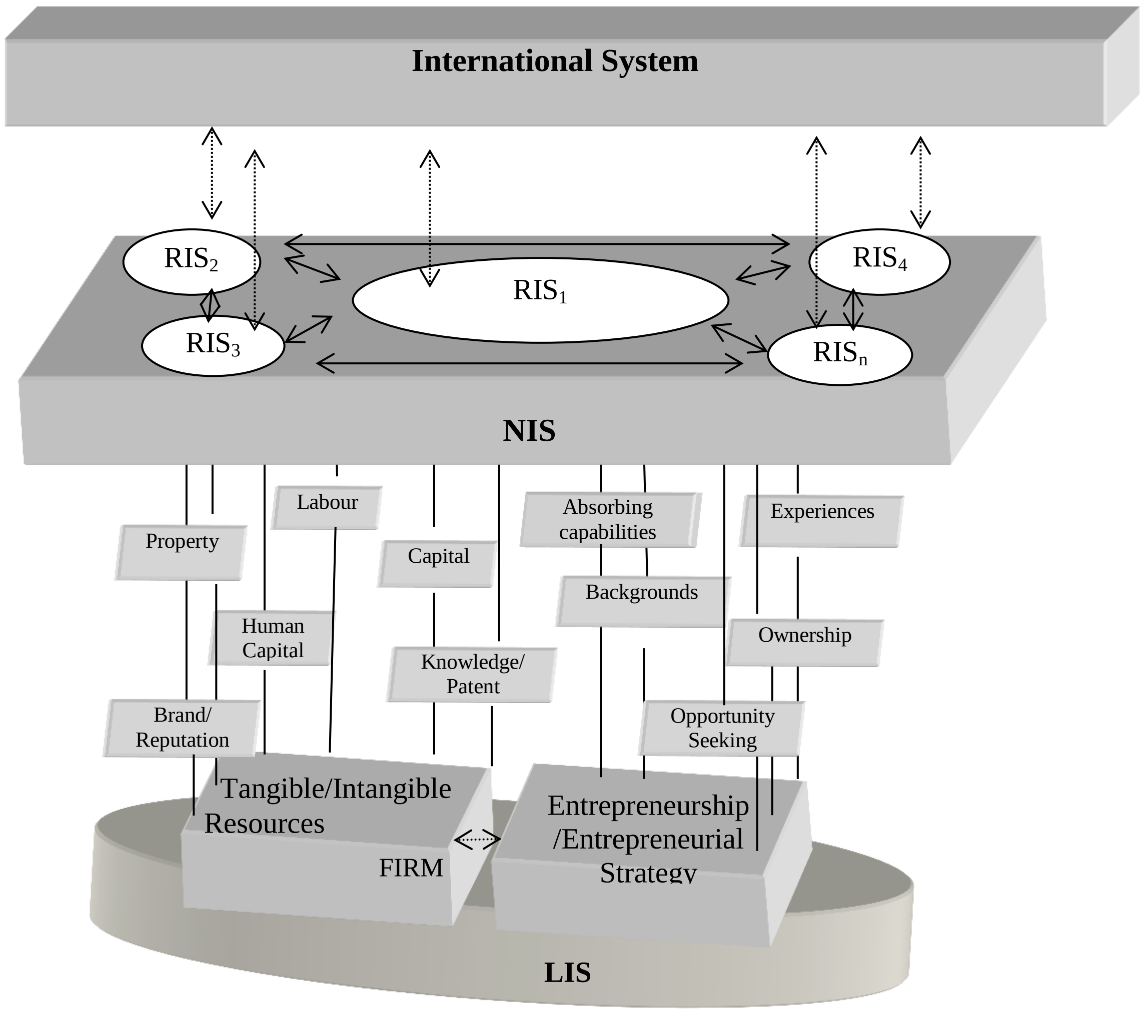

Figure 2-8 The relationships between NIS, RIS, and LIS

Source: the author

An increasing number of researchers have started to acknowledge this multi-level structure of an IS. Zeller (2001, p126), for example, by studying three biotech clusters in Germany, pointed out the necessity to take into consideration the overlapping of national, subnational, regional, and local innovation systems. Chung (2002, p486), in the same vein, argued that the NIS should be considered as comprised of regional and sectorial innovation systems. Muscio (2006), on the other hand, contended that one RIS can contain several LISs (industrial districts). Therefore in the following empirical study, the local level will be the base for studying the IS in Central China, but the influences of regional and national innovation systems will be given due attention to as well.

2.5 Innovation systems in place

Regarding the analyses on NISs, three broad methodologies are used. The first and most prominent approach is 'actor-centered'. It starts with identifying the most relevant actors in a NIS, and then tries to outline individual actor's characteristics and their linkages with each other. Nelson et al.'s (1993) comparative study on fifteen countries is perhaps the first and the most influential one using this methodology. The actors that were identified as important in all the cases were firms and the leading industries, laboratories, universities, governments and their policies, and financial sector. OECD (2008) adopted a similar approach to review the NIS of China. Its analysis focused on the business sector, innovation policy, public research institutes, labor market, R & D programs, and the linkages between these 'actors'. The advantages of this approach lie in: 1) its straightforward reasoning and close link with the theoretical distinction between the core and the supporting actors within an IS and; 2) its wider application and thus easy to compare between studies. Its limitations, however, would be found on one hand, in its reliance on a high level of abstraction, which in turn has the danger of sacrificing details on the lower levels (Carlsson et al. 2002). On the other hand, the possibly different significance of the same actor in different countries could invalidate comparisons between NISs (Edquist 2005).

The second approach, by contrast, is 'function-centered'. Authors advocating for this approach argue that the boundaries between different actors in NIS have become less profound than their functions. Therefore focusing on the functions of an IS would be wider applicable. Liu and White (2001) first came up with this approach when studying China's transitional NIS. Five basic functions were suggested by these authors, including: 1) research, 2) implementation, 3) end-use, 4) linkage, and 5) education (ibid. p1094). This method is plausible in that different combinations of actors are possible under the same function. By studying these different combinations as well as their dynamic changes, intra- and inter-country comparison is possible. Lundvall (2007c, p111), however, warned that without a clear assumption about the linkages between different foundations, this method may end up like ‘growth accounting exercises’.

The last method adopts a ‘micro-to-macro’ approach. Practitioners using this method are generally dissatisfied with the broad pictures depicted by the above two approaches, therefore they start with the specific regional or local level characters before exploring deeper into the bio-directional interactions. Chung (2002), for example, got the conclusion that Korea’s NIS is still weak by studying the competitiveness of its regions. OECD (1997) also tries to establish the linkage between cluster analysis and NIS study, suggesting that firm-level innovation surveys and cluster interaction studies would be valuable channels to study NIS.

For the studies on RIS/LIS, two sets of research methodologies are dominant (Doloreux & Parto 2005). The first set is through comparative studies. By studying and comparing different regional or local clusters, the general aim is to identify the desirable conditions and unique factors that nourish systematic innovation in specific regions. Saxenian’s (1994; 2000) research on Silicon Valley and Route 128 is an excellent example within this strand. Li (2009) quantitatively studied the diversified innovation capabilities of different RISs in China. His results showed that government support, regional innovation environment, and firms’ innovation mode were significant determinants for regional innovation disparities. The merit of comparative method lies in its strength at finding ‘crucial’ and ‘particular’ factors that contribute to the superior performance of one RIS/LIS. However, the limitations of this approach are twofold. First of all, which case to include and which to exclude is a difficult choice. Moreover, given the increasing number of innovation systems on the local level, the cases it can include are far from exhaustive. Secondly, the comparative studies on RIS/LIS are generally taking ‘snapshots’ of particular regions. As a result, it is difficult for this approach to present a dynamic picture of RIS/LIS.

The second set of methodologies is through a single case study. This approach focuses not so much on finding the 'particular' factors as the former, but more on assessing the development stage or quality of an individual NIS/LIS. Studies following this approach usually rely on historical analysis of local economic structure, culture, as well as community relationships. How this NIS/LIS adjusts itself under changing environment is often the focus of explanation. Smith (2000), for example, traced the development of a LIS in Oxfordshire, UK, and three actors stood up as important: the planning authority, Oxford University, and local voluntary organizations. The reports on the Cambridge phenomenon by Segal Quince Wicksteed and partners (1985; 2000) are also good examples in this vein, which depicted a comprehensive and dynamic profile of this LIS. More importantly, their studies could be read as one of the earliest attempts to explore a science park from a systematic viewpoint, which also inspired the current study to a great extent. In what follows, the existing studies on the science park phenomenon will be discussed. As will be explicitly pointed out in the summary, the practice of science parks has not been widely accepted as one way of building a LIS, which however, also resides the potential contribution of this research.

2.6 Science parks as local innovation systems

Studies on science parks are anything but unequivocal. The lack of a general consensus in this field may be caused by the different research methodologies used, the various scales of analysis, the diversified focal points and/or the special sectors chosen (Monck et al. 1988; Phillimore & Joseph 2003; Phan et al. 2005; McAdam & McAdam 2008). Along with the changing practices of science parks in reality, three stages of research can be identified from the literature, ranging from the linear model, through the interactive model, and now a systematic model (AURP & Battelle 2007, p8).

The first generation of science parks in the 1950s and 1960s was mainly located within or near universities, partly followed and partly popularized the linear view of innovation (Bush 1945). Promoting technology transfer from research institutes to industries was the forefront mission of these science parks (Worthington 1982). Correspondingly, the first stage of Science Park studies tended to read science parks merely as a property development (Carter 1989; Massey & Wield

1992a; Gower & Harris 1994). Scholars focused on the assumption of the linear model (Goddard & Thwaites 1983; Macdonald 1983; Reid 1984), trying to identify the linkages and knowledge spillovers between universities and firms (Simmie & James 1986; Jaffe 1989; Fukugawa 2006), and to assess the added-value that the science parks can offer (Wallsten 2004). Worthington (1982), for example, defined a science park as comprised of small to medium sized offices, sitting in close accessibility with HEIs, and devoted to the development of scientifically proven concepts from laboratories to production stages. Massey et al. (1992; 1992a; 1992b) criticized science parks as 'high tech fantasies'. They not only pointed out the inappropriate assumption of the linear model on which the science parks were supposed to base, but also depicted the severe social and geographical partitions within the science park areas. In summary, the first generation studies on science parks are dominated by skeptical conclusions, especially towards the linear model of innovation that science parks are supposed to rely on. These studies also reflect the blind 'copying' strategy of many politicians (Macdonald 1983; Cook & Joseph 2001; Macdonald & Deng 2004), and the 'selling square meters' practices (Cooke 2001, p24) of the early science parks.

The practices of science parks in the 1990s, in comparison, paid more attention to the all-round factors that influence firms' innovation activities, as well as companies' changing and diversified requirements at different life stages (AURP & Battelle 2007). Accordingly, researchers on science parks also broaden their scope to cover the various kinds of interactions both within and outside science parks (Phillimore 1999). Moreover, there was an encouraging shift of focus from concentrating solely on science parks' commercial achievements to their multi-dimensional progress (Monck & Peters 2009). Literatures on science parks in this stage based on the interactive model and tended to emphasize firms' characters (Watkins-Mathys & Foster 2006; Dai & Liu 2009), their stages of development (McAdam & McAdam 2008), and the interactions on various scales and scopes (Radosevic & Myrzakhmet 2009). Benneworth (2006) showed how university spin-off companies in North East of England, and Twente the Netherlands mobilized and localized global knowledge resources into their regions. Hu (2008) compared the mobility and social relationships of the human capital in Taiwan's Hsinchu and

Tainan Science-based Industrial Park. His conclusion was that as the science parks grew, so did the organisational and social proximities. Lofsten and Lindelof (2002; 2003; 2005) compared on- and off-park firms in Sweden. Their quantitative analysis not only identified some performance differences between these two groups of firms, but also found that firms' characteristics, such as motivation, management skill, and academic background, were all highly relevant for their innovation and marketing activities.

Although significant progress has been made on the second stage of science park studies, there are still missing elements in these research. For example, Phan, Siegel and Wright (2005, p165) in their executive summary for a special issue on science parks and incubators, suggested three areas for strengthening: first, a systematic framework to understand science parks and incubators; second, the dynamic natures of the parks as well as the firms; third, identifying and assessing the performance of science parks and incubators. Taking these suggestions, three more limitations in the current science park studies are relevant in this study. First of all, the theoretical foundation underpinning science parks is in an urgent need of upgrading. Many studies that hold a critical viewpoint towards science parks still assume the latter are based upon the linear model of innovation, without noticing that the daily practices of many science parks have been moving beyond this simple assumption. Secondly, insufficient consideration has been given to the 'soft' side of institutions that sustain a science park, while the bulk of studies are concerned with the 'hard' economic indicators, such as employment and revenue growth. Last but not least, there is a paucity of research on the role of public policies and governments on the growth and performance of science parks. The last two shortcomings would prove more problematic if studies are undertaken against the background of developing/transitional countries and regions. It is argued here that the IS theory, and especially the extended four-quadrant framework in this study, has a high potential to contribute to all the above limitations by offering a comprehensive, dynamic, as well as a systematic picture.

Although implicitly, some previous studies have already paid attention to the systematic characteristics of the science park practices. For example, Hardin (2008) traced the history of the Research Triangle Park in North Carolina, and found that it was the co-existence of supportive universities, the local 'generosity of spirit', and the right development time that worked together in creating this park's success. Westhead et al.'s (1994; 1995; 1997; 1998; 1999; 2000) comparative studies on the paired companies located on- and off-Park in the UK is arguably one of the few longitudinal quantitative studies on science parks. Their data covered the founders of the high-tech firms, technology sophistication, innovation input and output, financing, human resources, as well as the innovation environments, which helped to shed light on the systematic characteristics of the science park development in the UK. Cooke (2001) and Asheim & Gertler (2005) explicitly applied the RIS concept when referring to science parks or technopoles. 'Dirigiste regional innovation system' (Cooke 2004, p10) and 'regionalized national innovation system' (Asheim & Gertler 2005, p300) were the terms they used to summarise the characteristics of science parks, both of which referred to a planned innovation island with few interactions among firms and between the private and public sectors.

These few studies that explicitly adopted the framework of innovation system, however, still largely reached a negative conclusion on the value of science parks (see Bania et al. 1993; Cook & Joseph 2001). Nevertheless, it is argued here that the overwhelmingly critical opinions towards science parks are reached through a (mental) comparison to the most successful clusters in western countries, which are the prototypes of the spontaneous growth model. However, given the context and the development stage of science parks in developing/transitional countries, different conclusions might be possible. First, the mode of 'induced adoption' (Antonelli 1990) is arguably crucial and necessary in these developing countries/regions when their endogenous firms are mainly the 'traditional' or 'dependent' type. Second, under the context of Asian Pacific region in particular, the tradition for the local, provincial, and state authorities to be involved in economic development is profound (Markusen & Park 1993; The Allens Consulting Group 2005). Therefore establishing science parks may be an efficient way of 'networking the initial relations' between companies, universities, and governments there (Ciciotti 1998, p143). For example, establishing science parks has proven necessary for Russian firms to get used to technology cooperation and competition, as well as to leverage their skills in marketing, designing, and financial management (Kihlgren 2003, p65). In China, the science park model itself was a consequence of the interactions between entrepreneurs and governments (Cao 2004). Moreover, although most of the Chinese science parks are still in their infancy (OECD 2008), they nevertheless facilitated this country's transformation from planned economy to market economy (Tan 2006;Hong 2008), and mobilized the local entrepreneurship potential (Walcott 2002; Wu 2007; Dai & Liu 2009).

2.7 Summary

All in all, it is the author's belief that the IS theory, especially the extended four-quadrant framework proposed in this chapter, has the potential to uncover the rich historical and institutional dynamics of the science parks. However, an open-minded approach towards science parks is a prerequisite, as their added-value is only meaningful under a particular social and cultural context and against a dynamic background. Therefore the aim of this research is to conduct an in-depth study on the birth, growth, and dynamics of science parks in the context of less-favoured countries/regions, based on the IS theory. The next chapter will provide a preliminary test of the four-quadrant framework by reviewing some famous science parks in the world.

Chapter 3 The practice of science parks in the world

As reviewed in chapter two, science parks have been gaining in popularity since the new century (UKSPA 2000; Phillimore & Joseph 2003; Salvador 2011). Their daily practices, however, vary significantly across nations and regions, resulting partly from their diversified growth trajectories (Braunerhjelm & Feldman 2006), and partly from the distinctive national and regional innovation systems that they are parts of. This chapter will review the science park practices in the US, UK, France, India, Taiwan, and mainland China, which are chosen because of their representative economic and institutional architectures (Cooke 1992; Freeman 1995; Hall & Soskice 2009). Moreover, three factors will receive special attention, which are: 1) the leader(s) of this system; 2) the engine for its sustainable growth and; 3) the efficiency of this system to achieve its designed function. All three factors will be discussed and compared between the six chosen science parks. Reflections on their characteristics will be presented at the end of this chapter.

3.1 Science parks in the world

3.1.1 Silicon Valley in the US

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Figure 3-1 Silicon Valley: general location
Source: Destinations California (2012)

The earliest science parks were established in North America in the 1950s, and this country still holds a leading position in the quantity and quality of science parks (Saxenian 1985; Link & Scott 2003; Wessner 2009). Silicon Valley in Palo Alto is indisputably the ancestor of the science parks phenomenon, which remains to be the most successful one internationally (Hall & Markusen 1985). Its departure could be traced back to the start of the World War II, when a large amount of government funding was devoted to this area for research and development on aircraft and electronic technologies, thanks to the high reputation of Stanford University in electronic engineering (Castells & Hall 1994a). Moreover, the tremendous contributions of

Professor Frederick Terman were well documented and acknowledged (Tajnai 1985; Koepp 2002). One of his main efforts was to promote the construction of his ‘secret weapon’ – the Stanford Industrial Park – the first science park in the world in 1951. The growth of Stanford Industrial Park (later Stanford Research Park) was pushed by the demand from the private sector instead of being led by a Master Plan (Luger & Goldstein 1991). Nevertheless, the local government was involved in this park’s development through the arrangement of annexation, which led to cooperation between the public and private sectors, with the latter being able to influence the policy more favourably towards their benefit.

The importance of Stanford Research Park for the whole Silicon Valley now has been overshadowed by its limited space and the growing proportion of companies located outside the park. However, as the cradle of this high-tech hub, Stanford Research Park serves more like a symbol of an endogenous innovation system, characterised by grassroots initiatives and co-evolution between the economic structure and the institutional environment. The original leader of this LIS is arguably Stanford University and its entrepreneurially minded academics like Frederick Terman, who had positively cultivated a vibrant business atmosphere and a closely intertwined industry-university network. However, it is the dynamic private sector and the spontaneous enterprises that lead the growth of this LIS once it passes the embryonic stage. The vivid stories told by Koepp (2002) about how HP and Intel diversified themselves when facing crises just illustrate the importance of innovation and strategy management for a company’s survival, without which an IS will also collapse. It is this motivation for better performance by individual entrepreneurs that jointly leads the progress of this IS.

The widespread entrepreneurial spirit, competitive but also cooperative culture in Silicon Valley is arguably the ultimate engine sustaining the existence and competitiveness of this LIS (Saxenian 1994). This entrepreneurial spirit, on the other hand, is strengthened and sustained by a tensely connected community, comprising entrepreneurs, politicians, academics, spin-offs, and venture capital firms, to name just a few. When young David Packard shouted in a Stanford Conference that ‘manager has a responsibility to its employees, it has a responsibility to its customers, it has a responsibility to the community at large' (Jacobson 1998), this later-to-be billionaire demonstrated the value of networking to his peers. As this LIS grows, its community recognition and innovation spirit also expand in scope and scale, which in turn fuels this high-tech hub fully in power.

Notwithstanding the deteriorating living environment, high pressure, and social segregation (Koepp 2002), which are beyond the scope of this study, the effectiveness of this LIS as a 'secret weapon' to bring businesses in this area has far been fulfilled (Leslie & Kargon 1996). The tremendous wealth created by the two-county region that hosts Silicon Valley has surpassed the total GDP of some small countries (Luger & Goldstein 1991). What more importantly, however, are the leading-edge technologies and innovations that originate here. Off-shore businesses from Silicon Valley had contributed to the industrial upgrading of the 'four little dragons'. Now their newly preferred regions, such as China, Indonesia, and India, have been undergoing a similar industry restructuring process. What is more, the increasingly noticeable 'reverse brain drain' (Saxenian 2002; 2007) from this technology hub to developing regions enables the latter to share a piece of the 'high-tech cake' through returnees. Furthermore, the international popularity of the science park model could be largely attributed to the huge success of Stanford Research Park and Silicon Valley it gave birth to (Link 2009).

Among Silicon Valley's European counterparts, two stand out for different models and will be analysed fully in the following two sections: the first is the Cambridge Science Park and its surrounding high-tech cluster; and the other is the Sophia Antipolis in France.

3.1.2 Cambridge in the UK

(Figure has been removed as third party copyright material)

Figure 3-2 Cambridge Science Park: general location
Source: Global Business Parks (2012)

The Cambridge high-tech cluster is attributed as one of the few European cases that stands parallel to Silicon Valley, although thirty years ago this ‘Cambridge Phenomenon’ was far less noticeable to the world compared with Silicon Valley (Castells & Hall 1994b). The genesis and development of Cambridge, while sharing some similarities with the Palo Alto Valley, stands out on many perspectives worthy of attention.

The city of Cambridge is located in the south of Cambridgeshire, a county that used to be regarded as the ‘rural backwater’ of Britain, although Cambridge University had established its reputation since mediaeval times (Castells & Hall 1994b). The stronger government intervention in the late nineteenth century (Koepp 2002), the conservative attitude of the Cambridge Planning Committee and the Cambridge University had all partly resulted in the slow take-off of the Cambridge cluster (Segal Quince Wicksteed and partners 1985; Castells & Hall 1994b). Furthermore, the local ‘laid-back’ entrepreneurial culture might affect as well. For example, in their revisit to the Cambridge Phenomenon, Segal Quince Wicksteed (2000) asked companies’ long term goals of growth and location. Their results showed that eighty per cent of the surveyed companies were satisfied with running their business locally without any plans of expanding to elsewhere. Therefore it can be argued that the entrepreneurial culture in Cambridge is less ambitious compared with Silicon Valley, and the local government and the university are surely not the so-called ‘entrepreneurial pioneers’ in the public domain (Osborne and Gaebler 1992; Frank et al. 2007). Overall, the entrepreneurial spirit of the LIS in Cambridge is featured with a leisurely balanced life-work division, which was also reflected by the growth of its science parks.

The first university science park in Cambridge and even in Europe was conceived in 1970 by Trinity College (Segal Quince Wicksteed and partners 1985). After some difficulties at attracting tenants in the first decade, its development quickened afterwards, derived mainly from the growing number of spin-offs from the university and from the established companies (Cambridge Science Park 2011). Nevertheless, the contribution of Cambridge Science Park on the genesis of the local high-tech cluster is not fundamental, since its development largely lagged behind the local demand. What is more, the economic scale of Cambridge Science Park against the overall growth of the local high-tech cluster is also modest (Hayward 2008), even regardless the 'south-south' divides it partly contributed to (Crang & Martin 1991). Its role on the other hand, is mainly advertising domestically and internationally the science-based development of Cambridge.

In summary, the LIS of Cambridge represents a different type from the aggressive entrepreneurial model of Silicon Valley. The leader of this LIS is mainly the spontaneously grown enterprises, and their reactions to the international technological and market opportunities serve as the engine of the system's development. Cambridge University performs more like a highly productive intellectual spring instead of an enterprise-generator, as a result of its neutral or sometimes even conservative attitude towards commercialization. Moreover, the planning control of the local government was largely anti-productive at the early stage, although changes in the public domain are noticeable towards promoting the transfer of basic research to applicable products. Nevertheless, a leisure-styled innovation system might well persist in Cambridge in the perceivable future, whose efficiency in hitting the economic scoreboard might not be so impressive compared to Silicon Valley's aggressive model, but it surely would be ranked higher as a 'liveable' innovation system.

3.1.3 Sophia Antipolis in France

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Figure 3-3 Sophia Antipolis: general location
Source: Invest in Cote d'Azur (2012)

Sophia Antipolis is located northwest of Antibes and southwest of Nice in France. As one of the largest and most famous European technopoles, its genesis and growth stand out as another model of innovation system apart from the US and UK cases. Two features are worth noting here: the first is the closer relation between the private and the public sectors in the course of its development; the second characteristic is the outward development strategy of this technopole.

These two features and the three key factors that help to frame an IS – its leader, its growth engine, and the system's efficiency, will be discussed in this section.

The French Senator Pierre Laffitte is the mastermind and founder of Sophia Antipolis (Castells & Hall 1994b). Once again, the crucial role of a far-sighted and determinant individual with well-connected network presents here. The start of Sophia Antipolis was mainly a grassroots initiative with little government involvement, because Lafitte failed to convince the central government the value of a periphery science city at that time. The reaction from the President of Gaz de France was like 'when I go South, I want to relax; building a major innovation centre is too daunting a venture' (Pierre 1991). However, a development project so ambitious as the Sophia Antipolis would be impossible to sustain without the intervention and participation of the local and national governments in France, a country that is the prototype of a centralized administration system (Longhi 1999). Since the 1970s, therefore, the development responsibility of Sophia Antipolis was gradually transferred to the government. In 1972, for example, a National Inter-ministerial Committee acknowledged this technopole as of national interest (Pierre 1991; Castells & Hall 1994b). A strategic partnership between the private and the public sectors has been institutionalized and serves as the leading force of Sophia Antipolis thereafter, which also distinguishes the France case from many other western counterparts.

Besides this complicated private-public relation, another feature of Sophia Antipolis is the importance of FDI and its cosmopolitan profile. Its economic structure, in particular, is progressively dominated by Information-Telecommunications-Electronics (ITE) and its related sectors (Longhi & Quere 1993; Castells & Hall 1994b; Longhi 1999; Quere 2007), with large MNCs and SMEs formalizing a typical 'hub-and-spoke' industrial district identified by Markusen (1996). Therefore, an endogenous growth engine for Sophia Antipolis was missing for a large part of its development (Castells & Hall 1994b). However, increasing synergies in the ITE sector was observable (Quere 2007). Moreover, the importance of associations and various co-operation projects are increasingly emphasized by the partners of this technopole. Therefore there is hope that Sophia Antipolis would develop its endogenous growth engine, one that is not solely constructed by the home-grown private sectors, but by the cooperation between the endogenous and exogenous innovation players.

Regarding the contribution of Sophia Antipolis, the latest figures showed that on this 5,750-acre unique landscape, there were 1,452 corporations, providing around 31,000 jobs. Moreover, 40 per cent of the companies were involved in some kind of R & D activates and the total number of researchers reached 4,500 (Invest in Côte d'Azur 2011). These hard economic achievements would certainly put Sophia Antipolis on the list of successful innovation systems. However, its efficiency in achieving development and competitiveness is still unstable due to the embryonic synergy between the system components. As part of the leading forces for this LIS, the authorities need to shift their focus from over-emphasizing on attracting FDI to constructing the social fabric of this LIS. Only in this way, another vibrant and sustainable IS would be stabilized in France besides the Paris metropolitan area.

3.1.4 Bangalore in India

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Figure 3-4 Bangalore and its science park projects
Source: Wikimedia Commons (2008)

Bangalore, a traditional textile making city, has emerged in the 1980s as the ‘Silicon Valley of the East’ (Heitzman 1999). However, the study of Rosenberg (2002) showed a mixture of advanced IT service and poor, lagging economy in Bangalore, which makes it a unique case as a high-tech island emerged amid an ocean of poverty. In this section, Bangalore’s growth history and characteristics as an innovation system will be presented.

According to Heitzman (1999), Bangalore’s economic structure had experienced four restructurings since India’s independence in 1947. The first phase lasted between the 1950s and 1960s, characterized by the relocation of many public research and manufacturing factories to Bangalore, a city that is geographically far away from India’s two main military rivals, Pakistan and China (Rosenberg 2002). The second phase, beginning in the late 1960s and running through the 1970s, featured a flourish of these state-run businesses but tight regulation on the private companies (Dijk 2003). The decade of the 1980s is the third phase of Bangalore's development, when the rigid regulation on economy started to melt away, a change facilitated by the power transfer (Wikipedia 2011a). IT companies started to grow in this stage, with Bangalore emerging as a particularly attractive location, thanks to the proactive effort of the regional authority (Heitzman 1999; 2001). For example, three dedicated properties, i.e., the Electronics City, the Software Technology Parks, and the International Technology Park, were constructed with the strong support from the regional government. The fourth phase, beginning in the late 1980s, witnesses an increasing liberalisation of the private sectors and a more positive attitude towards MNCs (Weinraub 1991). For Bangalore, the wide availability and low cost of qualified IT engineers, the popularity of English in this country (Rosenberg 2002), and the highly specialized industrial structure (Heitzman 2001) put it on a competitive position not only in India but also across other Asian cities.

As emerged from the foregoing historical review, the leader of this LIS used to be the government, which has subsequently shifted towards the endogenous private sector. It was the entrepreneurial yet largely 'illegal' private activities that showed the government the promise of the IT industry; it is the returnees and their close ties with other leading IT centres in the world, such as Silicon Valley, that facilitates the knowledge circulation (Dijk 2003). However, the fatal drawbacks of Bangalore's innovation system lie in both its growth engine and its efficiency of achieving sustainability. Recent studies showed that the IT industry in Bangalore was heavily reliant on export and custom-tailored services. Many companies were actually quite happy with maintaining the status quo, with only a few desiring upgrading from software service to product design (Rosenberg 2002), which defines its supplementary and dependent entrepreneurial spirit. Therefore it can be argued that the dynamic of this LIS is mainly sustained by the movement of other industrial and innovation clusters, to which Bangalore holds a supplementary position. How to break the danger of being locked into the lower value-added end of the industrial chain is therefore the urgent question for the governments, if they want to escape from the possible dim future facing the 'Silicon Valley of the East'.

3.1.5 Hsinchu in Taiwan

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Figure 3-5 Hsinchu Science Park: general location
Source: National Synchroton Radiation Research Center (2007)

Hsinchu Science-based Industrial Park (HSIP) is located on the northwest coast of Taiwan, with easy access to the major cities of this island. Starting operation in 1980, HSIP is the first science park in Taiwan as well as in Asia. Among the six major industrial sectors presented on HSIP now, the sector of integrated circuits (IC) is now the backbone of this science park, contributing to over sixty per cent annual sales of HSIP (Hsinchu Science Park 2011). What is more, the role of the central government as well as some public research institutes, in particular the Industrial Technology Research Institute (ITRI), has been crucial in the growth of this science park and Taiwan's semiconductor industry in general. In what follows, the development trajectory of HSIP and the characteristics of this LIS will be summarised.

Three stages would be delineated along HSIP's growth (Castells & Hall 1994b; Rosenberg 2002; So 2006): The conceiving stage between the 1970s and 1980s was characterised by a political concern on the dominant low value-added manufacturing industries in Taiwan (Rosenberg 2002). The idea of a science park was proposed by the then Minister of Economic Affairs, aiming at attracting overseas Chinese and strengthening the political, economic, educational, and military power of the island (So 2006). The formal decision was made in 1976, which also started the second phase of HSIP's development. Since this stage, the role of ITRI has been crucial in preparing the technological foundation of the IC sector and cultivating local high-tech companies (Castells & Hall 1994b; So 2006). During the author's interview with the Secretary of the National Optoelectronic Laboratory in Wuhan, ITRI was frequently mentioned and appraised. For this laboratory, ITRI was the ideal model it wanted to mimic in China, which however, was still a dream to be realized [interviewed on 12th August, 2010]. The third stage of HSIP's development started in the mid-1980s, characterized by HSIP's reorientation to rely on endogenous forces, and the result was noticeable. By 1995, for example, 144 out of the total 180 on-park companies were locally owned, which accounted for 88% of the total investment (Lin 1997). So (2006, p75) went even further and argued that it was the Taiwanese who 'nourished their own domestic semiconductor industry and fostered their specific market niche in the world'. However, it was also found that the domestic companies in HSIP still lacked a strong R & D commitment: many companies on HSIP exhibited a follower's entrepreneurship spirit and admitted that their comparative advantage still lied in manufacturing but not in R & D (Rosenberg 2002, p181).

All in all, it has been the partnership between the government and the private sector that leads the development of HSIP. Moreover, because of the 'follower's strategy' of the private companies, Hsinchu's growth engine is arguably still fuelled by the technological diffusion from other innovation hubs to some extent. However, a close interaction between the various innovation actors, such as the government, knowledge institutions, and the on-park companies, is growing noticeably, which may serve as a trigger for endogenously relied innovations. Furthermore, the increasing numbers of returnees attracted by HSIP also pave the way for its transformation from a technology follower to a technology leader. The efficiency of this LIS to achieve its goal in political, economic, and education dimensions is high at this moment, yet how long this high efficiency would be sustained is another question, given that the strong political intervention persists on the way towards a closer economic integration between the mainland China and Taiwan.

3.2 Science Parks in China

In China, science parks are just one format of its various reform experiments, and therefore any study on this practice could be incomplete without a thorough understanding of this country's reform process. This section will start with the four reform stages of this country (Justin Yifu et al. 2003; Deyong 2010). Within each stage, the general reform measures, their regional reflections, as well as the corresponding science & technology (S & T) reforms will be discussed. Set against these wider backgrounds, the focus of this section will move on to the central topic of this study: the science parks in China and the Torch Program.

3.2.1 Background and cornerstones of China's reform

3.2.1.1 Pre-reform era

When the Chinese Communist Party (CPC) assumed its power in 1949, there was no ready-made recipe domestically towards organising its economic affairs. Therefore the natural choice for this newly established country was to follow the practices of the former Soviet Union. The dominant feature of this Soviet model was a highly centralized administration system and vertically separated sub-systems among different industrial sectors and between science, technology, and economy (Xiaomin 2007; SGST 2007). Moreover, planned development logic on a five-year basis was initialized in China in 1953. Through these 'Five-year Plans', the Central Government managed to organise and distribute a variety of resources and thus influence the economic activities directly.

Regarding the regional policies, Mao adopted a balanced development strategy with a focus on interior China, in order to establish a safe industrial and militarily backyard (Yi & Fulong 2012). This practice was quickened during the so-called 'Three-Front' construction period, when over forty per cent of the large state-owned enterprises were located in the eleven interior regions (Jiageng 2010) (fig. 3-6). Hubei province, which is located in the middle of Yangtze River away from the coastline, benefited significantly in this stage. Hubei's capital city Wuhan, in particular, became the focus of investment (Si-ming 2000) as indicated by numerous major projects, such as the Wuhan Iron and Steel Factory and Wuhan Heavy Machine Tool Plant (Changlin 2008; Chun 2011). These national projects paved the heavy industrial foundation of Hubei for its future development.

(Figure has been removed as third party copyright material)

Figure 3-6 Three-Front construction and Hubei province

Source: Li & Wu (2012, p64)

In the S & T domain, five self-contained forces were established, which were: 1) the Chinese Academy of Science and its subordinated branches; 2) the higher education institutes (HEIs); 3) the national research institutes (RIs) controlled by the Central Government; 4) the local RIs sponsored by the local governments and; 5) the national defence scientific research institutions (Xiaomin 2006). Cross-connection and interactions were minimalized under this vertically managed system, and the low efficiency of this Soviet model was largely undermined by its ideological legitimacy.

3.2.1.2 1978-1984: Reform started

The Cultural Revolution between 1966 and 1976 had affected the economic and social wellbeing of China severely. After Deng assumed power, the mistakes made during this Revolution were acknowledged, and decisions were made to shift the focus of CPC from class conflicts to constructing a modern socialistic country (Xuejin & Li 2009), initialized by the Third Plenum of the Eleventh Party Meeting in 1978 (Lewu 2011).

Since the start of China's reform, the previously balanced regional development strategy was criticized by Deng, who insisted 'efficiency goes first' and 'allowing some people, some places to get rich first' (Deng Xioping Research Team 2009). This staged regional development strategy was implemented on the city level first. In July 1979, for example, Guangdong and Fujian were approved to implement special policies towards foreign investment. Export Special Zones were established first in Shenzhen and Zhuhai, and later in Shantou and Xiamen. This 'pilot zone' model expands in the subsequent reform stages, as will be seen later.

In the S & T domain, the first National Science & Technology Conference held in Beijing in 1978 pulled the trigger on reform. In this conference, energy, computer, and laser, among others, were identified as key areas for catch-up (China Academy of Science 2006). Moreover, the 'Five Forces' were encouraged to (re)start, (re)construct, or extend their S & T activities (The Ministry of Science & Technology 1978). Encouraged by governments' support as well as the desire to commercialize their R & D results, spin-offs from these knowledge institutions started to emerge (Cao 2004). Zhongguancun area in Beijing and East Lake area in Wuhan were two leading areas to witness this early spin-off phenomenon.

3.2.1.3 1984-1992: Stretch and contract

The time between 1984 and 1992 is the second phase of China's reform, characterized by the most dramatic reform fluctuation in China's contemporary history. Being less-skillful in monitoring economy, CPC's reform measures soon heated-up China's economy. For example, in 1985, the net fixed asset investment increased by 94.5 per cent compared with 1983. The national retail price index reached 108.8, 6 points higher than previous year, and the living expense index climbed up to 111.9, 9.2 points higher than 1984 (Justin Yifu et al. 2003). This deteriorating economic environment in turn triggered social unstableness (Marc 2010). The death of the General Secretary of CPC, Hu Yaobang, on 15th April 1989, finally aroused the mass protection on the Tiananmen Square, as Hu was regarded as the advocate for democracy, and was believed being punished for his support to students (Christopher 2005; Deyong 2010). With the situation out of control, Martial Law was finally called upon on the 3rd June 1989 (B.B.C News 1989). In the immediate few years followed, the previous reform target on market freedom was replaced by planned growth, inflation reduction, and price control.

On the regional level, the unbalanced regional development strategy was further extended: The task for the coastal regions was constructing the Special Economic Zones and Coastal Open Cities for attracting FDI, while the Central and West China were mainly defined as the energy and agricultural supplying basements (State Council 1986). Fourteen more Coastal Open Cities, for example, were established in 1984 (Jun 2004; Dazhong Net 2009), followed by three Economic Open Regions (Xu & Li 1990), Hainan Special Economic Zone, and Pudong Economic New Zone. Enormous institutional opportunities were brought to the metropolitan cities along China's coastline, while the hinterland was largely left behind, waiting for 'prosperity to diffuse from the rich' (People's Net 2009).

Against this reform fluctuation, promising progress was still made in the S & T domain in this stage. In March 1985, for example, the ‘Decision on Reform the Science & Technology System’ was published. The state-owned RIs were classified into four categories, which in turn decided the proportion of their public funding (Ke 2004). As a result, 1,186 out of the 5,074 state-owned natural science RIs no longer received any public fund by 1991 (Xiaomin 2006), and the proportion of S & T expenditure within the state fiscal spending declined by around one per cent between 1980 and 1991 (National Research Council 2009). Other influential reform efforts initialized in this stage included: 1) the ‘Spark Program’, which targeted on rural areas and agriculture sector; 2) the ‘863 Program’, which aimed at catching-up the cutting-edge technologies in the world and; 3) the ‘Torch Program’, which is now the governmental support for science parks in China (Juqin & Fangying 2009). The implementation of these programs, however, was carefully controlled by Beijing and carried out on a very small scale (Christopher 2005; Marc 2010).

3.2.1.4 1992-1999: Reform re-launching

The depressive economic and political atmosphere nationwide upset Deng. Therefore from January to February in 1992, this 88-year-old man started his widely publicized tour in South China, championing the idea that reform and open-up, as the Party’s basic guideline, should be pursued for at least one hundred years (Deng Xioping Research Team 2009). Moreover, Deng paid special attention to the stronger resistance in Central China by stopping first at Wuhan in Hubei Province and then Changsha in Hunan Province on his way to Shenzhen. It was reported that when he was greeted by the Chief Secretory of Hubei, Deng warned the latter that China needed reform; those who went against this trend should resign from their posts, no matter how high they were (Haomeng 2005).

The time between 1992 and 1999 was therefore defined as the third stage along China’s reform, characterized by renewed reform and a maturing party leadership. The nature of China was affirmed as a socialist market economy in 1992, which is an institutional innovation that described by Marc (2010, p72) as the ‘market Leninism’. Moreover, the private ownership and overseas investment were acknowledged as the ‘important component’ of the Chinese economy in 1997. Corresponding reforms in enterprise (Central Committee 1993), finance (People's Net 2009), and price management (Zhigang 2003) were all on the fast track in the following years.

The unbalanced regional development strategy, however, was still left untouched. Furthermore, the reforms on state-owned enterprises had worked against the hinterlands more severely, since many of them, especially those engaged in heavy industries, were located in the interior regions. Justin Yifu et al. (2003, p227), for example, calculated the interregional income disparities between the three regions and intraregional disparities within them between 1978 and 1995. Their results showed that around half of the total income disparity was derived from the interregional disparities, which was slowly but continuously increasing as China's reform went deeper.

Regarding the S & T development, in 1991 the 'Ten Years Planning for Science & Technology Development and the Eighth Five-Year Plan' was approved, which required the economic development to rely on S & T advance and vice versa (The Ministry of Science & Technology 1991). The reform principle in this stage was to 'stabilize one end and set free the majority' (Xiaomin 2006; Li 2008), which means concentrating resources on some key research areas and research institutes, while loosening control over the majority. Furthermore, over forty science parks were established in this stage to agglomerate resources and to accelerate the R & D commercialization process (Ke 2004).

3.2.1.5 Since the new century: Reform extension in scale and scope

In November 2002, the Sixteenth National Congress launched the Comprehensive Construction of a Well-off Society (Zemin 2002). The newly elected Central Government expressed its intention to cater for five relationships, such as the relationship between different regions, and the relationship between economy and society (Sohu 2003). Shifting from 'efficiency priority' to 'caring for both efficiency and equity' is the most noticeable theme of the fourth and the most recent stage of China's reform.

Regarding the regional development, following the 'West China Exploration Strategy' proposed in 1999, and the 'Northeast Revitalization Strategy' in 2003 (Northeast revitalization leading team 2011), Central China gained the attention from Beijing relatively late in 2004, and the concrete measures were available even later in September 2009, when the 'Planning for Central China Up-rising' was announced (The Development & Reform Bureau 2010). In this guideline, eight key tasks were allocated to the six provinces in Central China, such as strengthening agricultural foundation; expanding energy and raw material supply capability; and developing modern equipment manufacturing and high-tech industries. This revitalization measure reflects the gained experience of Beijing on regional development, as the eight concrete targets are much easier to implement than the concept of 'do it first and test it first' that applied to the coastal regions. However, these goals may also restrict the initiatives of the Central Region by leaving them limited choices.

Adopting a systematic approach in S & T reform is prominent in this stage. For example, the 'Medium and Long Term Science & Technology Strategic Plan' was adopted in 2006, aiming at constructing a functioning NIS. Four limitations, however, could still be discerned in the current S & T management system, as illustrated by figure 3-7 below. First is the grid structure of the system, which results from the vertical and parallel divisions between different ministries and between the central and the local governments. The second feature is the increasing power of the regional and local governments in organising their S & T activates. Many state-controlled RIs, HEIs, and enterprises are now relying more on the local authorities for funds, making alliances with the latter crucial. The third feature is the negligibility of the service sectors in this system, which contrasts clearly with the western countries. Actually self-organised agencies used to be strictly controlled by Beijing till 2008 [interviews with the Secretaries of COEMA on 4th August, 2010]. Finally, while it is common for the knowledge institutes to influence the directions of the S & T policies in western countries; in China, the governments monopolize this role, although suggestions from these RIs may be adopted if they are in line with the government interest [interview with the Director of S & T Bureau of XX city on 19th August 2010].

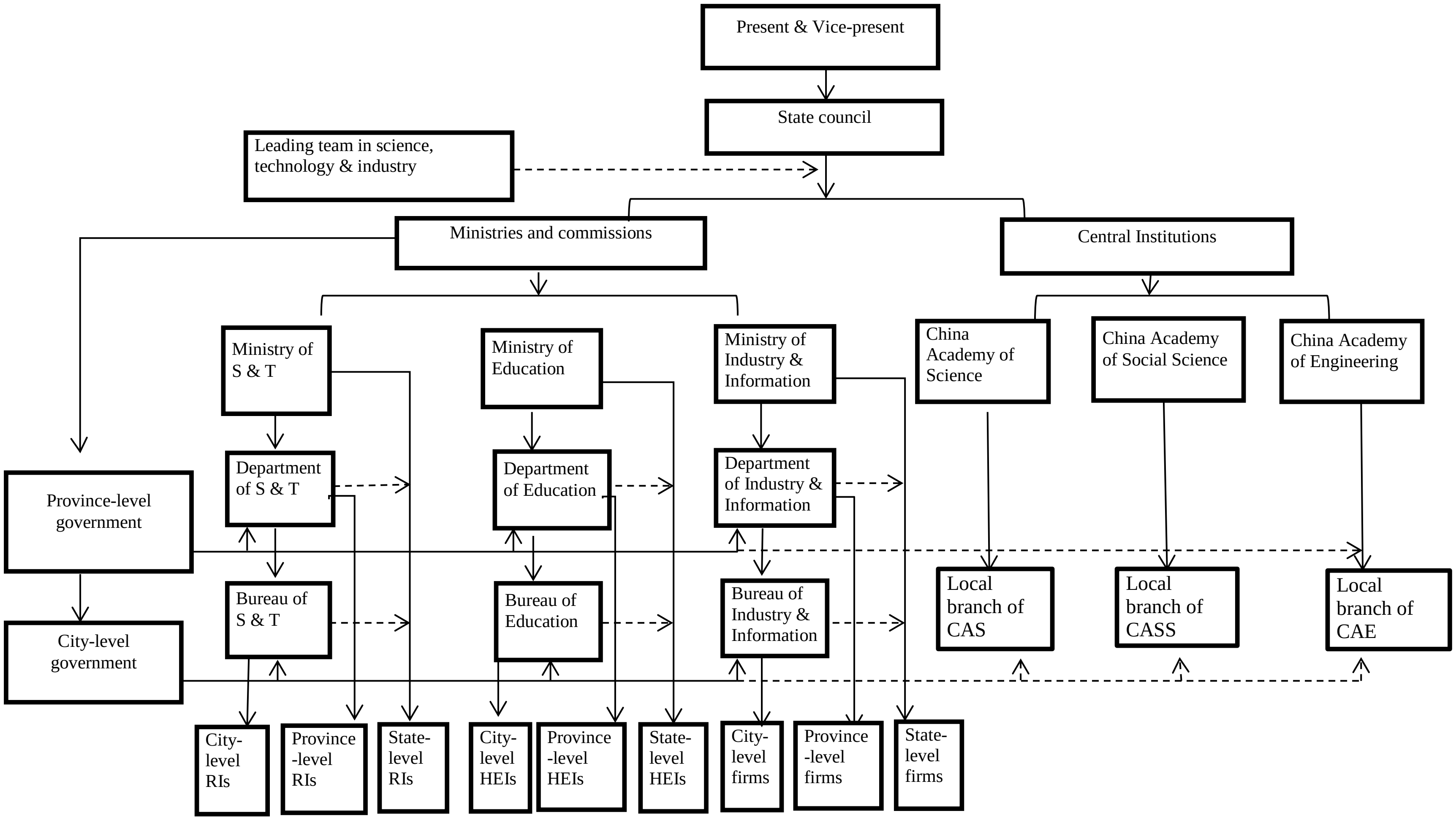

Figure 3-7 Science & technology administration system in China

Note: 1. ⟶ Direct administration; - - - -> Indirect influence;

2. Source: the author

In conclusion, China's reform and open-up since 1978 is not a smooth process – both mistakes and successes were evident. Table 3-1 below extends OECD's (2008) review on China's NIS by bringing in the foregoing discussed reforms and their regional impacts. Science parks, as a particular reform experiment along China's transition, will unavoidably bear with them the unique characteristics of this country, its regions, as well as its S & T system, which will be turned to in the next section.

Table 3-1 China's innovation and regional policies in transition

	Start 1978-84	Reform fluctuation 1984-92	Adjustment and deepening 1992-99	Comprehensive reform 1999-now
Context	Ending the culture revolution and starting economic reform	Expansion of the reforms into S & T sphere; unbalanced reform caused economic chaos	Fast economic growth, facing technology-based competition	Increasing concerns about the endogenous innovation capability & sustainability
Landmark policies	Open-up policy(1978) National S & T Conferences(1978)	Start the reform of the S & T system(1985) University reform(1985)	Ten Years Planning for S & T Development and the 8th Five-Year Plan (1991)	Welcome Knowledge Economy and Construct the NIS (1998)
Overall reform focus	Remove the ideological barriers; Rural reform as breach (78-84);	Loose price control; State enterprise reform started (84-88); Lagging institutional reform	Reaffirm the decision on reform and open-up; Market economy confirmed	Private economy, State enterprise reform deepened (97-02); Harmonious development
Regional impacts	Economic efficiency priority; East region get rich first;	Economic efficiency priority; Science park experiment started	Economic efficiency priority; regional and sector bias co-existed	Increasing consideration to equity
S & T system reform	Remove the ideological barriers; Address the limits of the soviet model of vertical division	Reform the funding allocation system; Open technology markets; science park experiment	Enhance firms' innovation capabilities; 'Stabilize one end and free the majority' for research institutes	Leverage the indigenous innovation capabilities; Put firms in the center of the IS

Source: the author

3.2.2 Science Parks and the 'Torch Program'

The development of science parks in China is organised under the Torch Program, which was initialized in 1988 as one of numerous S & T programs supervised by the Ministry of Science & Technology (MOST) (fig. 3-8). The ambiguously defined boundaries between these different programs, however, are highly noticeable, which would easily cause confusions to enterprises and even result in redundant investment. This characteristic is criticized by OECD (2008) as one of the main defects of China's NIS today.

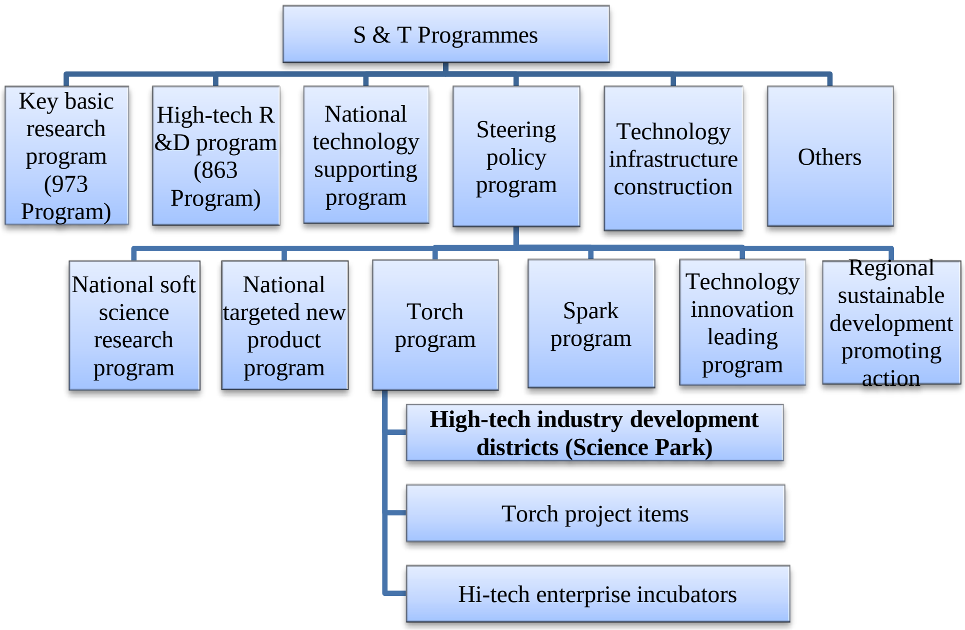

Figure 3-8 China's S & T supporting programs under the supervision of MOST
Source: The author

The Torch Center under MOST is in charge of organising the 'Torch Programs' as well as monitoring the development of science parks throughout China. Its aims lie in promoting the commercialization, industrialization, and internationalization of new/high technology industries. According to the Torch Center (2009b), science parks in China are defined by their main functions, which include:

1) A base to develop the high and new technology industries;
2) A radiator for diffusing high technologies and products to traditional industries;
3) An experimental zone for institutional reform and innovation;
4) A demonstration center for linking science, technology, and industry;
5) A new community that embodies modern socialism;
6) A school for cultivating high-tech enterprises and entrepreneurs;
7) An exhibition window to other countries.

Geographically, three types of metropolitan areas are preferred by the Central Government to host science parks (fig. 3-9), which are: 1) the core cities with better knowledge resources and industrial foundations (twenty-nine science parks fall into this category); 2) the coastal cities that are early-movers in the globalization process and have better presence of MNCs (thirteen are in this group) and; 3) the traditional industrial bases and regions that concentrated by military industries (twelve are established on this criterion) (Torch Center 2008).

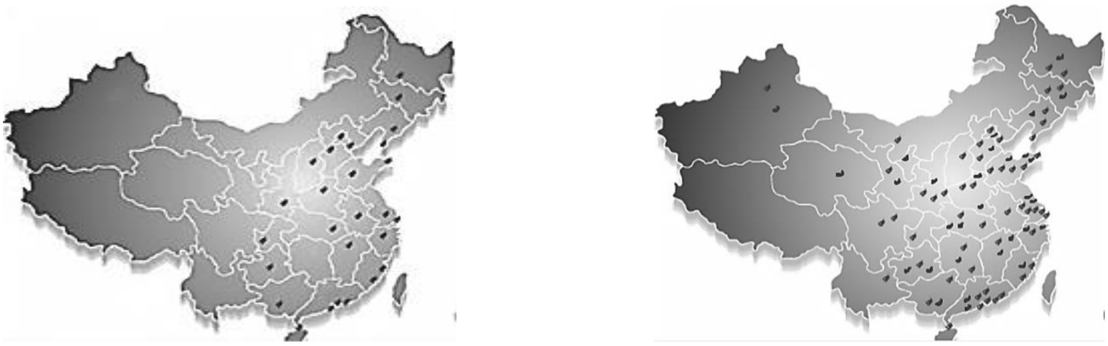

Figure 3-9 China's national-level science parks in 1991 (left) and 2010 (right)
Source: The Author

The growing popularization of science parks all-over China has arguably impacted the power relationships between the central and the regional governments. Although MOST is titled as the supervisor of the science park experiment, in reality these science parks are managed by the local governments or their affiliated departments (Torch Center 2008). An officer from the Torch Centre explained that the role of the Central Government is confined within making guidelines and picking winners in national projects. The local governments on the other hand, control the fixed-assets, financing, administration, infrastructure supply, and thus the practical power over their hosted science parks (fig. 3-10). What they value from the Central Government are the brands and honours brought by winning a national S & T project or a national title [interviewed on 20th August, 2010]. Through this tight institutional interdependence, science parks are adding to their host regions' bargaining power with Beijing. Therefore it is tentative to say that the institutional significance of the science parks, especially those located in the hinterland of China, might far outweigh their economic contributions.

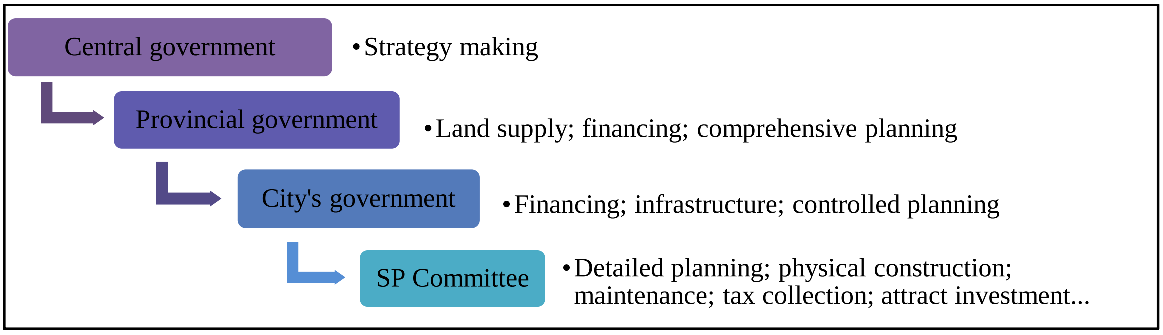

Figure 3-10 The hierarchies of the science park authorities and their responsibilities
Source: the author

Set against China's transitional background and complicated power relations, its science parks are also distinguished from the foregoing reviewed science park practices. In what follows, the most famous science park in China, the Z-Park in Beijing, will be briefly discussed. Again, attentions will be paid to the leader(s), the growth engine, and the efficiency of this science park.

3.2.3 Z-Park in Mainland China

(Figure has been removed as third party copyright material)

Figure 3-11 General locations of Z-Park and its sub-parks
Source: Zhongguancun Science Park (2011)

Z-Park is a general name for ten sub-parks that located in different districts of Beijing (Z-Park 2008). Within its 232 square kilometre's land, there were 47 national key laboratories by 2005, which accounted for 71.2 per cent of those in Beijing, and 25.8 per cent of China (HSP Administration Committee 2008). The Director from the OVC Strategy Research Institute told the author that 'no other regions and cities in China would match Zhongguancun in its high density of knowledge resources. It is the cradle of China's new industries and the innovation source that inspires the whole nation' [interviewed on 10th August, 2010]. Therefore Z-Park stands out as the most compatible Chinese case to the five science parks reviewed before.

Three stages can be identified in the development of Z-Park. The first National Science & Technology Conference in 1978 woke intelligentsia's enthusiasm on economic construction (Qianlong Net 2003) and also started the first stage of Z-Park. The first private venture in China was a part-spin-off from the Institute of Physics, China Academy of Science (CAS) in 1979 (China High-tech Industry Report 2008), which was followed by around ten spin-offs from the Institute of Computer in CAS and several joint ventures with the local universities in the following five years (Deping 2010). All these early enterprises were strongly supported or directly involved by their parent institutes, which differentiates them from the complete spin-offs in western countries, and represent the prototype knowledge diffusion from public institutions to industries in China. Since the mid-1980s, however, the political atmosphere started to change in China (Tan 2006). At this sensitive moment, the support of the local government, just like in the case of Bangalore, had helped this grassroots initiative to gain legitimacy from Beijing. For example, the government of Haidian District not only proactively lent starting capital to the young enterprises, but also provided free offices to companies (Deping 2010). Furthermore, the municipal government went against the conservative tide nationwide, and confirmed the value of Zhongguancun after its survey on this phenomenon in 1986. It further lobbied and convinced the Central Government on Zhongguancun' legitimacy in 1988 (Z-Park 2005; China High-tech Industry Report 2008).

Deng's south tour in 1992 took China's reform a big step forward, and also brought Z-Park onto its second stage of development. In 1992, two more parks in Fengtai and Changping Districts were established, followed by the Electronic City and the Yizhuang Park in 1999 because of the huge demand (Z-Park 2010b). The new century welcomed the third stage of Z-Park, characterized by its growing international reputation. Many leading MNCs, such as Hewlett-Packard, Intel, and Microsoft, have picked Zhongguancun as their headquarters (Z-Park 2008). At the end of 2000, the total industrial income and profit of foreign invested companies accounted for almost half of the total figures generated by Z-Park (Z-Park 2010c). Moreover, the political significance attached to this park is incomparable, as Z-Park is the first science park in China and the first one to be nominated as the 'Self-innovation Model Zone' (Z-Park 2010b). These 'early-mover' advantages had helped Z-Park to quickly build on its national significance by agglomerating all the necessary capital, human resources, and political preferences.

Nevertheless, Z-Park still faces many obstacles on its way to achieve international excellence. The first weakness relates with the poor innovation capability of the domestic companies. For many firms here, the competition strategy chosen is incremental improvement, differentiation, and specialization (Tan 2006) instead of risk seeking and innovating (Watkins-Mathys & Foster 2006). In the words of Liu Chuanzhi, the former chairman of Lenovo, Zhongguancun merely plays the role of a buyer, or even a 'porter' of foreign products and technologies (Zhou et al. 2001). The second challenge relates to the severe competitions from both the international and the domestic players. On one hand, the increasing number of MNCs in Z-Park is competing with the domestic ones on market share and resources. On the other hand, the growing number of science parks nationwide has diluted the economic and political prestige used to be reserved for Z-Park.

Based on the above analysis, the characteristics of Z-Park become clear. The leader of this LIS is the partnership between the public and the private sectors. However, the intervention of the government is overwhelming, which has unavoidably affected the autonomy of the private sector. Nevertheless, China's transitional environment and its numerous institutional and market loopholes might provide more opportunities to entrepreneurs than many mature economic systems in the world. The efficiency of Z-Park to promote industrialization, internationalization, and modernization has been increasing along with the deepened reform, whose sustainability, however, is still an open question due to: 1) the imitator's strategy adopted by many companies; 2) the persistent hostile attitude between the RIs/HEIs and industries; 3) its low value-added position on the global value chain and; 4) the severe competition from MNCs and other science parks. The very rare example of Chinese-originated MNCs, such as Lenovo and Haier, seems far from enough to transfer the overall entrepreneurial spirit of Z-Park from 'product imitators' to 'innovation aspirants'.

3.3 Summary and reflections

It has been argued that building a science park could be seen as one route of building a LIS from scratch. Therefore a close monitoring on the genesis and growth of a science park could shed light on the dynamics of innovation systems. When reviewing the worldwide science park practices, their leaders, growth engines, as well as their efficiencies were paid special attention to. Taken together, these three factors will frame the dominant entrepreneurial spirit of an innovation system, which are summarised in table 3-2 below.

The immediate conclusion by comparing the six cases is the huge diversity between them. Silicon Valley in the US and Cambridge in the UK are the two LISs that took shape mainly through the effort of the endogenous companies. The growth of the rest four cases, in contrast, is underpinned by a strong intervention from the local/central government. Furthermore, Sophia Antipolis, Bangalore, and Hsinchu are more external-oriented, as they attach more importance to attract FDI early on. Z-Park, on the other hand, is very unique in the sense that, China's domestic market is growing fast enough for sustaining an internal-oriented competition strategy. What is missing in this LIS, like in the cases of Bangalore and Hsinchu, is a strong desire to upgrade from an innovation follower to an innovation leader.

Any rush to generalization from these unique cases is dangerous; but a tentative classification of their characteristics and growth trajectories is still necessary for making this study comparable and applicable. Based on the leader(s) of an IS, three prototypes of science parks could be classified: private spontaneous, private-public cooperative, and public cultivated (tab. 3-3), although there are many more versions along the spectrum. The growth engine of an innovation system is arguably the networks of all the innovation contributors. Three types of growth engine would be identified according to the network orientation, which are: internal-networking, external-networking, and lacking network (fig. 3-12). Placing the leader(s) of an IS on the horizontal axis and its growth engine on the vertical axis, figure 3-13 presents the different types of ISs. The positions of the six science parks in this figure are allocated in a way that reflect their relative efficiencies in boosting innovation capabilities, while the dashed arrows represent their dynamics.

Table 3-2 Characteristics of the six LISs (science parks) worldwide

Case	Economic features	System Leader	System Engine	System Efficiency	System spirit
Silicon Valley, US	Removed as third party copyright material	Private sector	Constant opportunity seeking and creating by the tensely networked innovation actors	From moderate to high, but facing environmental and social problems	Aggressive-leader
Cambridge, UK	Removed as third party copyright material	Home-grown SMEs	Reaction to the international market opportunities by the networks of SMEs	From low to moderate; Relatively compatible with the environment and the culture	Leisure-styled entrepreneurship
Sophia Antipolis, France	Removed as third party copyright material	Cooperation between the private and public sectors	Reaction to the international market opportunities by the large MNCs and their local suppliers	From low to moderate; Relatively compatible with the environment	Dependent-aggressive entrepreneurship
Bangalore, India	Removed as third party copyright material	Home-grown SMEs, supported by the local government	Overseas' technological and market opportunities; Networks are outward-oriented	From low to high, but poor innovation, social, and environmental sustainability	Dependent-entrepreneurship
Hsinchu, Taiwan	Removed as third party copyright material	Strong partnership between the central government and home-grown SMEs	Overseas' technological and market opportunities; Networks tend to be outward-oriented	High efficiency in the domestic context, but innovation and environmental sustainability needs improvement	Follower-styled entrepreneurship
Z-Park, mainland China	Removed as third party copyright material	Partnership between the private and public sectors	Domestic technological and market opportunities; Networks are weak	Low to high efficiency, but threatened by the weak innovation and environmental sustainability	Imitator-styled entrepreneurship

Source: The author

Table 3-3 The three prototypes of science parks based on their leaders

Type	Enterprises	Governments	HEIs & RIs	Service sectors	Efficiency
Spontaneous	Take the lead	Liberal attitude	Take initiatives to engage	Attracted afterwards by the market potential	Low then high
Cooperative	Jointly with other actors or attracted in later	Supportive from the beginning	Encouraged or voluntarily engage from the beginning	Encouraged or voluntarily engage from the beginning	Moderate or high
Cultivated	Attracted in later	Take the lead	Pushed to engage	Lack initiative	Low or moderate

Source: the author

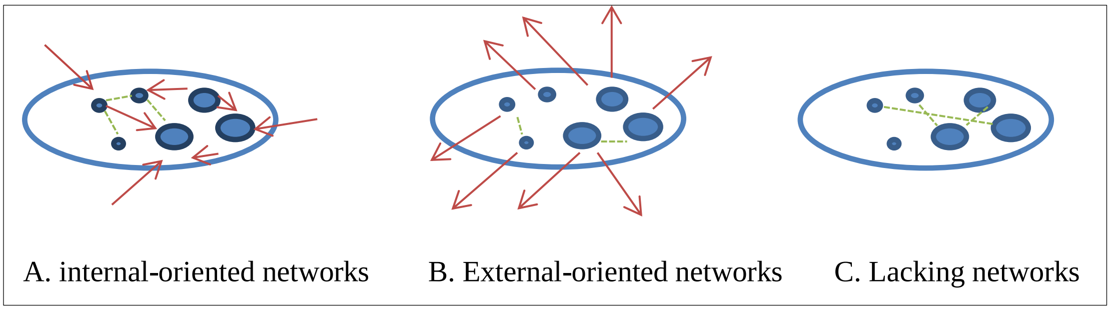

Figure 3-12 Three prototypes of science parks based on their growth engines
Source: the author

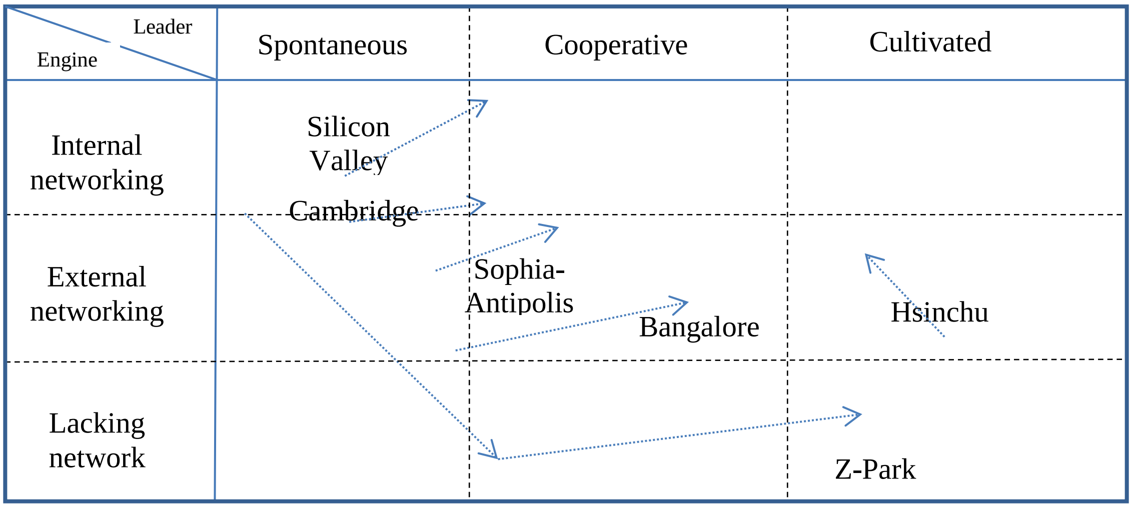

Figure 3-13 Prototypes of science parks and the positions of the six science parks
Source: the author

A spontaneous science park is the archetype science park associated with Silicon Valley, and to a lesser degree with Cambridge, Sophia Antipolis, and Bangalore. However, divergent growth trajectories emerged later as a result of the interactions between the institutional environment and the private sector. Although the start of a spontaneous science park can be slow and less noticeable, once it reaches the crucial threshold, other sectors will follow in and build on the synergy of this IS. Therefore the dynamic of a spontaneous science park may resemble the typical ‘S-shaped’ life cycle of a cluster (Audretsch & Feldman 1996a; Feldman & Francis 2001; Press 2006). A public-private cooperative science park, on the other hand, implies the participation of the government in an indirect manner. Given the enabling power of the government, its development goal for this LIS is crucial: a target that aims at strengthening the endogenous innovation capabilities of the companies, like in the case of Hsinchu, will very likely yield different results from the target that prioritizes local employment and wealth creation, like in the case of Bangalore.

The last category, a cultivated science park, is popularized in developing countries, and is often led by the political desire to mimic the most sophisticated innovation systems in the world. The government and its subordinate institutes are the leaders for its development. Private sector may be attracted in by the strong incentives, but it tends to take a longer time for the system synergy to emerge. The science parks of Hsinchu and Z-Park from China are representatives for this category. However, the difference between Hsinchu and Z-Park is most obviously shown by their networking characteristic: while Hsinchu largely relies on external linkages with the global innovation hubs, its internal network also starts to emerge as a result of the accumulative effect and coevolution of the actors; Z-Park on the other hand, still lacks a visible networking fabric among the various innovation actors. Therefore it is plausible to say that a cultivated science park might turn out to be a functioning IS at last, or just degrade to another implanted manufacturing base (fig. 3-14).

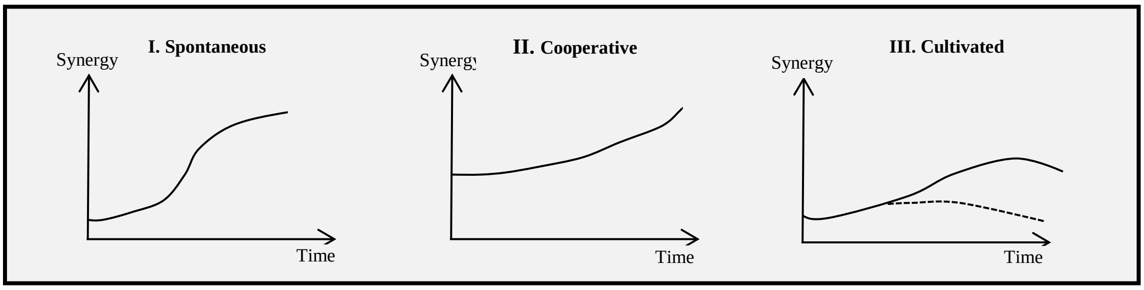

Figure 3-14 Synergy of the three prototypes of science parks
Source: the author

In the context of China, it is plausible to argue that most, if not all, of its science parks could be classified into the cultivated type due to the decisive role of the local/central government. Moreover, science parks in China are the experimental fields of reform led by different levels' governments, and therefore their development targets can be easily manipulated by the political priorities. In the new century, one of the responsibilities of these cultivated LISs is to promote a more balanced regional profile in China. To date, however, there is a scarcity of research on the efficiency of science parks in promoting the development of less-favoured regions in the hinterland China, to which the following chapters will turn to.

Chapter 4 Methodology

The research aim of this study is to analyse the genesis, growth, and value of science parks in developing countries/regions. To reach this aim, the empirical study is going to be based on the Optics Valley of China (OVC) in Wuhan, and try to explore its development trajectory and summarise the characteristics of top-down genesis mode of an IS in a less-favoured region. Regarding the general research method for conducting a single case study, Yin (1994) suggested using a protocol to control the process and quality, which 'contains the instrument but also contains the procedures and the general rules that should be followed in using the instrument' (ibid. p63). Atkins and Sampson (2002) further summarised a set of critical appraisal guidelines to assess the validity and rigor of a single case study. The twenty-nine crucial criteria defined by the above authors to assess the 'way of thinking', 'way of controlling', 'way of working', 'way of supporting', and 'way of communicating' (ibid. p107) will be followed in order to improve the credibility of this study. More specifically, the framework of the IS theory provides support for 'thinking' and 'controlling'. The four-quadrant dynamic model (fig. 2-1) and the relationship model between NIS, RIS, and LIS (fig. 2-6) are the conceptual developments of the IS theory. At the same time, they also provide guidelines for 'way of thinking' and 'way of working'.

In what follows, the research questions and methodologies raised in the introduction will be elaborated ('way of thinking and working'). Then the conceptual framework will be operationalized by specific indexes and items (Babbie 2004) derived from previous studies, taken into consideration the data availability under China's context ('way of controlling and working'). Detailed data collection and analysis techniques will be illustrated next, followed by acknowledgment of the restrictions and difficulties in conducting this study ('way of working, controlling, supporting, and communicating').

4.1 Research questions and methodologies

Four research questions have been briefly discussed in the introduction. Here these questions will be extended and elaborated by their sub-questions and the corresponding hypotheses.

Question 1: How was OVC born?

Hypothesis 1:

H 1.1 As an institutional innovation, the initial development of this LIS was triggered by local firms' economic activities but institutionalized later by the government.

H 1.2 Private and various shareholding enterprises are increasingly becoming engines for this LIS's development, and they are actively interacting with and influencing their innovation environment.

Question 2: What did OVC's growth trajectory look like?

Hypothesis 2:

H 2.1 Firms' internal resources and entrepreneurship have been increasing as they grow.

H 2.2 Co-evolution of the local institutional environment along with the growth of firms could be observed, and the institutional factors have been getting more sensitive to firms' needs.

Question 3: What are the power relations between LIS, RIS, and NIS?

Hypothesis 3:

H 3.1 The relationship between various LISs in China is mainly competitive than cooperative.

H 3.2 The bottom-up influences were small but have been increasing.

H 3.3 The top-down influences were significant but have been decreasing.

Question 4: Statistically, what is the performance of OVC?

Hypothesis 4:

H 4.1 Firms' internal resources, entrepreneurship level, and the institutional environment are significant variables determining their innovation performance.

H 4.2 Local and regional linkages have been most prominent for firms in OVC.

H 4.3 OVC has been upgrading to a synergic system after almost three decades' growth.

To address these questions, the research method of case study is chosen in this study. A case study is 'an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident….it copes with the technically distinctive situation in which there will be many more variables of interest than data points' (Yin 1994, p13). These are exactly the features of this research, as the science parks are embedded within a wider social, economic, and institutional setting. Their co-evolutions with the institutional environment are usually intangible and thus undesirable to evaluate only with econometric indexes. In addition, the explorative and explanatory nature of this study fits in well with the typical situation where a case study strategy is pertinent, that is, according to Yin (2004) and Shavelson & Towne (2002), when questions posed are either descriptive ('*what*') or explanatory ('*how*' and '*why*'), and the researchers have little control over events.

What is more, a single case strategy based on OVC is adopted here for the following reasons. Firstly, China is probably the largest transitional economy in the world, where the top-down growth mode is dominant and the institutional environment bears more significance. This in turn results in the development logic of its science parks different on many standards from the west (Hong 2008). So a thorough study against China's background could be valuable for other countries/regions facing the similar situations. Secondly, it is noted that almost all the research on Chinese science parks by now are based on the Coastal Region, or more specifically, on the science parks in Beijing (Z-Park), Shanghai (Zhanjiang Science Park), Jiangsu (Suzhou Science Park), or Guangdong (Guangzhou science park). In practice, however, the science park phenomenon is far from restricted within the coastal area. This contradiction between the nationwide popularity of science parks in reality and the deficient attention paid to the vast hinterland in research calls for a shifted focus to the interior regions of China. Thirdly, one of the focuses of this study is the mutual-interactions and power redistributions among the different layers of innovation systems. More specifically, it is concerned with China's biased regional development strategies since the 'open-door' era (Zhao & Tong 2000; Fujita & Hu 2001), and the more recent decentralization and deregulation process (Hong 2008; Yi & Fulong 2012) on the efficiency of science parks. These institutional factors and dynamics, in turn, are present nowhere more obvious than Central China – the 'political periphery' region in China now (China Economics 2005; China Finance 2006; China Economy Weekly 2009).

Fourthly, among the nine national-level science parks in Central China, the Optics Valley of China (OVC) in Wuhan, Hubei province is chosen for the following reasons: first of all, OVC is one of the earliest science parks in China, which was born at almost the same time as Z-Park in Beijing. This long existence makes OVC the most possible candidate evolving into the mature stage of LIS, since time is a crucial factor for the performance of a technopole (Castells & Hall 1994b). In comparison, the rest of the science parks in Central China, especially those local and regional ones, started operation very recently. Furthermore, OVC is arguably the most successful science park in Central China (tab. 4-1). As will be shown in chapters five to seven, OVC benefited from a focused industrial development strategy from the beginning, which was also constantly adjusted to reflect the market situation. Comparatively, other science parks in Central China lack an industry focus and strength. Therefore OVC qualifies as a 'unique' case (Yin 2004, p7). The fact that no 'confirmatory', 'contrasting', or 'theoretically diverse' case can be found in Central China invalidates the general rule of conducting a multiple-case study (Yin 2006, p115). Last but not least, the relatively cooperative attitude of the park managers, the wider media coverage, and most importantly, the better personal networks of the author in Wuhan, all make OVC the most desirable candidate in this study.

Table 4-1 Main economic index of science parks in Central Region 2006

(Table has been removed as third party copyright material)

Source: MOST (2007)

4.2 Operationalization of the conceptual framework

4.2.1 Industry setting

Optoelectronics is the focus of this study, as it is what OVC famous for: around half of its tenants (42.3%) and industrial output (49.0%) were contributed by this industry (Wuhan East Lake High-Tech Development Zone 2006). Moreover, focusing on a single industry helps to control the heterogeneity of industries and technologies, which has shown significant influence on firms' innovation activities (Fagerberg & Verspagen 2002; Pavitt 2002). It also allows the researchers to apply industry-specific knowledge to assess factors that impact performance (Bottazzi et al. 2005; Hendry & Brown 2006).

Optoelectronics is an emerging and science-based industry that relates to a wide range of subjects, such as photons, chemistry, physics, material, electrons, and electronic machines (Huang 1994). As a result of its recent popularity and "fusion" nature (OECD 1993), there is no widely accepted definition. The Canadian Advisory Council on Science and Technology defines photonics as 'the integration of optical and electronic techniques in the acquisition, processing, communication, storage, and display of information' (ACOST 1988). The report by the UK Department of Trade and Industry (DTI 2006, p10) applies the broadest definition of this industry, referring to the optoelectronic companies as 'those organizations for which the manufacture or use of photonic enabled products is a key aspect of their business', and where photonic enabled products are 'products that would not be possible without their photonic content'. Regarding the industrial linkages of optoelectronics, Hendry and colleagues (2000, p131), following Miyazaki (1995)'s classification, analysed this industry on three levels, which were: 1) the underlying generic technologies, 2) the key components and, 3) end-user products and systems.

China, although still facing enormous technology gaps, has done relatively well in some sectors of the optoelectronic industry, especially in the laser sector. For example, the first professional optical institute – the Optical Precision Instruments Machinery Research Institute – was established in Changchun as early as 1957 (eTeacher 2012). In 1981, laser and optoelectronics were identified as 'important items' in the national sixth Five-Year Plan, and in 1987, they were included in national high-tech '863 Scheme' among five others. The subsequent importance attached to optoelectronics through the seventh to the eleventh Five-Year Plans promotes the rapid development of optoelectronic industry in China (Zhang et al. 2003; MOST 2006; COEMA 2009a). However, China also lacks an official definition for optoelectronics like many other countries. According to the classification provided by the Directory of Photonics Industry in China (2010a), the whole optoelectronic industry is made up of eight sectors, such as laser, optics, and LED/OLED. Each sector in turn is comprised of upstream, midstream, and downstream products.

In the case of OVC, three sectors are particularly noticeable, which are: 1) the optical communication, 2) laser technology, and 3) mobile communication (Liangzhi et al. 2008). For optoelectronic communication, its upstream chain includes optoelectronic material, fibre and cable production, middle chain covers optoelectronic devices, and downstream chain includes system device designs and productions (fig. 4-1). Among the upstream products, the highest value-added part is the fibre preform, the technology of which is mainly controlled by developed countries. The growth of this sector, nevertheless, is influenced by the demand of their downstream companies (Liangzhi et al. 2008, p54). The global IT crisis since 2000 had also struck the optoelectronic communication sector significantly. In China, however, the nationwide project called 'Fibre to the Home' (FTTH) and the construction of city-scale LAN promoted the recovery of this sector.

(Figure has been removed as third party copyright material)
Figure 4-1 The industry chain of the optoelectronic communication sector
Source: Chuantie et al. (2010, p88)

Laser technology is another relatively strong sector in OVC with many self-developed technologies. The raw components, laser transmitter and equipment, and laser applications are the three main links on its industry chain (fig. 4-2). While the laser transmitter is the most important and the highest value-added link, the downstream laser applications nevertheless hold a bigger market potential. However, the global economy declining since 2001 had impacted the laser market as well. In China, on the other hand, the limited integration with the global economy and the vast domestic market had saved it from dramatic shrinkage (Liangzhi et al. 2008).

(Figure has been removed as third party copyright material)
Figure 4-2 The industry chain of the laser sector
Source: Chuantie et al. (2010, p90)

Mobile communication has the most complicated industry chain among the three sectors. Moreover, the market of mobile transformation and communication are expanding exponentially, especially in the customer utilization areas. For example, according to ABI Research (2011), there were 1.2 billion mobile subscribers in 2008, which increased to 5.5 billion in 2010. Over half of this mobile market was contributed by the Asia Pacific Region, among which China alone had accounted for one third of the regional market share, amounting to 0.86 billion subscribers. The current dominant communication system in China, however, is still the 2G communication equipment, although an increasing investment in the 3G system is expected (ABI Research 2011). Some optoelectronic companies in OVC are taking a lead in China's 3G system construction, which will be discussed further in chapter seven.

4.2.2 Geographical boundary

There is always ambiguity in identifying the local and the regional boundaries (Martin & Sunley 2003; Hall & Pain 2006), a problem that also exists in the IS studies (Doloreux 2002; Doloreux & Parto 2005). Some researchers rely on the administrative boundaries, while others give more weight to the intensity of economic linkages, such as Rantisi's (2002) analysis on the garment district, New York; and/or to the level of institutional embeddedness, such as Muscio's (2006) research on the LISs in Italy. In practice, this ambiguity is often circled by researchers through their own understanding of the concepts, the aims of their research, as well as their knowledge about the real contexts.

Scanning the research on LIS and RIS in China can lead to the conclusion that, the administrative boundaries are adopted most frequently. China's administration system is characterized by a hierarchy of province (also includes municipality and autonomous region), city, county and town (Xie & Du 2008). The province or municipality border, in particular, is utilised as the regional boundary by the bulk of studies on China (see for example Fujita & Hu 2001; Yang 2002). Recent publications by Jon (2004), Xie and Du (2008), however, argued that the three spontaneously emerged metropolitan economic regions, namely the Yangtze River Delta, Pearl River Delta, and the Bohai Economic Rim, fit better with the idea of RIS. While it is true that these three regions are 'meso-level entities between local and national governments', and thus serve as proper unit of RIS in Cooke et al.'s (2000a, p2) definition, it is also an undeniable fact that their thick economic linkages beyond the administrative boundaries are the exception rather than the rule in China. The barriers set by the administrative boundaries are especially striking in the hinterland regions. Batisse and Poncet (2004), for example, calculated the index of regional protectionism based on domestic trade flow. The average scores for coastal, central, and western regions in 2007 were 3.11, 3.36, and 3.80 respectively. Therefore, this study will also adopt the provincial border as the geographical boundary of RIS, given that there is still a long way to go for the six provinces in Central China to form a unified regional market.

Comparing to the growing number of studies on China's RIS, studies on the local level activities are rare. One of the few publications that explicitly utilised the term 'local innovation system' is Wu's (2007) analysis on university-industry linkage in Shanghai. The geographical boundary of this innovation system was delimited by the municipality area, but the focus of the author was on the knowledge transfer activities of Shanghai Jiaotong University and Fudan University. On the other hand, the more locally concerned research on innovation activities in China are generally based on the idea of 'cluster' (see for example Yeung et al. 2006) or 'industry district' (see for example Wei et al. 2010). Considering that the science parks in China are increasingly becoming distinct economic units with relatively high autonomous power (Cao 2004; Sutherland 2005; Zhu & Tann 2005), it is decided to take the boundary of OVC as the borderline of LIS in this study, rather than that of the city or its districts.

4.2.3 Firm identification

After defining the geographical boundaries of LIS and RIS in this study, there is still a challenge to identify the optoelectronic firms due to the lack of official classification. A preliminary company list was obtained from the Directory of Photonics Industry (2010b). This directory is provided by China Optics & Optoelectronics Manufactures Association (COEMA), the only national-level optoelectronic industry association approved by State Council in 1987 (COEMA

2009b). One of the preconditions for a company to join COEMA is ‘optics and optoelectronics enterprise that formally registered within the boundaries of China’ (COEMA 2009c). By the time the field work was conducted in 2010, there were 7,243 registered members.

This company list obtained from COEMA was further complemented by the firm directories published by Wuhan East Lake High-Tech Development Zone (OVC 2009), Guangzhou Optics and Optoelectronics Manufacturers Association (GZOEMA 2010), and Wuhan Laser Association of OVC (WLA 2008). A comprehensive company list was constructed by retaining all the optoelectronic companies located in Hubei mentioned by any one of the above four sources, which yielded 203 companies in total. This comprehensive list was in turn double checked either by telephoning or web-searching, in order to validate the accuracy of firms’ information, and more importantly, to establish the most suitable respondent to complete the questionnaire. The final company list included 184 optoelectronic companies, among which the bulk of 166 were registered in Wuhan (147 registered in OVC), and the remaining 18 were located in other cities of Hubei. Extra information, such as the companies’ addresses, contact numbers, as well as a short introduction, was also retained in the final company list.

4.2.4 Variables and measures

Five concepts are important in the four-quadrant conceptual frameworks proposed in this study, which are: 1) firms’ internal resources, 2) entrepreneurship, 3) innovation performance, 4) institutional supporting environments, and 5) interactive learning. Identifying proper, practical, and comparable indexes in the real world for these concepts is an important prerequisite for empirical study (Babbie 2004). In practice, the author had tried to combine multiple types of indexes for each concept, as long as there was theoretical support and data availability.

Following Romer (1999, p70) and Lundvall (2007c, p101), firms’ internal resources were classified into hardware, software, wetware, and orgware. Hardware is the basic physical requirement for conducting business, such as office space, stationery, and IT facilities; while software refers to the knowledge assets of a company. The total capital of a company might be the best proxy for its hardware and software, because this index includes a company current assets, long-term investment, fixed assets, and intangible assets. Wetware describes the tacit knowledge that is contained in firms' human capital. Following Westhead and Storey (1994), Siegel et al. (2003a), and Lindelof and Lofsten (2005), the number of employees, entrepreneurs' education background and work experiences were chosen to measure this aspect. Orgware is a term introduced by Lundvall (2007c, p101) to describe the structural and cultural aspects of a company, which however, is the most difficult one to find a suitable representative. Among the available data, the number of employees with a higher than college degree in a company is a potential candidate, because skilled workers are expected to value a pleasant working environment.

The definition of entrepreneurship adopted in this study depicts firms' capabilities in two dimensions: internal resource mobilizing and external opportunities seeking. The capability of entrepreneurs to mobilize their internal resources is evaluated by two broad items: training opportunities and organisational culture. Training is an effective way of expanding and updating employees' knowledge storage, which on the more intangible level, could also help to cultivate a learning atmosphere in the firm (Bigliardi et al. 2006; Lundvall 2007c). Organisational culture, on the other hand, deals with the institutional side of a firm's entrepreneurship, which is closely related with the way people behave and interact in the company (Miller 1987; Acs et al. 1994; Rothwell 1994). Entrepreneurs' external opportunities seeking capability, on the other hand, is measured by their reactions to the market, technological, and institutional opportunities. These in turn were captured in the questionnaire by companies' self-perceived competitive advantages, the reasons for their establishment, and the importance attached to different innovation partners.

Regarding firms' innovation performance, two types of distinct but also related indexes are widely used. The first set of indexes utilises a company's general performance, which is assumed to reflect its innovation capabilities. The commonly used items in this set include sales and employment growth (Ferguson & Olofesson 2004; Lofsten & Lindelof 2005). The other set of indexes, in comparison, tries to capture companies' innovation achievement more directly. Some plausible items in this category include the number of patents a firm registered (Jaffe 1989; Squicciarini 2008; Feldman & Lendel 2010) and innovation counts in its broader definition (Acs et al. 1994; Westhead 1997). Both advantages and disadvantages of these indexes exist: while the first set of indexes is indirect, it is relatively easy to obtain; whereas the opposite is true for the second set of indexes. Therefore, this study utilised both indicators in the questionnaire survey.

The institutional environment is classified on the local, regional, and international levels. LIS or the science park environment is evaluated by the necessity of the park location (Felsenstein 1994; Hogan & Dublin 1996; Chan & Lau 2005), satisfaction with the management team (Carter 1989;Westhead & Batstone 1999), services provided (Baxter & Tyler 2007; McAdam & McAdam 2008), and the community recognition of the on-park companies. RIS is measured by two items: the perceived competitiveness of Hubei by the surveyed companies, and Hubei's political environment (Nelson 2000) and business culture (Lai & Shyu 2005; Dettwiler et al. 2006). NIS is assessed by companies' evaluation of the national support and preferential policies they could get access to. What needs to be pointed out is that, all these items are concerned with companies' perceptions and are measured on a five-scale division. Objective bias might be a problem here. However, because the sample is a relatively complete list of the optoelectronic companies, and that no comparison with other science parks is required; this potential bias would therefore not cause serious problems in this study.

Following Vedovello (1995) and Lundvall (2007c), the interactive learning process contained by this LIS is measured on three dimensions: 1) the relative importance of different actors involved; 2) the geographical distributions of firms' linkages and; 3) the interactions between the private sector and the knowledge institutions. The actors that have been identified as important for firms' innovation activities include suppliers, customers (Rosenberg 1982; Lundvall 1992b; Freeman & Soete 1997), associations, service agencies (Avnimelech & Teubal 2006), universities (Freeman 1992; Asheim & Gertler 2005; Chen & Kenney 2007), and governments. The geographical distribution of these linkages is crucial for evaluating the local embeddedness and institutional thickness of OVC, which were defined on the local, city, provincial, national, and the international levels. Regarding the interactions between companies and the knowledge institutions, six different types were specified in the questionnaire for capturing the format and intensity of these linkages.

Moreover, some important characteristic variables are introduced in the survey, which include companies' 1) age (Colombo & Delmastro 2002; Lofsten & Lindelof 2002); 2) main activities (Hogan & Dublin 1996); 3) ownership (Li et al. 2005) and; 4) specific location. The last two factors, in particular, are presumed to have significant influences on companies' performance, and will been given due attention to in the quantitative analysis. Table 4-2 summarises the various measures and items used in the empirical study.

Table 4-2 Summary of variables and measures

Concepts	Measures	Items
1. Firms' internal resources	1a. Hardware & software	Total assets
	1b. Wetware	Employment, entrepreneurs' characteristics
	1c. Orgware	Highly educated employees
2. Firms' entrepreneurship	2a. Internal resource mobilizing	Training and organisational culture
	2b. External opportunities seeking	Reason of establishment, partners
3. Firms' performance	3a. General performance	Sales per employee
	3b. Innovation	Patents and innovation counts
4. Institutional environment	4a. Local level	Location choice, community sense
	4b. Regional level	Political environment, culture
	4c. National level	Innovation programs, special support
5. Interactive learning	5a. Actors involved	Suppliers, customers, agencies
	5b. Network distribution	Local, regional, national, international
	5c. knowledge institutions	Formal and informal
6. Characteristic variables	6a. Age	In years
	6b. Main activities	R & D, manufacturing, distributing
	6c. Ownership	Public, private, overseas
	6d. Location	Postcode

Source: the author

4.3 Data collection and analysis

The research flow chart in figure 4-3 shows the techniques and procedures of data collection and analysis. Following the micro-to-macro research logic, the profile of OVC was the starting point of enquiry, whereas the influences of RIS and NIS were gradually added in. Different data sources were utilised in order to "triangulate" the case study (Fukugawa 2006). Moreover, the procedures of data collection and data analysis were progressed in parallel in order to complement each other (Yin 1994; Patton 2002; Cassell & Symon 2004). However, the concurrent procedure of data collection and data analysis had led to some minor modifications of the data collection design, especially during the survey process.

The original survey strategy was to cover all the identified 184 optoelectronic companies in Hubei either by post or email. However, no response was gained after two-rounds of sending emails and posts. Confined by time and finance, the survey strategy was adjusted to face-to-face survey instead, with the 147 on-park companies as the sole target. Nevertheless, the fact that around eighty per cent of the identified optoelectronic companies were registered within OVC assured that concentrating on this science park was a more effective and efficient way of collecting data with tolerable missing information. On the other hand, face-to-face survey meant the author had to physically show up at each company and to convince the managers to participate in the survey, which was very difficult and time-consuming. In the end, 138 usable questionnaires were obtained, equalling to a high response rate of 93%. This is very encouraging if taking into consideration the difficulty of getting companies involved in academic research in China (Wright et al. 2008). Among the returned questionnaires, 23 (16.7%) were secured by telephone interviews, 9 (6.5%) were surveyed through emails, and the rest (76.8%) were covered by face-to-face interviews. Moreover, all the questionnaires were completed by at least the junior manager(s) from the company, and over half (71 questionnaires or 51.4%) were answered directly by the CEO.

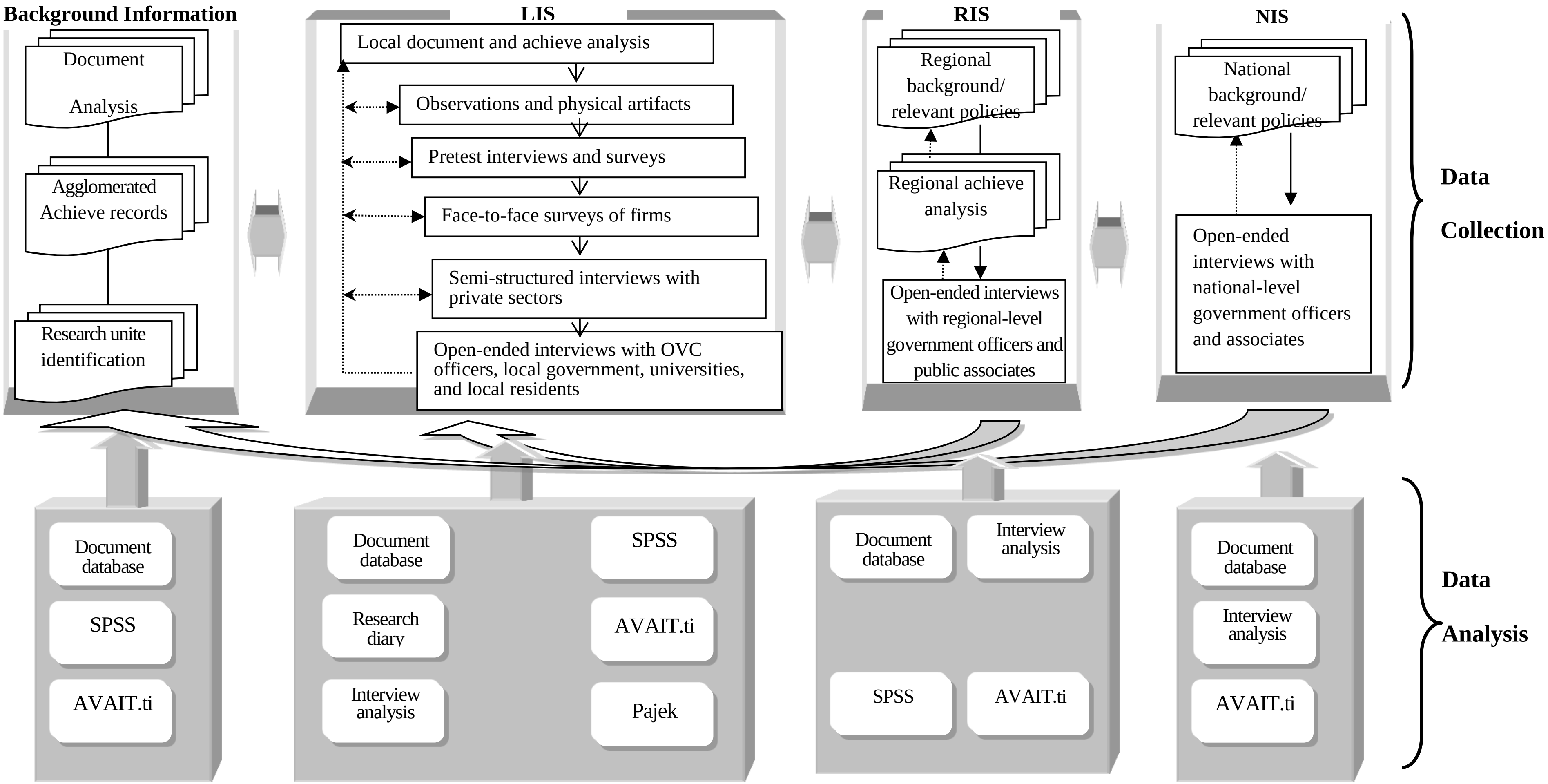

Figure 4-3 Data collection and analysis flow chart

Source: the author

The author's personal relationships were pushed to their limit during the field work, and this was also how a complementary official annual survey was given as a personal favour by a senior officer from OVC. More specifically, this database was part of a standard annual survey questionnaire designed by the Torch Centre, which requires the Management Committees of all the national-level science parks to report the performance of their on-site companies. Five sections and one appendix are included in this standardized questionnaire, which are: 1) the general profiles of companies, 2) their economic performance, 3) personnel situations, 4) main products, 5) R & D activities and related performance, and the appendix 6) technology projects involved. Totally there are around 200 indexes used to evaluate these six sections.

However, these survey results are ranked as confidential by both the individual science park as well as by the Torch Centre, and therefore by no means would it be obtained through publicly accessible channels. The only spread sheet the author got was part of the whole company survey done by the Management Committee of OVC in 2010, which covered only the optoelectronic related sectors and a limited of 158 indexes. In more detail, this survey database comprised 550 companies engaging in a very broadly defined optoelectronic industry, ranging from electronic machinery, software, GPS design, IT, hardware, and multimedia, to the more narrowly defined optoelectronics, which included laser, fibre, and optoelectronic components. Two out of the six sections, namely the companies' main products and the appendix of the technology projects a company engaged in, were purposely cut-off by the provider. What is more, the author had been required not to make any individual company's information public. Therefore, this database was only utilised to provide an overall profile of the optoelectronic companies in OVC, as well as to cross-check the author's own survey results.

The detailed research methodologies utilised in this study comprised of a mixture of qualitative and quantitative approaches, including:

1. Theoretical and empirical literature review. The aim was to identify the most relevant factors for the innovation process as well as for the whole innovation system, the various research methods used, and their main conclusions. More attentions were given to the studies concerned with science parks and those against China's background.

2. Targeted document analyses. The collected documents covered the national, regional and local levels. The key documents included: 1) national high-technology development strategies (e.g.: Decision on Implementing the Medium- and Long-term Strategic Plan for the Development of Science and Technology and Improving the Indigenous Innovation Capability, 2006); 2) key science & technology programmes (e.g.: Torch Program); 3) regional development policies (e.g.: 'Central China Up-rising'); 4) industrial preferential policies (e.g.: Preferential Policies for Investing in High-tech Industries); 5) regional annual reports and achievement records; 6) OVC's special privileges (e.g.: Preferential Policies for Hi-tech Enterprises; Preferential Policies for Returnees) and; 7) development plans for the Science Parks (e.g.: Five-Year Plan of East Lake High-Tech Development Zone).

3. Secondary data collection and analyses. The data sources covered a wide range with different focus on innovation systems: 1) macro-level information was collected with focus on China's NIS and the contributions of national-level science parks; 2) meso-level information was concerned with industrial structure, economic performance, innovation performance, and knowledge foundation of Hubei province; 3) local-level information on OVC included firms' types, revenues, innovation capability, and the relative position of OVC on the national and regional hierarchy of science parks. These second-hand data were mainly obtained from publications on the governmental websites (such as national and local Science & Technology Bureaus), public agencies (such as Torch Programme), academic studies, and various media sources. What is worth noting here is that through the author's personal network, a whole set of internal publications on OVC were given as a gift. This set of books collected the major media reports on OVC from 1985 to 2008, which is very helpful for tracing the history of this science park, given that e-publication has just started in China very recently.

4. Direct observations and physical artefacts. On-site observations of the economic activities, infrastructures, property market, and business environment of Wuhan and OVC helped to draw an outline of this LIS and got a general idea of its economic performance. Furthermore, by observing these 'solidified historical heritages', such as city layout and architectures, the author was able to get a sense of the more intangible culture and social texture of this targeted case study.

5. Face-to-face survey of on-park companies. The aim was threefold: 1) to collect the information listed on the questionnaire; 2) to explore respondents' interpretations of this local innovation system, with focus on the learning culture, the interactions between different actors, and the local entrepreneurial atmosphere; and 3) to obtain a sense on the power redistribution between different levels' innovation systems.

6. Semi-structured/open-ended interviews. Questions in these interviews were organised around two themes: self-exploration and external-exploitation. For the former, the strategy of 'crucial event recall' was adopted. Interviewees were asked to retrospectively review the histories of their institutes and the cornerstones along their growth. For the latter, questions were mainly concerned with the special resources provided by OVC, interactions with other actors, and the obstacles they had encountered or expectations that had not been met. Similar questions were presented to the government officers and university staff in order to compare and complement each other. What is more, in order to overcome the conservative attitude of the public representatives, the author used a 'critical response' strategy, which means presenting the officers some critiques from other interviewees, and asking for specific responses. This approach had proved useful to uncover some controversial issues and avoid those 'over-polite' answers. In total, nine officers from OVC, two from the City's Government, two from the Central Government, ten staffs from the knowledge institutions, and twenty-seven managers of the companies (five were outside Wuhan) were interviewed with semi-structured questions, while four government officers, two university staff, and ten private managers openly provided their viewpoints on various issues related to OVC (see appendix A for the list of interviewees).

4.4 Summary: challenges met and overcome

The difficulties in collecting data for this study were tremendous. First, there were limited official publications on the performance of science parks, especially for individual science parks (limitation of availability) (Owen-Smith et al. 2002). Secondly, some indicators were simply not covered by the statistics bureau or only have been collected very recently along with the popularity of internet in China (limitation of coverage), which also highlights the importance of the internal publications given to the author. Thirdly, some governmental statistics were just faked in order to meet the official targets (limitation of authenticity) (Watkins-Mathys & Foster 2006). That was why original data from surveys and interviews were preferred in this study to governmental statistics.

On the other hand, challenges were even more substantial for surveys and interviews. For one thing, firms in China are generally not so cooperative in academic research compared with those in western countries. For example, in the survey conducted by Hong (2003), the valid response rate was only 14.6%, much lower than the 65% response rate in Westhead and Storey's (1994; 1995), 50.6% in Lofsten and Lindelof's (2005), 53.4% in Link and Scott's (2006), and 65% in Phillimore's (1999) studies. In the author's own experience, it was like 'bread-and-butter' to be refused several times before a company agreed to participate. One visited manager even accused the author for 'trying to steal the industrial secrets from China' as soon as he spotted a foreign university's title on the author's business card. Moreover, out of business or political considerations, respondents in China tend to be more reluctant in offering an honest opinion. This fact was most vividly felt during one interview with the CEO of an optoelectronic company. Although this CEO started with a more critical and open-tone towards the institutional environment of OVC, as soon as the author revealed unintentionally that it was a local government officer that helped in this field work, this CEO changed his opinion dramatically, emphasizing exclusively on the 'good services' provided by the local government.

In order to overcome these problems, pretest interviews and surveys were conducted first with four companies, in order to make sure the questions were in an informal manner and easy to understand. The eighth and final version of the questionnaire lasted only two-A4 pages while retaining the most important information (see appendix B). Furthermore, the interviews were mostly set in an informal environment, and the more critical and sensitive questions were left at the end to secure a relatively smooth and comfortable starting. With all these hard work, the author was able to depict a relatively complete growth history of this LIS, in a scale and scope that few previous studies on the science parks in China have ever reached. In what follows, the birth, the growth, and the dynamics of OVC will be presented.

Chapter 5 The birth of OVC: 1984-1991

To clarity it at the beginning, the title 'Optics Valley of China' can be seen as the nickname for East Lake High-Tech Development Zone (ELDZ), the official name for OVC. ELDZ branded itself as the 'Optics Valley of China' since 2000, after it was granted as the first 'National Optoelectronic Industry Base'. The governance of this science park takes the mode of 'two brands, one team', which means that all the essences of OVC and ELDZ are the same, except for their names. In this study, the name of OVC is chosen to refer to this LIS.

Based on documentary analysis as well as face-to-face interviews, the growth trajectory of OVC can be divided into three stages, which in turn are the themes of the following three chapters. Within each stage, three issues will be discussed in turn, namely: 1) the actors that comprise this LIS and the leader(s) that set its growth direction; 2) the mutual interactions between the private sector and their institutional environment and; 3) the engine and efficiency of this LIS. In this chapter, the three growth stages of OVC will be outlined first. Then the focus will be on resolving the first research question proposed in the introduction, i.e., how OVC was born.

5.1 The history of OVC: three stages outline

According to its official website and related report, OVC has experienced the following eight major events:

Table 5-1 Milestones along the growth of OVC
(Table has been removed as third party copyright material)
Source: WLDZ (2011)

Not all of the above events, however, are equally crucial in shaping the growth orientation of OVC. The Director of the XX Bureau of OVC remarked that:

> 'The growth of OVC by now has experienced three stages: Before 1991 was the stage of permission to establishment. From 1991 to 2001 was the stage of preliminary establishment, achieved by winning the National Optoelectronic Industry Base in 2001, which also won us the title of 'Optics Valley'. From 2001 to 2009 was the developmental stage. In 2009, OVC was further upgraded as the second National Self-Innovation Model Zone after Z-Park, which

> I believe will start a new phase in OVC's development history' [interviewed on 28^{th} July 2010].

Therefore the acknowledgement of OVC as a national-level science park in 1991 and the establishment of the National Optoelectronic Industry Base here in 2001 stand out as cornerstones on OVC's growth trajectory. The international backgrounds underpinning these three stages are summarised below, with more detail being revealed in the following chapters:

Stage one (1984 – 1991): Birth of OVC, signalled by the establishment of East Lake Knowledge Intensive Zone. As reviewed in chapter three, the time between 1984 and 1991 was a period of reform reorientation from supportive to tight-control in China. OVC was born in such an unstable social background. Its corresponding characteristics will be explored in this chapter.

Stage two (1991 – 2001): Slow departure, starting with its nomination as a national-level science park. Deng's south tour reaffirmed the party's intention to reform and open-up. A lot of innovative and experimental reforms were implemented in this stage, many of which were tested first in these national-level science parks. OVC, as the one of the first group national science parks, also initialized some reforms, but confined them within small scales and scopes. The characteristics of OVC in this stage will be discussed further in chapter six.

Stage three (2001 – current): Accelerated growth, realized by its nomination as the first National Optoelectronic Industry Base. The new century saw a much more stable international and national environment. High technologies and high-tech industries became the forefront of competitions between different regions and nations. As the incubators for high-tech companies, science parks were allocated more importance by the Chinese governments, which also accelerated the growth of OVC. Since 2008, in particular, the effort of Beijing to promote high-tech industries and to leverage Central China has finally complemented each other. This favourable national environment in turn provided OVC the best opportunity so far to leap-forward. These emerging opportunities as well as the challenges facing OVC in this stage will be summarised in chapter seven.

5.2 The birth of OVC

The establishment of the East Lake knowledge Intensive Zone in 1984 was the traceable start of OVC. However, the official media did not provide much detail on how this Zone was conceived: almost all the available records on the birth of OVC summarised it with one sentence: 'In 1984, The East Lake Knowledge Intensive Zone was quietly established without much notice.' When discussing this lack of historical records with some interviewees, the author was informed that 'this was a sensitive issue because it was related to the Party's internal conflicts, especially among the top authorities' [interviewed with the Deputy Director of the XX Bureau, OVC on 27th July, 2010]. Confined by the scarcity of information from official channels, the author had to seek to local annals, newspapers, individual blogs, and celebrity biographies for information. As a result, what is going to be presented here needs to be read with caution.

In 1983, the CPC held a conference called the 'Countermeasures against the Global New Technology Revolution', encouraging intelligentsia to share their ideas on technology development in China. Furthermore, the local governments were required to organise similar discussions and identify concrete measures fitting their local situations (Xiaojie 2011). Against this background, in February 1984, the Government of Wuhan held a corresponding forum. Many attended scholars suggested setting up a new-technology industry zone in East Lake area, where most of Wuhan's HEIs and RIs were located. In July, a survey on the feasibility of this idea was carried out. However, unlike the survey conducted in Z-Park, in which experts on industrial development took the lead, the survey in Wuhan was complemented by a team comprised of officers from the Science & Technology Bureaus of Hubei and Wuhan (Laoge Blog 2008; People's Government of Wuhan 2011). The news about constructing a knowledge intensive zone was also announced in a local newspaper in order to collect feedbacks from all walks of life (Yangtze Daily 1984). Enlightening feedbacks did emerge. For example, a scholar suggested strengthening East Lake's competitive industries like laser, optical fibre communication, IT industry, and bio-engineering. Others emphasized the importance of local HEIs, FDI, transport and communication facilities, and the necessity of reforming the administration system (Xiaobin 1984; Nansheng 1984; Jian 1984). On 4th December, 1984, the

General Secretary of CPC, Hu Yaobang, was invited to visit the site of East Lake. He later became one of the most crucial figures in supporting the establishment of an experimental zone here. At the end of December, the Planning Office of East Lake Knowledge Intensive Zone was set up by the Government of Wuhan, responsible for planning, advising, coordinating, and supervising its development (Wuhan Party History Reserach Centre 2009). One year later, East Lake, among Beijing, Shanghai, Guangzhou, and Tianjin, was selected as pilot for constructing a New Technology Development Zone (People's Government of Wuhan 2011). East Lake went even further and set up the first enterprise incubating centre in China – the Wuhan East Lake New-Tech Entrepreneurs Centre – in June, 1987 (China High-tech Industry Report 2008).

In December, 1988, the Management Office of ELDZ was officially set up to replace the Planning Office. According to the original design, this on-site Management Office was established as a bureau under the Government of Wuhan. The highest administration level was a Leading Team comprised of government officers from the provincial and the city levels, which took responsibilities for not only policy making and personnel management, but also coordinating other on-site offices dispatched from the city's government, such as Tax, Finance, Industry and Commerce. This Leading Team would organise regular 'on-site working days' to discuss and solve the development issues facing ELDZ (Bixia 1989). In March 1991, ELDZ was approved by the State Council as one of the twenty-six national-level science parks (WEHDZ 2005; People's Government of Wuhan 2011), which also announced the start of OVC's second development stage.

This short historical review on the establishment of ELDZ could lead to the tentative conclusion that, the birth of OVC was mainly promoted by the local authorities, and facilitated by the support from some top party leaders. This route contrasts clearly with the birth of Z-Park, which was mainly conceived at the grassroots level and later institutionalized by Beijing. OVC's genesis and growth thus requires a flexible and open-minded management team, as well as a reciprocal relation between the private sector and their institutional environment, which will be discussed in the following sections.

5.3 Components of the this local innovation system

5.3.1 The core of the system: companies

The industrial structure of Hubei and Wuhan, as briefly mentioned before, used to be dominated by heavy manufacturing industries, such as automobile and shipbuilding. Its industrialization started as early as the first and second Five-Year period, but its leading position in China had gradually shifted in the 1980s. As recalled by the Director of XX Urban Planning Bureau:

> 'Now the influence of Wuhan as industrial and commercial harbour in China has been replaced by cities like Shenzhen and Shanghai. The traditionally competitive industries in Wuhan used to be automobile, shipbuilding, and mechanical manufacturing. However, the local government arbitrarily changed Wuhan's development strategy in the mid-1980s, concentrating on sectors like services and transport instead of industries…Consequently, many traditional industries in Wuhan collapsed, and many skilled workers were unemployed' [interviewed on 13th August, 2010].

In the case of the optoelectronic industry, it was found that before 1984, there was only one identifiable optoelectronic enterprise located in this area – the Yangtze Laser Electron Co. Ltd, later renamed as the Wuhan Telecommunication Devices Co. Ltd (WTD 2011). According to the company's official website, WTD was established in 1980 as 'the first-applied and the second-approved Sino-overseas joint venture in China, specialized in long-wavelength optoelectronic devices' (WTD 2011), although in 2004, the Chinese partner procured all the equities held by its US partner and transferred it into a domestic company. Because this company existed before the establishment of OVC and was implanted by the Central Government, it cannot be used as an example of OVC's impact study. However, WTD's existence provided the preliminary industrial foundation for OVC's later development.

The anecdote about the first grassroots initiative and the first private enterprise in OVC – the East Lake Intelligent Development Enterprise – might provide more insight on its institutional environment. The establishment of this enterprise was in reality promoted by Hu Deping, the son of the then General Secretary Hu. Like his father, Hu Deping also believed in democracy and the market system. One of his main contributions during his working term in Hubei was supporting the commercialization activities of the local HEIs and RIs. With his help, the East Lake Intelligent Development Enterprise was set up in June 1984, four months after the forum in Wuhan. The orientation of this company was to explore and industrialize the rich knowledge resources in the public institutions around East Lake. Hu was also senior enough to lobby for and agglomerate wider support from the local and central authorities. For example, the Chief Governor of Hubei was titled as the chairman of this enterprise and a professor from Wuhan Hydraulic and Electric Institute was appointed as the Chief Excusive. 108 universities and institutes were united as the knowledge support to this company, and the State Council even approved this enterprise as a reform pilot in Hubei[1] (Wenqi 2001; Quanying 2009; Yanjin 2010).

This embryonic privatization initiative in Hubei, however, did not last very long. Since 1985, the social instability locally and nationwide quickly shifted CPC's tolerant attitude towards privatization and liberalization. Especially in Central China, the local authorities were prone for a more reserved attitude towards economic reform and privatization. In Hubei, for example, the nature of this enterprise was changed dramatically from a 'reform pilot' to a 'big and severe case on breaking economic regulations'. Twenty-six out of the twenty-nine managers of this company were arrested (Quanying 2008; Quanying 2009, p173-6).

The contrast between the birth of Z-Park and OVC was again prominent here regarding their institutional environment. Although the reforms in China provided entrepreneurial opportunities to both LISs, the ecosystem of OVC, however, was not in a strong position to bargain with Beijing, nor did the local institutional actors flexible enough to respond to companies' needs quickly. The first shortcoming is related to the power distributions between the different levels of ISs in China, which will be discussed later. The second drawback, on the other hand, reflects the self-defection of OVC as an IS. More specifically, it shows the slow response of the institutional domain towards the local entrepreneurial activities, a process illustrated by quadrant IV in the four-quadrant model, and the reluctance of the institutions to adjust

[1] The guess here is that the special position of Hu and his father in CPC might have helped in its nomination.

themselves, which is presented by quadrant III in the conceptual framework. These obstacles were improved noticeably in the third stage of OVC's growth, as will be shown in chapter seven.

5.3.2 The supporting environment of the system

Because of the conservative attitude of the local authorities towards the self-grown private companies, the channel through which OVC gradually built its market foundation at this stage was mainly through reforming the local knowledge institutes and the state-owned enterprises, which in turn highlights the importance of the knowledge institutions and the local government. Therefore in what follows, these two supporting components as well as their intertwined relations with the private sector will be discussed.

5.3.2.1 Local government

The focus of the local government in this stage was revitalizing its traditional industries through high technologies. Confined by the absence of private service sectors and the lack of cooperative culture between industry and research, the local government of OVC had to take the responsibility of mobilizing and assembling the various innovation components. Two methods, in particular, had been utilised extensively by the local government to build up this LIS from scratch. The first one was picking and funding major projects, and the other was encouraging the commercialization activities of HEIs. While the first measure could be seen as providing various opportunities to the private sector (Quadrant IV); the second approach reflected a self-reflecting process within the institutional domain, i.e., trying to adjust itself for a better fitness of the whole system (Quadrant III).

'Major Project' is a general term referring to any big and important project that supposes to boost the local economy significantly (Lantian 2007). Nationwide major projects are decided and announced in the national 'Five-year Plans', while the local 'Five-year Plans' can identify their own major programmes according to their priorities as well as the national blueprint (Cnii 2004). Therefore this project-based development, inherited from the planned economy and retains its popularity in China now (Naughton 1990), is essentially different from the spontaneously developed relations between the governments and companies in western countries. In the case of OVC, twenty-six major programmes were declared when the construction of OVC started, covering such industries like optical fibre communication, laser, micro-electrics, and new materials (Jiacheng 1988c; Jianmin 1989b). Three of them, in particular, had strengthened the industry foundation of OVC, which were: 1) the establishment of Yangtze Optical Fibre and Cable Company Ltd. (YOFC); 2) the construction of a pilot production plant in Wuhan Post and Telecommunication Research Institute (WRI) and; 3) the construction of a communication network between Jingzhou and Wuhan.

The construction of YOFC started in 1988. It was a joint venture among: 1) Wuhan Optical Communication Technology Company (37.5% stocks), which used to be controlled by the former Post and Telecommunication Bureau of China. In 2002 this bureau was restructured into a state-controlled stock-holding company called China Telecommunication Corporation (China Tele) (YOFC 2011). Now China Tele is one of the three giants monopolizing China’s communication industry; 2) Wuhan Trust Investment Corporation (25% stocks), which was essentially a venture capital company but controlled by the city’s government (An 2001) and; 3) Philips Optical Fibres and later Draka Comteq of the Netherlands (37.5% stocks) (Draka 2011). The prerequisite for Philips Optical Fibres to enter the Chinese market was technology transfer, while its Chinese partners would provide labour and fixed assets (Wan 1990c).

The manufacturing of YOFC started in 1992, and since 1993, YOFC has been continuously in need of physical expansion. In 2004, the company became the third largest fibre manufacturer and the fifth largest cable manufacturer in the world after its seven extensions (YOFC 2011). In 2010, YOFC jumped to No.1 in fibre manufacturing capabilities worldwide after its ninth expansion (Shangmin 2010). Now it is the only company in China with the complete production capability in both fibre preforms and cable.

(Figure has been removed as third party copyright material)

Figure 5-1 Picture of YOFC

Source: YOFC (2011)

However, if one takes a closer examination on the time sequence, it is not difficult to notice that YOFC was not established as a reaction to the local authority's effort on building a science park. Actually its construction was a National Major Project that conceived, organised, and negotiated by the Post and Telecommunication Bureau of China as early as 1985 (Vanesky 2011). According to the Chief R & D Director of XX company, one of the most important reasons for setting up YOFC in Wuhan was because the presence of WRI [interview on 7th July, 2010]. As will be seen later, WRI is one of the earliest and the strongest RIs in China concentrating on optoelectronic technology. By locating near to WRI, YOFC could easily recruit highly skilled labour and experts from the start. This R & D Director confirmed that their first group technicians almost exclusively came from WRI. In this regard, the construction of YOFC in OVC could be seen as an accidental event in the first place. However, its existence further provided technological and institutional opportunities to the potential entrepreneurs and strengthened the industrial foundation in this area.

The second major programme initialized in this stage was the establishment of a pilot plant in WRI with a total investment of 13 million YMB. This plant was designed with an annual fibre production capability of 8,000 km. The third major project was the construction of the 252 km optical fibre communication system between Wuhan and Jingzhou. This communication system was ready to use at the end of 1987, and was the longest system in China exclusively relying on domestically produced equipments (Jiacheng 1988c; Song & Bixia 1989; Wan 1990c).

The above major projects are crucial not only because they laid the industry foundation in the early stage of OVC; but more importantly, they provided technological, market, and institutional opportunities for the potential entrepreneurs. Regarding the technological opportunity, both Philips and Draka Comteq of the Netherlands were required to transfer their advanced technologies to its Chinese partner for market access. This knowledge diffusion from MNCs thus greatly improved the fibre communication technologies in Wuhan. The Chief R & D Director of XX Company recalled that:

> 'Before establishing this company, our country had little foundation in optical communication sector. We could not even produce cables, let alone the optical fibre at that time…As a result, the Central Government decided to set up such a company. One of the preconditions of choosing our foreign partners was the agreement on knowledge transfer, so we could produce these products by ourselves in the future' [interviewed on 7th July, 2010].

Regarding the market opportunity, the potential domestic market for optoelectronic industry was enormous in China in the late 1980s, and all three major projects in OVC clearly catered for this. The construction of the pilot plant in WRI, for example, mainly aimed at increasing its production capability, and it was reported that the products of WRI had covered all over China at the end of the 1980s (Song & Bixia 1989). The project of the optical fibre communication system between Wuhan and Jingzhou, on the other hand, was a direct market boost through government procurement.

Regarding the institutional opportunity, two points are worth noting here: the first type of institutional opportunity relates to the institutional reform in China. As discussed in chapter three, foreign capital used to be treated consciously in this country. YOFC, as one of the earliest joint ventures in China, provided a signal to other interested parties, showing that foreign investment was possible and welcomed. The other type of institutional opportunity is concerned with the growth of OVC. As these national major projects were more or less coincident with the effort of the local government to build a science park, the possibility for multi-level cooperation was high. The local government, in particular, could bet on these mega-projects and gain a better position in bargaining with Beijing.

The second channel of building the industry foundation in OVC was through encouraging the commercialization activities of HEIs, which was common at the early reform stage of China. According to the 'No.1 Announcement of the People's Government of Wuhan' in 1988, a number of human resource exchange centres were going to be established, the purpose of which was to 'set free' the staff in research institutes (Jiacheng 1988b). On the other hand, HEIs and RIs were encouraged to set up their own enterprises or cooperate with established companies. For example, various types of contract managerial responsibility systems and joint ownership were allowed. These knowledge institutes would set up or merge enterprises in order to establish the so-called ‘research-focused enterprises’, which were similar to present scientific ventures. Encouraged by these favourable policies, ‘jumping into the business sea’ became common in East Lake area. By the end of 1990, for example, all of the 102 high-tech companies acknowledged by the Planning Office of OVC were directly or indirectly related to these knowledge institutes (Wan & Dewei 1991; Dewei & Wan 1991).

In order to facilitate the entrepreneurial process and provide support to small companies, the first high-tech enterprise incubator in China was established in East Lake in 1987. Conceived by a young officer in the East Lake Management Office and a staff in Wuhan University, this idea soon gained support from the Science & Technology Committee of Wuhan, which not only certified this incubator as a government institute, but also provided 800 thousand YMB seed capital (Tinggao 2000, p7). The services provided were very basic in this stage, including shared offices and facilities, and keeping the entrepreneurs’ personal records and organisational relationships. The last service is a vivid reflection of the rigid human resource control under the planning system of China, i.e., every individual has a personal record following throughout his or her life. Whichever institute one was going to work for, he or she had to hand over their records as precondition. By this arrangement, a person was bound with an institute, because moving one’s personal record was very difficult if not impossible. Employees might even risk the possibly of losing their party membership if they wanted to leave their institutions without permission (Jiacheng 1986). In this sense, the last service provided by this incubator is perhaps the most crucial one in motivating the latent entrepreneurs in the knowledge institutes.

Two enterprises moved into the incubator the year it was set up, and the number of incubated firms increased steadily afterwards (Jiacheng 1987; 1988a) (fig. 5-2). In June 1990, two companies graduated from this incubator, among which was Chutian Laser. According to a report from *China Computer* (2005), Chutian was conceived by some technicians from the Laser Research Group of Huazhong University of Science & Technology (HUST), one of the most prestigious HEIs in China. Together with Wuhan Optics Research Institute and Wuhan

Optical Device Factory, HUST established Chutian Laser in 1985 on site of the Wuhan Optical Device Factory. Because of its advanced technology and competitive price, Chutian gradually gained its market share. But the fundamental difficulties in finance and employment remained: On one hand, the three funding institutions did not provide sufficient financial support to this start-up; on the other hand, the workers in Chutian were mainly employees in the Optical Device Factory, who still had their personal records kept in this factory. As a result, it was difficult for Chutian to motivate and regulate these workers. It was under these situations that Chutian decided to move into the incubator, hoping that it would gradually gain independence on managing human resources, capital, and facilities. After moving out of the incubator in the early 1990s, the CEO of Chutian successfully transformed this state-owned company into a joint-limited enterprise. Now it has developed into the largest private enterprise in OVC and also a leading company in China, specialized in industry laser, medical laser, and laser processing technologies (Chutian Laser Group 2011).

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Figure 5-2 The number of incubated enterprises in East Lake Enterprise Centre

Source: Jiacheng (1987); Xiang (1988); Jiacheng (1988a); Zhifa (1989); Xiang (1989); Jianmin (1989a);Wan (1990a);Wan (1992)

5.3.2.2 The knowledge institutions

The most noticeable feature at the early stage of OVC was the growing number of spin-offs or part-spin-offs from the local knowledge institutes. Wuhan, compared with other inland cities, has its advantage in human capital, as it is regarded as one of the most populous areas with university graduates and researchers. The East Lake area, in particular, is blessed with a higher proportion of famous HEIs and RIs than any other locations in Wuhan. Among the twenty-one HEIs, fifty-four RIs, and ten state key research laboratories in OVC now, Wuhan Post and Telecommunication Research Institute (WRI) and Huazhong University of Science & Technology (HUST) take the most crucial role in fostering the development of the optoelectronic industry. Their importance in paving the knowledge and industrial foundation of

OVC was confirmed by many interviewees during the author's field work [for example the Director and Secretary from National Optoelectronics Research Laboratory, interviewed on 28th July, and a professor from HUST, interviewed on 12th August, 2010].

WRI was established in Wuhan in 1974. As the widely-regarded cradle of China's optoelectronic industry, WRI manages to keep its leading position even now. For example, this institute engaged in almost all the National Key Technology Projects identified in the '863 Programme' and the 'Five-Year Plans' that related with optical fibre communication. Since the reform and open-up of China, WRI has contributed to more than 500 R & D achievements in the area of optical communication, and has been awarded over 170 prizes by the central and local governments (Baidu 2011b). Further, the first identifiable optoelectronic company in OVC, WTD, is a subsidiary of WRI. By now, WRI has specialized in four areas with its own intelligent rights, which are: 1) Application specific integrated circuit design, whose construction started as early as 1987; 2) The embedded system and application software design. Three IP standards proposed by WRI was adopted by the International Telecommunication Union (ITU), which was appraised as 'the ground-breaking event for China' (China Computer 2005); 3) Optoelectronic design and manufacturing. WRI developed China's first long-wave optical communication device in 1981. Now it has twelve production lines covering the whole industrial chain of optical communication sector; 4) Optical fibre design and manufacturing. WRI hosts many prestigious figures in the optical fibre area, such as the so-called 'father of China's Optical Fibre', Academician Zhao Xinsen, who designed and produced the first optical fibre in China in 1976 that met the international standard (WRI 2007; FibreHome 2011).

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Figure 5-3 Fibre Home (left) and WRI (right)

Source: The author (2010) and CnHubei (2009)

The role of Huazhong University of Science & Technology (HUST), like many other HEIs at the start of China's education system reform, was mainly confined within human resource cultivation and supply in this stage. According to the Director of the XX Bureau of OVC, 'the Ease Lake area is the second most populated area with human resources after Zhongguancun. It ranks the third on the number of HEIs and RIs in China, but jumps to No.1 on the number of on-campus students' [interviewed on 12th August, 2010]. The name of Optics Valley, as recalled by its conceiver, Professor X from HUST, was also partly inspired by the fact that there were so many students graduated from HUST, who stayed and started their enterprises around the university afterwards, a situation that mimics the young Silicon Valley [interviewed on 12th August, 2010]. Their optimism, however, needs to be read with caution, as most of the interviewed companies complained about the difficulty in employing high-qualified labour during the author's field work, a puzzle that will be turned to in the following chapters.

Figure 5-4 HUST (left) and the College of Optoelectronic Science and Engineering (right)
Source: the author, 2010

The most relevant college for optoelectronic industry is the College of Optoelectronic Science and Engineering in HUST. It can be dated back to the university's Optical Instruments Research Institute and Laser Research Group in 1970, which is the first institute specified in laser technology in China. Since 1974, this Laser Research Group had undertaken R & D tasks for many national major research projects (HUST 2011a). In the 1980s, this Laser Research Institute developed the carbon dioxide laser device and the laser welding machine that were highly competitive internationally (HSEI 2006). Moreover, this Research Group also witnessed its first spin-off, the Chutian Laser, in 1985, which has been introduced earlier. As a result of HUST's leading position in laser technology, the State Key Laboratory for Laser Technology was approved to establish in HUST in 1986.

In 1985, the CPC announced its 'Decision on Reform of the Science & Technology System' (Central Committee 1985), which permitted the establishment of the technology market and the cooperation between HEIs and companies in China for the first time. The local governments of Hubei and Wuhan also published their corresponding policies. These decisions thus provide further market and institutional opportunities to the latent entrepreneurs in the 'ivory tower', and many local institutes expressed the desires to commercialize their R & D results. The question, however, was how to realize them in reality. Since these Decisions permitted establishing small economic units within the institutes, most HEIs therefore chose the form of university-run enterprises, which means the universities still controlled the bulk of the companies' stocks and engaged in their daily operations. For example, by 1991, 14 out of the 23 HEIs within OVC had their own companies, which amounted to over 200 university-run enterprises, employing around 10,000 university staff (Wan 1991d). However, the economic contribution of these university-run enterprises is questionable, as revealed by a report:

> 'Although one university has established more than ten companies in the Zone, their total economic achievement still lags behind many individual private companies. The reason…is that these university-run companies are still confined by the regulations of the university, which disables the 'special' policies they can enjoy by locating on a 'special zone'' (Haiyan and Song 1992b).

Notwithstanding their small economic scales, the emergence of these part-spin-offs should still be seen as a positive 'layering' process in the institutional domain (Martin 2010). The role of the governments in facilitating this process is also noticeable (Dong 1988; Jiacheng 1988c), and it is arguably the Central Government that functioned decisively in setting the tone of China's reform and directing the general orientation of OVC in this stage.

5.3.2.3 Other supportive components

As pointed out in the foregoing discussion, the local government of OVC had to bridge the private and public sectors due to the incomplete market architecture. Its role in the financial sector was prominent in this stage. For example, on one of the 'on-site working day' of the Leading Team in 1990, the Mayor of Wuhan explicitly required the financial department to arrange a science park development fund every year to meet the capital needs of the companies in OVC (Wan 1990b). Moreover, banks were asked to set aside an amount of money for loans to the on-park companies. On another 'on-site working day' in 1991, the local government decided to set up two to three venture capital funds. One of such companies was established by the financial department with a total allocated fund of 2.75 million YMB (Wan 1991a). However, the priority of the local government was still constructing the industrial foundation of OVC and increasing the number of companies. Therefore other services were deemed as less important by the local authorities and difficult to trace by the author. A growing effort on providing these value-added services is noticeable in the later stages of OVC's growth, which will be discussed in the following chapters.

In summary, the birth of OVC was underpinned by an embryonic market economy, unstable political environment, experimental mode of reform, and dominant state sector. By reviewing the genesis of OVC, it is plausible to say that the emergence of the optoelectronic sector in this LIS was mainly pushed by its immediate institutions, which makes OVC another example of the cultivated innovation system. Furthermore, given that the optoelectronic companies emerged in OVC in this stage were mainly originated from the public sector, it is reasonable to say that the industrial foundation of the optoelectronic sector was embedded in this LIS from the day of its birth (see fig. 5-5). This feature also distinguishes the first generation companies from the more recent ones, as will be discussed in the following chapters. Nevertheless, the contributions of the governments on different levels were more complicated: although the local authorities of OVC had assumed the direct leading role in this stage, they nevertheless mainly followed the decisions of Beijing with limited courage to become the 'first person dares eating crab' ('Diyige chi fangxie de ren' in Chinese). So it seems the role of the Central Government was more crucial in the genesis of this LIS.

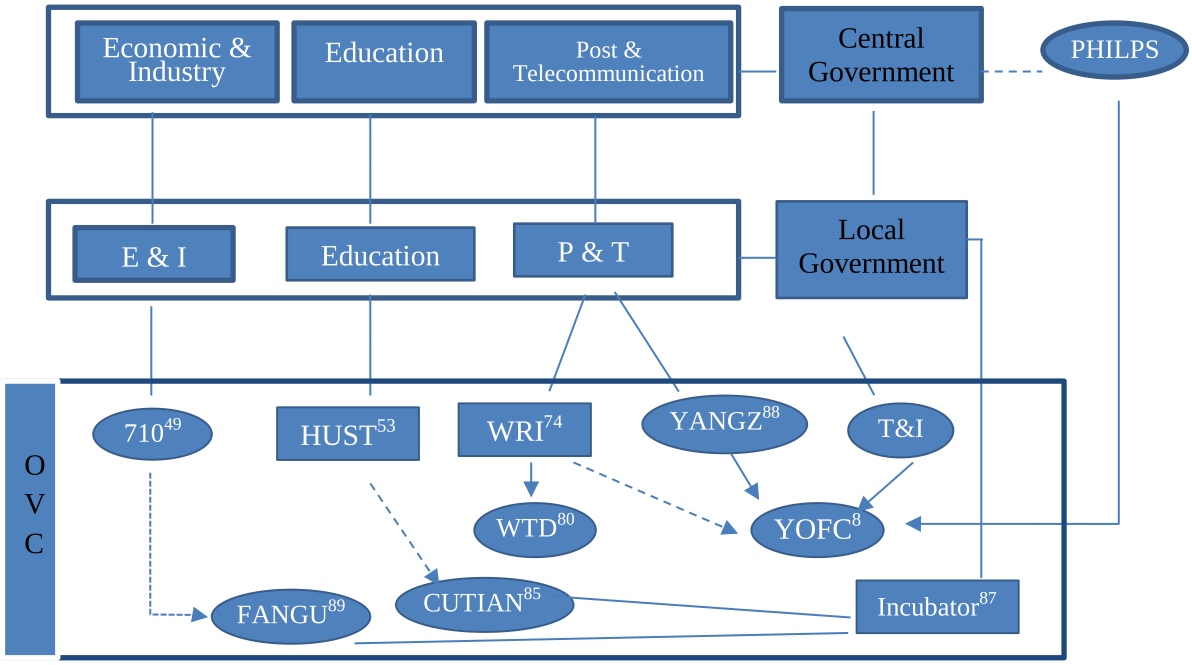

Figure 5-5 The embryonic innovation system structure of OVC in its first stage

Note: 1. Figure next to the institute refers to the year it was established.

2. Source: the author

5.4 Learning between innovation systems

One of the main arguments in this study is that the innovation systems on different geographical layers are not isolated from each other but are intertwined and mutual-influential. The birth of the Z-Park, as reviewed in chapter three, vividly represented the two-way interactions between the NIS and the LIS. Similar interactions between the different levels of innovation systems could also be identified in East Lake area in this stage, while it is admitted that the influence of the NIS was overwhelming. For example, Beijing's desire to reform the science & technology system and to release the huge knowledge resources in China found it echo in East Lake area: the first science and technology service company and the first technology transaction exhibition were held there in 1981, which were encouraged by the Central Government's 'Guidance on Promoting Technology Diffusion and Encouraging Compensatory Technology Transfer' in 1980. What is more, the first enterprise incubator in East Lake was inspired by a speech given by the Director of the National Science Committee in Wuhan one year's earlier (Yangtze Net 2007).

If these multi-level interactions were sustained, OVC should have stood out in a much more competitive position and even challenged the achievement of Z-Park. However, two factors impeded its progress and deprived OVC's 'first mover' advantage: The first factor relates to the relationship between the NIS and the LIS. As said before, China's NIS was highly dominant in the early reform stage, whose preference and support were therefore decisive in the emergence of any LIS. Zhongguancun, in this regard, definitely surpassed East Lake as the Central Government's favourite son. The reason was explained by an officer from the Torch Centre, According to this officer, Zhongguancun is located in Beijing, a much more reachable location for the Central Government compared to Wuhan. This geographical proximity is very important at the initial stage of reform: although a general consensus on developing high-tech industries was reached among the top party leaders, they nevertheless wanted to keep the speed under control, especially at the time of economic inflation and social instability [interviewed on 20th August, 2010]. Moreover, compared with the coastal regions, Central China carries more weight in securing the safety of China's heavy industries and primary industry. Therefore while

Guangdong was chosen as the first Special Economic Zone and Zhongguancun as the Pilot for Science and Technology Reform, OVC gained a much lower attention from Beijing (fig. 5-6). Two examples would illustrate this point: Firstly, when the proposal of establishing the East Lake Knowledge Intensive Zone was handed over to the Central Government, some leaders had suggested East Lake to wait and prepare for a longer time. The reasons they gave were the lack of capital in this area and the incomplete infrastructure construction (Haiyan et al. 1992). Secondly, while East Lake was picked up as one of the five pilots for commercializing R & D results in 1985, the suggestion from Beijing was to do it stealthily, because it worried that the reform could go out of control and the high technologies would be disclosed (People's Government of Wuhan 2011).

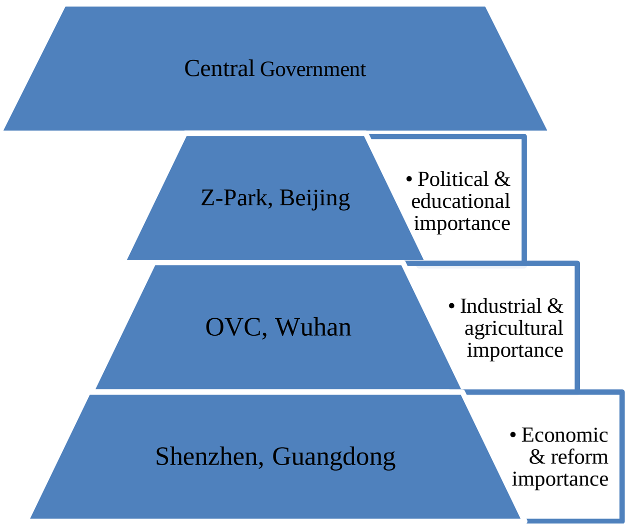

Figure 5-6 The power structure of different RISs in China

Note: 1. The size of the layer approximates the independence that RIS/LIS can enjoy in leading their reform activities. The distance of the layers from the top implies the geographical distance of the RISs from the central government;

2. Source: the author

The second factor, on the other hand, concerns with the relationship between the RIS and the LIS. The doomed destiny of the East Lake Intelligence Development Company, for example, contrasted clearly with the prosperity of the private companies in Zhongguancun area, although these two high-tech clusters emerged roughly at the same time, and both were appointed as a pilot zone for economic reform. The different attitudes of their RISs counted significantly here: the leaders of the Beijing Government, for example, hold a much more open and positive stand towards the private companies. It was recorded in the *Zhongguancun Annals* that, in order to support the development of private enterprises in the mid-1980s, the Haidian District adopted a flexible administration style called ‘one meeting for one individual case’, which means the local authority would like to take into consideration the specific situations of an individual company and provide corresponding help (Zhongguancun SP 2011). In comparison, the regional and local government of OVC were much more sensitive to the political changes on the upper level. For example, when Zhongguancun was acknowledged as the first High-tech Development Experimental Zone in China in 1988, the local governments of OVC read this as a positive sign, and summited two applications to the State Council in 1988 and 1989 respectively, lobbying for the acknowledgement of OVC (Haiyan, Song, & Dehuai 1992). However, it has also been pointed out earlier that the local authorities of OVC lacked the courage to initialize dramatic reforms: When the political atmosphere changed in the late 1980s, this region was among the first to retreat to the ‘high-pressure’ administration style.

Regarding the direct interactions between the paralleled RISs and LISs, few examples would be identified in this stage. The reasons could be found in the unchallengeable hierarchy system at that time, and the sensitive political atmosphere in the late 1980s. However, informal interactions were very active. For example, when the first technology transaction exhibition was held in Wuhan in 1981, thirteen cities, such as Shanghai, Guangzhou, and Xi’an, sent their officers to learn the experience. In 1982, Wuhan and Shenyang co-organised the Science and Technology Service Forum in Wuhan, eighteen Science Committees from different cities attended. When OVC established the first incubator in 1987, Shenzhen soon followed and opened the second incubator later in the same year. Monitoring and learning between the various LISs soon popularized this practice all over China (tab. 5-2)

Table 5-2 Total number of enterprise incubators in mainland China

(Table has been removed as third party copyright material)

Note: 1. Figures might not be absolutely accurate as some were obtained in the middle of a year.

2. Source: Tinggao (2000, p8)

Besides the top-down and bottom-up interactions between the NIS, RIS, and LIS, China was also significantly influenced by the international environment. When being asked why China had adopted the science park model in the very beginning, the officer from the Torch Centre explained that:

> 'Around 1986 and 1988, there were some international events that influenced China significantly, such as Reagan's Star Wars plan and Europe's Eureka scheme. China was irritated by these projects and four Academicians handed over a report to Deng in March, 1986, which led to the famous '863 project'… and later the 'Torch Programme' in China. We had learnt a lot from the global experiences beforehand, such as Silicon Valley and the Route 128, and we wanted to duplicate these successful cases in China' [interviewed on 20th August, 2010].

Furthermore, returnees might represent another channel of interactions between different NISs across borders. Their contributions to China and to OVC in particular, will be elaborated in detail in the following chapters, since few returnees would be identified in this stage.

5.5 Summary

In conclusion, the industry foundation of the optoelectronic industry in OVC was mainly pushed by the local government through major projects and commercializing the R & D results in the knowledge institutions. Central Government's reform decision and the leading practice of Zhongguancun also encouraged the genesis of a LIS in East Lake area. Because of the limited number of private companies in OVC in this stage, the role of the local RIs and HEIs, like in the early stage of Z-Park, was crucial in spinning off the first generation private companies. Therefore, public entrepreneurs are a noticeable feature of the innovation systems in OVC and nationwide when China's reform just started. Nevertheless, the changing political atmosphere, the more conservative attitude of OVC's authorities, and the largely untouched human resource management system all impeded the early departure of OVC, which reflect the importance of a reciprocal relationship between the innovation systems on different layers.

Chapter 6 Departure of OVC: 1991-2000

6.1 Acknowledgement as the national-level science park

When Zhongguancun was acknowledged as the first High-tech Development Experimental Zone in China in 1988, other LISs with compatible industrial foundations, such as OVC, also wanted this honour. However, it was not until Deng's South Tour that this practice was acknowledged (Hong et al. 2007): in March, 1991, the State Council upgraded twenty-six science parks to national level. OVC was one of them. In April, the first meeting among these national-level science parks was held in Beijing. Deng specially expressed his support to the Torch Programme and confirmed the value of science parks. Encouraged by Deng's support, the State Council further acknowledged twenty-five local initiatives as national-level science parks in November 1992 (Torch Center 2008; China High-tech Industry Report 2008). After this science park explosion, the Central Government nevertheless held its urge and wanted to see the effect. As a result, only two more local science parks were promoted onto the national level until 2010.

The approval of OVC as one of the first group national-level science parks in 1991 can be seen as a milestone leading towards its second stage development, as science parks had finally been accepted by the Central Government and the local authorities were assured with their legality. In this stage, OVC slowly departed to build on its LIS, but the speed was slow and the scale was small. This chapter will investigate some noticeable features of this embryonic LIS.

6.2 Components of this local innovation system

6.2.1 The core of the innovation system: companies

The industry foundation in OVC, as discussed in the previous chapter, was largely paved by the existence of WRI, HUST, and the joint venture YOFC. After OVC was acknowledged as a national-level science park in 1991, its industrial foundation was also expanded and strengthened. This section will look at the features of the companies in OVC in this stage, with two questions being of particular interest: 1) How did these companies come into being, or in other words, what realized their potential entrepreneurship? 2) Where did their innovation capabilities stand?

The ownership of the companies, although not accurate, reflects the origin of the enterprises. Generally speaking, there are three ownership types in China, which are the state/collective-controlled enterprises, the private ones, and the foreign-invested ventures. Enterprises run by the knowledge institutes are generally state-owned, which will be fully discussed in the following section. Another type of state-owned company is the traditional large factories established under the planned economy, many of which had nothing to do with the optoelectronic industry. The private enterprises and especially the foreign-invested ventures started to emerge in OVC in this stage, which will be the focus here.

In 1991, the state/collective-controlled enterprises comprised fifty-three per cent of the total registered companies in OVC. However, in 1997 this figure dropped to thirty-nine per cent, while the foreign invested ventures increased from eight per cent to twelve per cent, and the private enterprises rose from thirty-nine per cent to forty-nine per cent (Guang & Sheng 1997e). Figure 6-1 below shows the number of companies with different ownership in OVC between 1995 and 2000. The joint ventures were clearly the main contributors for the growing number of companies in OVC in this stage. However, compared with the national average (fig. 6-2), the state/collective-controlled companies in OVC were still over-represented.

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Figure 6-1 Number of companies with different ownership from 1995 to 2000
Source: The Torch Centre, MOST (2001)

(Figure has been removed as third party copyright material)

Figure 6-2 Ownership of the firms in OVC and in the national science parks in 2000
Source: The Torch Centre, MOST (2001)

Scanning the large amount of secondary data as well as the information gained through interviews, five channels would be identified as the genesis routes for a private company: 1) Spin-offs from the public sector, which include complete- and part-spin-offs from government and knowledge institutes. 2) Establishing joint ventures. 3) Relocating of the established enterprises. 4) Foreign-invested companies. And 5) spontaneously developed companies (see figure 6-3). The focus here will be on the first four channels.

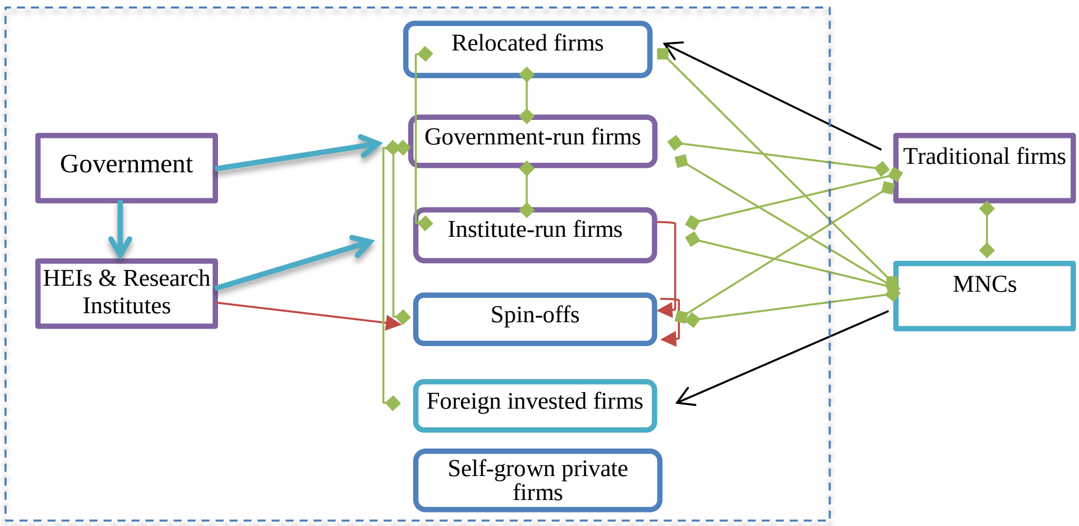

Figure 6-3 The genesis types of companies and their ownership

Note: 1. State/collective owned; Private or joint venture; Foreign-invested; Boundary of OVC; Restructure; Spin-off; Joint venture or merger; Subsidiary

2. Source: the author

6.2.1.1 Spin-offs

Spin-offs were more noticeable at the start of the second phase of OVC. As remarked by a Vice Director of the General Office of OVC, there were around 180 high-tech companies in OVC by 1992, of which a quarter were spin-offs from established companies (Wan & Mingyang 1992). The CEO of Wuhan XX Laser commented on this spin-out phenomenon:

> 'Wuhannese love setting up their own ventures. When our talented employees learn the skills of running a company, they tend to establish their own enterprises…Our excellent employees, some may be in charge of the marketing, some for product development, and some are regional representatives, are all well connected within the company and communicate a lot after work. By talking to each other, they will gradually learn the big market potential of the optoelectronic industry, and believe that they can earn more by spinning out of this company

> and be their own boss. In Wuhan, even a couple can establish a firm' [interviewed on 9th July, 2010].

Large numbers of spin-offs are generally read as a positive sign for cluster growth (Henry & Richard 2002). In OVC, however, this spin-off phenomenon bears with it the specific transitional background of China. It is preferable and necessary to separate the first generation spin-offs from their successors, as noticeable differences exist in both the reasons underpinning these spin-offs and the contributions of them.

The first generation spin-offs in OVC, pioneered by researchers, engineers, and graduates from HEIs and RIs, were mainly triggered by institutional reform in China and in Wuhan in particular. Because these early spin-offs were mainly engaged in commercializing high-tech R & D results or transferring technologies that were formerly neglected and wasted in the laboratories, their contribution to the growth of high-tech industries in the region was undeniable. What is more, these spin-offs often stood out as entrepreneurial models in the early reform stage of the region. In comparison, the later spin-offs were mainly from the established companies after they grasped the basic technologies and skills of running an enterprise, without a necessarily close tie with the knowledge institutes (Chun 2010). More than often, these potential entrepreneurs in OVC were easily satisfied with the knowledge they learnt on running a firm, but paid much less attention to the core technologies their own companies were going to be built upon. As boasted by a sales representative in XX Electronics:

> 'Establishing a company is not mysterious for me. I have worked in this company for several years and I have learnt a lot about running a business now. Basically what you need to do is to establish a supply chain and find your customers. I have my own business contacts now and maybe one day I will set up my own company too' [interviewed on 13th August, 2010].

Without solid knowledge and technology skills, many recent spin-offs in OVC had to rely on price competition but not innovation. 'Most of the newly established companies in OVC are too busy at calculating their profits to investing on R & D', as remarked by Professor X from HUST [interviewed on 12th August, 2010]. Furthermore, because the bulk of these later spin-offs were repeating the businesses of their parent companies, they too often competed with but not supplemented to their parent companies, a problem that impeded the formation of a thick local business network. This will be turned to again in the next chapter.

6.2.1.2 Joint venture

The percentage of joint ventures in OVC had increased significantly since the mid-1990s. These ventures were either jointly established by the newly established high-tech companies, or between the high-tech companies and the traditional ones (Guang & Sheng 1998). Their growing popularity of course reflects the market logic, but the wider and deeper development of this format was made possible in the first place by the Central Government's decision on enterprise reform, and more specifically, by the promotion of the shareholding system since early 1990s in the national-level science parks. In 1991, for example, OVC, among four other national-level science parks[2], was appointed as the Comprehensive Reform Pilot Science Parks, and was encouraged to trial-and-error reforms in areas of property rights, distribution system, and human resource management (The Natioanl Science & Technology Committee 1991). As a reaction to this nomination, thirty-six companies in OVC were permitted as shareholding reform pilots at the end of 1992 (Mian 1993). In 1993, the Management Committee of OVC announced the 'Temporary Measures on Shareholding Partnership', and sixty-eight more companies were approved to establish shareholding organizations. This increased the total number of joint ventures to 108, accounting for ten per cent of the companies in OVC by 1993 (Wei & Feng 1993; Bin 1994).

Another motivation behind the government's enthusiasm for joint ventures was to revitalize the bankrupting state-owned companies. From 1992 to 1994, for example, the high-tech companies in OVC had acquired 10 factories along with their 3,600 employees, and took over 1 bankrupt factory with 900 employees (Zhiwei 1994). What is more, over 1,000 high technologies and 1,500 technicians had been transferred to these dying factories (Songqing & Lisha 1994). Establishing joint ventures could be a win-win solution for the start-ups, the dying state-owned companies, and the government. However, there was possibility that the old, planning-based

[2] The other four pilots included Beijing Zhongguancun Experimental Zone, Shenyang South Lake Technology Development Zone, Chongqing High-tech Development Zone, and Zhongshan Torch High-tech Development Zone.

system was not compatible with the new, market-based system even after their marriage. *Yangtze Daily* once reported a government-matched merger between Maichi Technology United Company and the state-owned 709 Factory. Maichi, as a private and market-oriented company, was expecting an increasing market share but confined by its poor R & D capability. The 709 factory, on the other hand, used to be a military research institute and therefore held many advanced technologies that needed by the former. This merger thus could have brought benefits to both partners. However, many unexpected conflicts emerged on the way to cooperation, especially on the issue of employment. The 709 factory insisted that none of its human resources, except the four top managers, would be employed by this joint venture, because it worried that the salary difference would drain all its technicians away. What is more, the condition of using the production line of 709 Factory was that, all the operators on this line would never be fired by the joint venture, as otherwise the factory would have to rearrange jobs internally for those dismissed workers (Guang & Sheng 1997a). These different operating systems and management modes thus hampered the real value of many joint ventures under the similar situation, which also undermined the 'good intention' of the government.

6.2.1.3 Relocation of established companies

Establishing a joint venture with the high-tech companies or being passively acquired were not the limited choices for the established state-owned companies. Some still competitive ones, such as Wuhan Iron and Steel Factory, Yangtze Boiler Factory, and Wuhan Wireless Device Factory, had moved to OVC or established their R & D subsidiaries there through the so-called 'one factory, two systems' mode, which means that the head offices of these established companies were still state-owned, while their subsidiaries in OVC would be operated under different ownership. The authorities of OVC were again the strong backers for relocating these established companies, and many preferential policies were specially made to facilitate this process (Shuyun & Hongxin 1999).

However, many of these relocated companies continued their traditional businesses and retained their supplier-user relationship (Guang 1998b), which made their contributions to the local optoelectronic industry questionable. Unfortunately, no official data on these relocated companies were available, but according to Sheng and Tao (1996), the three largest optoelectronic companies in OVC, namely YOFC, Wuhan NEC, and NEC Zhongyuan Electronics, had contributed to almost forty per cent of the total revenues generated by OVC on average. These figures help one to infer that those relocated traditional factories were not outstanding revenue generators to OVC, let alone complementing to the optoelectronic industry chain. What is more, the agglomeration of these big companies in OVC might attract skilled labour away by offering them 'golden bowl'. They may also get more attention from foreign investors due to their government background, both of which could leave the small optoelectronic companies in a vulnerable situation.

6.2.1.4 Foreign-invested companies

Foreign-invested companies were a relatively new group in OVC in its second stage, thanks to the painstaking efforts of the local government. For example, in 1992 the city's government set the target of attracting at least eighteen foreign-invested enterprises within a year (Dong & Ximin 1992). Moreover, exhibitions and forums were frequently organised to introduce OVC to potential investors and business partners. In 1992, for example, OVC organised the Wuhan Acrobatics Festival and Technology Open Week. Although acrobatics show was the headline, what the local government really wanted was to exhibit the high-tech products of the local companies to visitors (Honggu 1992). Moreover, the 'Yellow Crane Friendship Prize' was established specially for rewarding foreign experts and the CEOs of the foreign-invested companies here (Hongping 1998b).

Attracted by these government promotions as well as the industrial growth in OVC, foreign-invested companies increased significantly in this stage. By 1995, for example, the number of foreign-invested companies had reached 281, which accounted for over half of the total number of enterprises in OVC (Zhong & Liang 1995) (fig. 6-4). One conspicuous investment in the 1990s was Wuhan NEC, which mainly engaged in optical fibre production, sales, and technology services. Its arrival thus further completed the optical communication sector in OVC.

The whole optical communication industrial chain, from the optical fibre supplied by YOFC, the optical terminal machines produced by Wuhan NEC, to the optical devices specialized by WTD, and finally the professional assembly lines provided by WRI, was thus relatively established in OVC before many other regions in China (Feng 1994). Another case was NEC Zhongyuan Electronics, which was a joint venture between NEC and Zhongyuan Electronics with a focus on mobile phone manufacturing (Guang 1996). Mobile communication was relatively weak in OVC in this stage, but the arrival of this company provided possibility for OVC to attract other mobile phone manufacturers, and to trigger the local entrepreneurship in its third development stage.

(Figure has been removed as third party copyright material)

Figure 6-4 Registered number of foreign-invested companies in OVC
Source: Honggu (1993a; 1993b), Jianzhu (1993a), Shanla (1993), Guang (1994b), Zhong & Liang (1995), Wan, et al. (1997), Zhiyuan & Sheng (1998)

Although the quantity of foreign-invested companies had seen a steady increase in OVC, their quality, on the other hand, was questionable. Two problems were highly relevant here. The first problem was related to the industrial sectors these foreign-invested companies engaged in. According to the Ministry of Commerce (MOC) (2007), between 1997 and 2004, only 0.18% of the utilised FDI in Central China had gone to Information Communication, Computer, and Software, in which the optoelectronic industry is covered. What is more, R & D and technology service only attracted 0.72% of the total registered projects and 0.46% of the total utilised investment.

The sector distribution of FDI in Central China was partly encouraged by the inclusive policy of many local authorities, i.e., to forcefully attract FDI regardless its relevance. As remarked by an officer from the National Investment Promotion Bureau, MOC:

> ‘It used to be a common practice on the local level to set tasks on the amount of FDI the region had to attract within a certain time, and then distributed these tasks down the government hierarchy…This task distribution could lead to many negative effects. One example was the usage of the ‘Mass Tactic’, which means to use staff from totally irrelevant

departments, such as from the Women's Union and the Court, to fight on the front line of attracting investment' [interviewed on 4th August, 2010].

This officer's remark was further confirmed by the Director of the Investment Promotion Bureau of OVC, who told the author that:

'The starting of this development zone was burdened with economic targets, because the government evaluation system in China was primarily based on economic indexes, such as the economic scales of your industry and the amount of foreign investment. Therefore, the previous authorities of OVC had made attracting FDI their top priority, and had tried their best effort to attract foreign investment' [interviewed on 12th August, 2010].

The second problem was concerned with the technology sophistication of these foreign-invested companies, as well as their willingness to diffuse their technologies. More than often, the foreign invested enterprises were attracted by the cheap labour and resources in China. The highest value-added links along the industry chain, such as brand, R & D, design, and marketing, were all firmly controlled by the head offices of these MNCs. Even when the foreign-invested companies did engage in relatively high-tech industries, how willing they were to transfer their advanced technologies is questionable. The previously mentioned joint venture, NEC Zhongyuan Electronics, had witnessed the divorce of NEC and Zhongyuan Electronics in 2000 (Yun 2004). As told by a former engineer in this company and now the engineer of XX Wireless Electronics, 'the cooperation between Zhongyuan Electronics and NEC was not very smooth most of the time…The Japanese were highly sensitive to technological issues and it was almost impossible for us to learn their technologies through the cooperation' [interviewed on 30th June, 2010]. A fortuitous interview with an anonymous worker in Wuhan NEC during the author's field work provided more evidence on this point, according to this interviewee:

'The activities in Wuhan NEC are limited to system installation and packaging. All the core parts are manufactured somewhere else, especially in Japan. Speaking of system installation, I do not think there are any technologies involved. What we do is to plug in the mobile phone with the computer, download the pre-written systems to the phone, turn the phone on, test it, or should I say play around with it, and then pass on to the packing department. However, the staffs working on the assembly line suffer seriously from the computer radiation, and you will have your eye-sight decreasing quickly if you work for a long time. NEC chose Wuhan as its assembling factory all because of the cheap labour here. I work in Wuhan NEC and the majority of us are college interns. We only earn a mean salary of 800 YMB per month and no insurances' [interviewed on 5th July, 2010].

Overall, the arrival of foreign-invested companies in OVC had their pros and cons. On the promising side, the investment of the influential MNCs in the optoelectronic industry strengthened some sectors, especially the optical communication sector. Secondly, their advanced technologies and sophisticated business management, to some degree, could be diffused to the domestic companies. Thirdly, their appearance would significantly increase the international exposure of OVC and raise the global market awareness of the endogenous companies. However, their contribution to OVC and to Central China in general, should not be over emphasized: the relatively small amount of FDI, their biased sector concentration, and the reluctance to diffuse their advanced technologies all constrained their contribution to the optoelectronic industry here.

6.2.2 The supporting environment of this innovation system

6.2.2.1The local government

When OVC was upgraded to the national-level science park in 1991, the entrepreneurship of the local government was also boosted. In May 1991, the People’s Government of Wuhan announced thirteen articles targeted on this Zone, such as infrastructure construction, management system restructuring, and attracting capital, technologies, and human resources from overseas (Dong 1991). These measures served as a guideline for OVC’s development during this stage; they also shed light on the channels through which the government was going to improve its services. In what follows, the efforts of the local authority on improving the infrastructure and strengthening the management of OVC will be discussed.

The physical construction of OVC started in this stage, but the progress was unimpressive. According to some interviewees, ‘at that time (early 90s), this place was basically a rural area, and Huazhong Science & Technology University was the limited urban construction. Local people used to call it ‘*rural area resided by many professors*’ [interview with Professor X on 12th August, 2010]; and that ‘in the 1990s, the development of East Lake, and even Wuhan in general, were almost suspended. I think it was only until 2005 that this city has really started to change' [interview with the Technical Instructor, National Optoelectronics Research Laboratory on 12th August, 2010]. The reasons would be attributed to the limited fund available from the local authorities on one hand; and the low importance attached to OVC at that time on the other.

The boundary of OVC was decided by the National Science Committee in March 1991, ranging from the riverbank of Yangtze River on the left to HSTU on its upper right corner. According to this plan, OVC covered only 43 km^2 in total, among which 24 km^2 were usable, because much of the land had already been developed. The local government also initialized the construction of the first inside science park – the Guannan S & T Industry Park, since September 1991, covering a total area of 4 km^2. In December, the construction of the Guandong S & T Industry Park started, which covered an area of approximately 1 km^2 (fig. 6-5). These two projects not only minimized the financial burden on the government, but also economized the infrastructure provision. Therefore this government-led 'parks within the park' development mode was inherited by the successive authorities of OVC. For example, in 1994, the construction of the East Lake High-Tech Agricultural Park was started (Guang & Mingyang 1994). In 1995, the news on constructing an Information Industry Park was announced, which attracted the attentions from Siemens and HP (Guang 1995d), although neither of them invested. In 1997, the construction of the Returnees Entrepreneur Park was started, with a designed office space of 10,000 m^2 (Guang & Sheng 1997c). In 1998, the Hubei Software Park began to take shape (Bing & Hengzhong 1999a); and in 1999, the United University Science Park and the Taiwan Software Park were under preparation (Xiaohong & Jing 1999).

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Figure 6-5 Boundary of OVC in 1991
Source: The People's Government of Wuhan (2011)

The construction of these themed parks, however, was confined by the land availability. Therefore how to extend OVC's boundary while minimizing the need to obtain Beijing's permission became urgent for the local authority. Two measures were figured out by the government: the first one was through planning. For example, in 1992, a new planning idea was proposed, with the aim to develop OVC into the so-called ‘Technology New Town of Wuhan’, one of the four ‘New Towns’[3] that was supposed to revitalize this city. The physical layout of this New Town was built on the so-called ‘One Point (the Torch Mansion), One Line (Wuhan Science & Technology Street), and One Area (the two science parks)’ (Jianzhu 1993b). But this planning blueprint was soon replaced by a more ambitious expansion plan, as will be shown in the next chapter.

The second and arguably more ‘creative’ measure to expand OVC’s boundary was through ‘entrustment’ (or ‘Tuoguan’ in Chinese). This is a way for OVC to use the land entrusted from other districts without changing the administrative boundaries. In 1993, for example, the Miaoshan district, which originally belonged to the Miaoshan Country, announced joining OVC and extended its coverage by 10 km^2 (Guang 1994a). In 1996, Wuhan Government further extended OVC to the south by 30 km^2. In 1997, four villages belonged to Hongshan District were entrusted to OVC, bringing another 11 km^2. In 2000, six villages belonged to Jiangxia District were entrusted to OVC, along with their 20 km^2 land. In the same year, the South Lake Agricultural Park and the Wuhan Institute of Engineering Science and Technology were also entrusted to OVC (People's Government of Wuhan 2011). By the end of 2000, the total area of OVC had been extended to proximately 90 km^2, almost twice the size of its original coverage (fig. 6-6).

(Figure has been removed as third party copyright material)

Figure 6-6 Boundary extension of OVC in its second development stage
Source: The People's Government of Wuhan (2011), Wuhan Planning Bureau (2009).

Along with the physical expansion, the internal resources and management structure of OVC were also adjusted in order to keep pace. The first expansion of OVC’s Management Committee happened soon after it was acknowledged as a state-level science park. As permitted by the city’s government, the departments under this Committee were increased from three to six, ranging from 1) Industry Development, 2) International Investment and Affairs, 3) Policy and

[3] The other three ‘New Towns’ were the Commerce Town, Automobile Town, and the Iron & Steel Town.

Regulation, 4) Planning and Construction, 5) General Office, and 6) Human Resources Management (Wan 1991c). Besides recruiting more staff, the East Lake Management Committee also tried to improve its internal efficiency. For example, in 1996, this Committee introduced new measures in regulating the civil servant system (Guang & Sheng 1996b), and it was among the first organisations to adopt the contract system in Wuhan. Senior officers were required to pass an assessment before resuming their employment (Wan 1991c).

Notwithstanding these encouraging improvements in the institutional domain, the power relationship between the Management Committee of OVC and the local government was largely untouched. For example, the fundamental controls of personnel and finance were still in the hand of the relevant bureaus under the city's government. Furthermore, as the boundary of OVC was continuously expanded to cover more than one district (fig.6-7), coordinating these different local authorities was difficult, as the Management Committee had no administration right but had to rely on the mediation of the Leading Team. As a result, the sustaining vertical and parallel power division left little authoritativeness to the Management Committee, who often found itself dependent and vulnerable from the pressures imposed from other interested parties.

This power dilemma facing the Management Committee of OVC reflects a deeper issue of China's decentralization process, i.e., the unwillingness of the government to 'let-go'. For example, in June 1991, the provincial government published 'The Notice on Accelerating the Construction of the Economic & Technology Development Zone', which promised more authority to the Management Committee of OVC. However, when the *Youth News* interviewed a Director from the Management Office, the latter nevertheless 'pointed at the articles in the Notice one by one, and complained to the reporter: 'We don't have the permission right for the investment projects of more than thirty million RMB; we don't have permission right for projects relating to energy and transport; we don't have permission right for foreign investment of less than five million RMB…although all of these have been literately deregulated to us long time ago' (Haiyan & Song 1992a).

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Figure 6-7 Overlapping of OVC with other districts
Source: The Planning Bureau of Wuhan (2009)

One way of solving these tough issues was through the Leading Team's 'On-site Working Day', which has been introduced in the previous chapter. It was supposed to be attended by the governors of Wuhan and Hubei, the officers from various administration bureaus, and the relevant companies. On a typical 'On-site Working Day', the companies and institutes could list their problems that involved with multiple departments, and then the officers would try to negotiate a solution and require the related bureaus to put these solutions into practice (Wan 1990b; 1991a; 1991b). While this method might have been highly efficient, its low frequency still restricted its feasibility.

6.2.2.2 HEIs and RIs: more experienced?

The local HEIs and RIs were the main producers of the first generation enterprises as shown in the last chapter. When OVC was acknowledged as the national-level science park, the enthusiasm of these knowledge resources was further aroused. By 1992, for example, there were eighty-one high-tech companies originated from the HEIs and RIs, which accounted for fifty-three per cent of the total high-tech companies in OVC (Qinsong & Song 1992). HUST for example, established ten high-tech enterprises, with three more research centres under preparation; the Wuhan Branch of the China Science Institute opened fifteen high-tech companies, which contributed to one fifth of the total revenue of OVC (Qinsong & Song 1992).

As reviewed by Frank and his colleagues (2007), four indexes are widely acknowledged as reflections of universities' entrepreneurship, which are: '(i) entrepreneurial research, (ii) productivity of technology transfer offices, (iii) new firm formation and, (iv) environment context including networks of innovation' (ibid. p706). Compared to these common entrepreneurial formats in developed countries, three different channels were particularly noticeable for the Chinese HEIs to cooperate with companies, which were: 1) directly engaging in entrepreneurial activities; 2) indirectly through the human flow, and 3) mediated by the authority of OVC, if the cooperation related to established companies or MNCs.

The political reason for establishing university-run enterprises has been discussed previously. Other reasons for locating on the campus were explained by the CEO and the Sales Manager from Wuhan XX Service Centre, which was established in 1992 and now still operates inside the department building of the Institute of Optoelectronic Engineering of HUST:

> 'We established this company here because the department provided free offices and facilities. Moreover, many of our employees are part-time professors in HUST, so this on-campus location can save their travel time and fit in their working schedule easily' [interviewed on 27th July, 2010].

So it is clear that, the campus location could save the young companies' spending on hardware and software. It would also meet the companies' needs for human capital, since the entrepreneurs of the companies were mainly staff of the HEIs. On the other hand, the parent institutes would benefit from their companies as well. For example, many of these university-run companies had to provide internships and trainings to students, or even directly engaged in the postgraduate education. HUST, for example, had over 2,600 students receiving internships in these on-campus enterprises annually. Moreover, the profit of these companies was an important supplement to the incomes of their parent HEIs (Wan 1991d). All in all, these university-run enterprises present a unique complementary relationship between the private sector and the knowledge institutes, as shown by quadrant II of the four-quadrant conceptual model.

Compared to HEIs' direct engagement in establishing companies, the RIs in OVC could be seen as following a different route of commercializing their R & D results, i.e., to transform completely from a non-beneficial institute to an enterprise on the market. This transformation was largely pushed by the Central Government's reform decision, as discussed in chapter three. WRI for example, started adjusting its structure in this stage. The bulk of its personnel, around 850, were shifted to the Department of Production and Sales, which in reality was doing business on the market. Another 170 staff were in the Department that providing R & D support to its own enterprises, and thus equalled to the R & D centres of many big enterprises. Only around 300 personnel were retained in perusing leading-edge research (Guang 1995c). When the 'Decision on Accelerating Technology Progress' was published by the Central Government in 1995 (The State Council 1995), WRI also quickened its reform process and restructured completely into a joint venture called Fibre Home in 1999, with the state as the dominant shareholder (China IT Industry Net 2006).

Regarding the local human pool and human circulation, OVC had a higher percentage of R & D personnel than the average level of science parks in the 1990s, which might reflect its rich human resources (fig. 6-8). However, as noted by the Torch Centre (2001), less than half of the registered companies in OVC were included in its statistical records, therefore the data might be biased towards the high value-added end dominated by big companies. Moreover, the gap between OVC and the national average level was reducing with time, which might be read as a sign of deteriorating human resource pool.

(Figure has been removed as third party copyright material)

Figure 6-8 The percentage of R & D personnel in OVC and in all national science parks
Source: The Torch Centre, MOST (2001)

Moreover, retaining, mobilizing, and attracting human resources are arguably more important than the absolute number of human capital for knowledge circulation. Along with the deepened reform in China, human capital liquidity also increased in OVC, which had two immediate consequences: the first one was related to the growing frequency of job switching, and the other was the outflow of skilled labour. As reported by the *Yangtze Daily*, the job shifting rate in Wuhan used to be lower than one per cent before the reform, which steadily increased to two per cent, three per cent, and even five per cent in its peak time (Guang 1995b). This growing labour mobility should have been welcomed as a positive progress towards market economy. However, worried that they might lose their skilled labour, several big companies in OVC reverted back to the permanent employment system, especially in their key departments such as sales and R & D (Sai 1996). This retrogression nevertheless gained the sympathy and support from the local authority as well as other leading companies in OVC, which might reflect the conservative attitude of Hubei towards reform, a characteristic that has been noted in the foregoing chapter.

The second influence of the increasing human capital mobilization would be found in the net outflow of skilled labour from OVC. Fibre Home (WRI), among many others, was impacted by this 'brain drain' severely. For example, in 1995, one of its senior technicians was bought over by its strongest competitor in Shenzhen; In 1996, one American company attracted five core staff in the optical device research department, resulting in the almost paralysis of this research unit; In 1997, more companies in the south targeted on Fibre Home for technicians, and various recruitment advertisement could be found throughout the company. Attracted by their tempting offers, more than ten scientists left this company in succession, no matter how forcefully the latter had tried to retain them (Hongping 1998a). The loss of skilled labour in OVC continues and even gets more severe today.

The local authority acting as a mediator might be even more crucial in accelerating and smoothing the entrepreneurial activities of the knowledge institutes under China's context, and it was hard to find a single case where the local government had not been involved when it came to the more influential cooperation. Two approaches were particularly noticeable here. The first one was trying to fix the complicated management system on research personnel. For example, in 1994 Wuhan decided to include the national subordinated scholars and scientists into the 'Government's Special Allowance Programme', which proved to be very effective. By the end of 1994 for example, there were 257 enterprises in OVC that were established by externally managed institutes (Guang 1995e). One interviewee, Professor X from Huazhong Agricultural University recalled that:

> 'I was rewarded the special allowance by the City's Government in 1995, and that was when I started to feel I am a Wuhannese as well. I think a lot of my colleagues have the same feelings. We used to think we belonged to some national research institutes or the national education committee' [interviewed on 14th July, 2010].

The second way was functioning as the lubricant for the growth of these institute-run enterprises (see Guang 1998a; 1999). For example, in 1992, the Management Committee of OVC learnt that the New Medical Centre of Wuhan University was negotiating a technology deal with the Southern Pharmaceutical Company from Guangzhou. On hearing this news, the officers of the Committee visited this Centre, and were told that there were many difficulties in commercializing its R & D result in Wuhan. However, all these difficulties were quickly solved by the authorities, who introduced a local pharmaceutical company to set up a joint venture with this Centre, and provided ten million YMB as its seed capital (Wan & Dong 1992).

The transformation of the knowledge institutions in OVC and the linkages established between the public and private sectors once again illustrate the cultivated nature of this LIS. Therefore, the simple dichotomy between ‘technology push’ and ‘market pull’ is misleading under transitional regions’ backgrounds. Moreover, it could be argued that the influence of the local authorities was growing since this stage, whereas direct intervention from Beijing was significantly reduced, which might reflect the growing autonomy of the LIS and RIS from China’s NIS.

6.2.2.3 Other supportive sectors

The resource-based view of company argues that firms have to interact with external environment for complementary resources. Government and the knowledge institutions are the two most important external factors identified in the context of OVC. Other system components, such as the service sector, the human resource market, and the financial sector, however, hardly existed when OVC was born, but they were growing substantially in this stage. Nevertheless, all these elements were carefully constructed from scratch by the local government, as we will see later.

The private service sector in OVC was still taking shape in this stage. Nevertheless, some semi-private service companies were set up by the Management Committee of OVC, such as R & D transfer, social insurance, real estate development, as well as accounting (Wan & Dong 1992).

Although these public-private combinations suffered from ambiguous ownership and thus were not the best choices in a market economy, they nevertheless represented positive progress and filled the market gap in this specific stage. For example, the CEO of the Wuhan XX Investment Company complained that the development of the private service agencies in China was very slow and their service standards were very low. Most of the time, these agencies merely followed the old ways of doing businesses without specific knowledge and necessary experience [interviewed on 7th July, 2010]. Besides their low quality, the Director of OVC's Strategy Research Institute told the author that 'Wuhan doesn't have many private consulting companies yet' [interviewed on 29th June, 2010], and the Sales Manager from XX Optoelectronics admitted that 'our company did seek finance from some private agencies before, but many of them were usurious loans in nature' [interviewed on 15th July, 2010]. This weakness in OVC's innovation system persists today as identified in the questionnaire survey, when the 'Private Service Sector' was ranked by companies as the least important in their innovation activates (see chapter 9).

Regarding the labour market, a dedicated Human Resource Market was established by the local government in May 1993 (Yang 1994). Its services included constructing and updating a human resource database and even recruiting employees on behalf of the companies. However, the bargaining power of this Human Resource Market on behalf of the employees was very limited. The R & D Director of XX Company told the author that:

> 'I used to be a teacher in one local university before I joined in this company in early 1990s…my leave, however, was not permitted by the university, which retained my personal record even though I tried to seek help from the human resource market. This company however, replied that: 'I don't need your record for joining in', so here I am now' [interviewed on 7th July, 2010].

A special group of human resources, the returnees, deserves more attention as the knowledge circulator (Saxenian 2002; 2007). However, returnees only accounted for a small share of OVC's labour force. For example, in 1997 the total number of returnees in OVC was 285, which accounted for less than one per cent of its total employment size (Guang & Sheng 1997b). In order to attract these special human resources, a Returnees' Entrepreneurial Park had been under construction since 1997. Its marketing package included such favourable policies like providing entrepreneurial fund, remission or refund tax, low rent of offices (Bing & Guang 1999), and priorities in obtaining loans from banks (Guang & Sheng 1997d). It was in July 1998 that the Returnees' Entrepreneurial Park welcomed its first tenant, a former employer in a Japan company, who obtained his graduate certification from an American university (Yanhua 1998). One year later, the number of enterprises in this Park increased to seven, covering such sectors like bio-technology, environment, and IT. By the end of 1999, the tenants here further increased to ten (Bing & Hengzhong 1999b).

Figure 6-9 Returnees' entrepreneurial park (left) and International enterprise center (right)
Source: the author (2010)

Sufficient financial flow along a company's life cycle is highly important for its survival, especially for the high-tech firms because of the large capital investment required for R & D. In China, the governments on different levels used to be the main sponsors of S & T activities (Bach et al. 2008), which, however, had dropped in importance from the mid-1990s (STS 2011a).

In the case of OVC, however, the public fund had always been crucial, whereas the private venture capital and entrepreneurial fund were either research topics for scholars or political promise on the paper (Ruifeng 1984). For example, in 1994, the authority of OVC established the East Lake Construction Company, aiming to manage and mobilize the state properties in the market economy. One of its innovative practices was to apply for loans on behalf of the high-tech companies, guaranteed with the revenues of the whole development zone. In 1996 alone, this company managed to obtain nearly two million YMB loans for eight high-tech companies

(Sheng 1996; Guang & Sheng 1996a). Its model was soon duplicated. A technology R & D Fund, for example, was jointly set up by the financial department of the city's government and the East Lake Management Committee, with the same purpose as its forerunner (Yuebo 1996).

The reluctance of the banks to finance high-tech companies is explained by Game Theory with the asymmetric information and imperfect competition (Victorio 2008). The authorities of OVC thus served as the guarantors between banks and companies. This extension of government's role could be seen as a reaction to the needs of the firms, and thus it exemplifies a reciprocal relationship between the components of the innovation system, as illustrated by quadrants II and III of the four-quadrant model. Conversely, government acting as a mediator also had its limitations, such as the possible biases in picking winners and corruption in the process. Therefore, this intimate involvement of government in economic activities should only be a temporary choice. As soon as the market takes shape, this role should be gradually transferred to the private sector. The following chapter will turn to this point again.

6.3 Summary

The second stage of OVC had seen commendable progress in both private and public domains. However, many co-existing problems remained. For example, in the private sector, the spin-offs in this stage were mainly engaged in low value-added manufacturing activities. The foreign-invested companies were generally attracted by the cheap resources with no intention to diffuse their leading-edge technologies, so their contribution to the local optoelectronic industry was very limited. In the public domain, the independency of OVC's Management Committee was low, and the local governments were deeply and sometimes directly involved in the economic activities. For the supporting environment, 'brain drain' in Wuhan was deteriorating as the income differences between different regions were widened. The financial market was almost completely sustained by the local government, and its development speed was slow compared to the coastal regions. The new century has seen a new stage on OVC's growth history. Many persistent limitations are receiving attention, and many new features are emerging. These will be the focus of the coming chapter.

Chapter 7 Accelerated growth of OVC since 2001

The decision to build a National Optoelectronic Industry Base in East Lake in 2001 was the biggest boost to OVC in its development history. Increasingly more attention had been devoted to this science park from both the local and the national levels. However, to win the brand – the 'Optics Valley of China' – was not an easy job, and how to live up to it afterwards is still an open question. In this chapter, the story on how East Lake won such an accolade will be recounted first, followed by a discussion of the most important components of this IS. Finally the interactions and linkages between these components as well as with other innovation systems will be illustrated. The features of OVC in this stage will be summarised at the end of this chapter.

7.1 Fight for the brand of 'Optics Valley'

It is worth separating this history as an individual section because of its importance. Unlike the birth of the East Lake Knowledge Intensive Zone, the idea of constructing an optics valley in Wuhan was very much a grassroots initiative, but realized only after the local government recognized its potential (Wuhan Party History Reserach Centre 2009). Professor X in HUST was the first person coming up with this name (Dajun 2008; People's Government of Wuhan 2011). A personal interview with this professor revealed a more detailed story on how this brand was conceived:

> 'In September 1998, I visited Glasgow University where I met Zhou Ji, who was then the President of HUST and now the President of the Chinese Science Research Institute. He said to me: 'Professor Huang, it seems the optoelectronic industry in Wuhan needs more attention', which just coincided with my idea. Encouraged by this consent, I wrote a report to the City's Government in November, and that was when the name 'optics valley' was first proposed…. three months later the General Secretary of Hubei assured me that the government will pay due attention to optoelectronic industry. So here it is: our suggestions are only suggestions. It is hard to have anything done in China without the agreement and promotion of the government. If it was not for the strong support from the General Secretary, who later became the Governor of Hubei, it is impossible to have this Optics Valley in Wuhan now' [interviewed on 12th August, 2010].

Observing as an outsider, the Deputy Secretary of the China Optics & Optoelectronics Manufactures Association further complemented the above story:

'Personally speaking, the most crucial factor in the birth of Wuhan Optics Valley should be attributed to the quick reaction of the Hubei and Wuhan Government...The development mode in China is just like this: as soon as the local government pays attention and provides support, a project will get kicked-off…But of course there were a lot of disagreements at that time: I still remember the Association Meeting when Professor Huang propagated the idea of 'optics valley'. Another fellow was so angry in the debate that he even pointed at the nose of professor Huang, saying 'you cannot be called the Optics Valley of China, because you cannot represent China. Just call yourself the 'Optics Valley of Wuhan' is more than enough'. I also heard other critiques when the name was just brought public, such as 'optics valley, optics valley, at the end you will only have a bare bottom' ('Guanggu, guanggu, guangguang de pigu' in Chinese) as other regions were not convinced…However, no matter it is mainly a brand promotion or a real industry cluster, the local governments have paid extra attention to this place continuously and invested a lot of money for the past ten to twenty years, so a favourable environment has been gradually framed there' [interviewed on 4th August, 2010].

From the public media, what could be found was a serious of promotions taking place at the start of the new century: In January 2000, the Hubei government declared its intention to win the brand of 'Optics Valley'; In March 2000, thirteen National Committee members from Hubei province proposed the construction of 'Optics Valley of China' on the Ninth National Committee Meeting (Li 2000); On the 8th May, twenty-six national academicians in Hubei signed an appeal to the Central Government, asking the permission to establish a national optical electronic industry base in Wuhan (Qing 2000a); On the 9th, the governor of Wuhan, who was going to present in the 'Governor's Forum' held in Beijing, changed his topic at the last minute. The new speech concentrated solely on the topic of 'Wuhan Optics Valley', and the governor elaborated the various advantages of Wuhan and the concrete construction measures (Shouhai 2000); On the 10th, the National Academy of Engineering expressed its support to the construction of Optics Valley in Wuhan (Mingqiao & Jinsong 2000); By the end of May, forty-two Optics Valley related brands had been registered by OVC's Management Committee (Qing 2000b). Under these overwhelming promotions, in 2001, the Central Government finally agreed to set up the first national optoelectronic industry base in Wuhan, which is commonly seen as the justification for a new name of ELDZ – the Optics Valley of China, Wuhan.

However, since the name of 'Optics Valley' first appeared in 2000, there had been increasingly severe competitions between different regions in China for this brand (China News 2000; Haiwei & Pingfan 2000; Junpeng 2009). According to the Executive of the Shanghai Optoelectronic Industry Association, there were sixteen optoelectronic industry bases in China by 2005 (Zhaomou 2005), all targeted on similar sectors (Shuyu & Yong 2001; Junpeng 2009) (fig. 7-1). East Lake stands out here mainly thanks to: 1) its rich human capital and knowledge resources in the optoelectronic industry; 2) its relatively complete optoelectronic sectors since it concentrated on this industry early (Liulin 2001) and; 3) the quick reaction and strong support from the local governments, as emphasized by the above interviewees. For example, in order to win the brand, the Hubei government specially published the Tenth 'Five-Year Plan' for Wuhan Optics Valley. According to this plan, one of the main targets of OVC in the new century was to establish a first-class optoelectronic information industry corridor internationally, and to become the growth pole of Hubei and Wuhan (OVC Management Committee 2000). As a result, 'there is only one place can be called Optics Valley now, which is us. A lot of people, especially the foreigners, get to know OVC before they know ELDZ and even Wuhan'. Professor X proudly told the author [interviewed on 12th August, 2010]. However, winning a brand does not secure the success of a LIS. Its journey afterwards will be explored by the rest of this chapter.

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Figure 7-1 Optoelectronic Industry Bases in China and their targeted sectors by 2005
Source: Zhaomou (2005) and Junpeng (2009)

7.2 Components of the innovation system

7.2.1 The core of the local innovation system: the companies and the industrial chain

7.2.1.1 Industrial performance

In 2001, there were 463 registered companies in OVC, which had increased almost threefold to 1,650 by 2008. These companies generated 175 billion YMB revenues and an industry output of 156.5 billion YMB in 2008 (fig. 7-2).

(Figure has been removed as third party copyright material)

Figure 7-2 Number of firms, total revenues and product sales between 2001 and 2008
Source: Wuhan Party History Reserach Centre (2009)

In the optoelectronic communication area, OVC had become the largest manufacturing base of optical fibre and cable in China by 2004 (Xiaonong et al. 2004), and the second internationally by 2008 (Wuhan Party History Reserach Centre 2009). In the laser sector, OVC had accounted for over half of the domestic market share by 2008. In the mobile communication sector, Fibre Home signed a supply contract with the Hubei Mobil in 2008, which signalled the start of the 3G network construction in Hubei (Hong & Xingfen 2008). Co-operated with the subsidiary of Potevio Group in OVC, Fibre Home also won the bid in constructing the TD-SCDMA network for China Mobile in twelve provinces (Lai 2009).

Besides the general growth trend, two more intangible characteristics were noteworthy regarding companies' performance. The first feature is the contradiction between the large companies and the SMEs. The second is the different roles played by the endogenous and the exogenous companies.

The economic gap between the large companies and the SMEs was increasing as OVC grew. For example, In 2006, 83 companies (7.79%) had their annual product sales surpassing 0.1 billion YMB, but their total product sales accounted for 89.54% of the total amount achieved by OVC in that year (OVC 2007). On the other side of the coin was the poor economic performance of the SMEs, which was partly resulted from their low technology sophistication. For example, in 2006, there were 567 (53.19%) high-tech SMEs with revenue lower than 5 million YMB in OVC. However, the S & T capital assembled by these small companies were 0.233 billion YMB, contributing to only 5.97% of the total assembled capital; their S & T spending was 0.191 billion YMB, accounting for only 2.48% of the total spending in OVC (OVC 2007).

Moreover, the lack of attention and support from other components of this IS, especially from the governments, had made it more difficult for SMEs to grow. Those companies with a revenue higher than the government defined 'threshold' (0.1 billion YMB) were the 'very important companies' (VICs) to the local authorities, since they were the bonus points on the latter's assessment sheet. Little doubt then were there more public resources and attentions devoted to these VICs. Reading through available news and broadcasting on OVC, it was repeatedly found that officers from different levels of governments were visiting these leading companies, or holding forums with the managers of these significant economic contributors (see WEHDZ 2005;Changchun 2006; 2007; 2008; 2009). On the other hand, SMEs were frequently heard complaining about the difficulty of surviving, and that the government did not pay enough attention to their needs for finance, land, and other necessary supplies. The R & D Director from XX Electronics put it more explicitly:

> 'The local government typically 'loves the rich, hates the poor'. One example is the NEC Zhongyuan Electronics. When this company was prosperous in the late 1990s, the government treated it as a valuable and honoured guest; as soon as its development went downwards, nobody ever cared about it' [interviewed on 13th August, 2010].

The CEO from XX Electronics was also very critical:

> 'The governments only exert negative effect on the development of industries. One case in point is their excessive financial expense, the deficit of which would largely be transferred to our companies… the purpose of the national '863 programme' is to support the innovation of companies, but only the tip of the iceberg (i.e., the large companies) would get financial support' [interviewed on 18th July, 2010].

The second noticeable contradiction in this stage was the different roles played by the local and exogenous companies. In OVC, the number of MNCs in 2006 almost tripled compared to that before 1992 (OVC 2007), but compared with the national average level (tab. 7-1), these MNCs' economic contributions were still limited. Furthermore, their role in innovation and knowledge circulation was worth speculating, which has been pointed out in the previous chapter. The Director from the OVC Strategy Research Institute remarked on the limited contribution of exogenous companies: 'now we have around five hundred active companies in OVC. Among these five hundred companies, the ones contributing most on innovations are still our endogenous companies' [interviewed on 10th August, 2010].

Table 7-1 Profiles of companies in OVC according to their ownership in 2006

(Table has been removed as third party copyright material)

Source: OVC (2007), the Torch Centre of MOST (2006)

7.2.1.2 Local Industrial linkage

As discussed in chapter four, the optoelectronic industry covers eight broad sectors, among which the optical communication and the laser technology were OVC's competitive sectors with relatively complete industry chains (Liangzhi et al. 2008). The innovation capabilities of the engaged companies could also be ranked as first-class domestically, with some even competitive in the international market. Other sectors, however, were less presented in this science park.

The optoelectronic communication sector had the most advanced industrial linkage in OVC by far. In 2008, there were around eighty-three specialized companies with total product sales of 24.9 billion YMB (Chuantie et al. 2010). YOFC and Fibre Home (WRI) were the two leading companies in this sector both domestically and internationally (Lei & Ying 2003; Ruoyuan et al. 2004). However, there were still shortcomings in this industry chain: first of all, many companies in OVC were engaged in the upstream link – the fibre and cable production. However, both the international and the domestic markets for fibre and cable have been nearly fulfilled since 2004, so competitions between companies are increasingly based on price. Secondly, through mergers and joint ventures, the transactions between companies were gradually internalized into the large company groups. Fibre Home is just a case in point (fig. 7-3): in the area of optical fibre and cable, Fibre Home itself was highly competitive in China. Regarding the optoelectronic device, its subsidiary company, WTD, was the leading suppliers for various modules, devices, and chips in the domestic as well as the international market (WTD 2011). In the communication system area, Fibre Home could cover all the ranges of the communication systems and it had engaged in almost eighty per cent of the national '863 Programmes' concerned with fibre communication (Ruoyuan, Jianhua, & Hui 2004; FibreHome 2011). Especially in the project of 'Fibre to the Home' (FTTH), Fibre Home is the only company in China that has all the technology solutions and the whole set of necessary equipments (Fu & Lan 2006). The Deputy Director of the XX Optoelectronics remarked that:

> 'Fibre Home has built the optoelectronic communication industry chain all by itself. Its subsidiaries or joint ventures have covered the cable, the device, and the system links along

the industry chain. Now its business has been extended to the wireless area, which in reality is a network again, so Fibre Home is actually building and extending its internal industry network' [interviewed on 15th July, 2010].

(Figure has been removed as third party copyright material)

Figure 7-3 The organization structure of WRI-Fibre Home along the value chain

Source: WRI-Fibre Home (2011)

The crucial role of large companies for the development of optoelectronic industry has been documented by Hendry and his colleagues (Hendry et al. 1999; 2000). What is worrying here, however, is the function of the large numbers of SMEs in OVC: In a well-developed LIS, the SMEs mainly fulfil the niche market, or become suppliers, co-operators, or outsourcing partners to these large companies (Lsaak 2009). In the case of OVC, however, the bulk of the SMEs were largely marginalized in this LIS, which served mainly as processors, manufactures, or even selling agencies for companies from other regions, as will be seen later.

In the laser sector, OVC had kept its leading position in both technology and industry achievement. By 2008, there were around eighty-four laser companies in OVC, occupying almost half of the domestic market share. Three out of the four laser companies with over 100 million YMB sales in China were located in OVC, which were the HUST High-tech Group, Chutian Laser, and the HUST Unity Laser; all in turn are related with HUST.

Table 7-2 Leading domestic companies in the three regions along laser sector's value chain

(Table has been removed as third party copyright material)

Source: Chuanlie et al. (2010)

Nevertheless, shortcomings still existed in the laser sector. First of all, most of the laser companies in OVC were upstream or midstream companies engaging in the laser transmitter and laser processing equipment productions. There were fewer ancillary companies located in this area that could provide high-quality materials, packing, and basic devices. The R & D Director in XX High-tech Group told the author that 'the industry chain in the laser sector is not complete at all in OVC and in Wuhan'. And this Company found it very difficult to find high-quality local suppliers and servicers, so it had to refer to the Pearl River Delta or Yangtze River Delta for the basic materials and services such as packing [interviewed on 9th July, 2010].

Secondly, formal interactions between these laser companies in OVC were negligible. This weakness was admitted by the CEO of the Wuhan XX Laser:

> 'We do not have any cooperation with the paralleled companies here…as we all hide our technologies as secretly as possible from each other….we do not even apply for patents for many of our core technologies, so that we can improve these technologies continuously and others (mainly refers to competitors) will never know' [interviewed on 9th July, 2010].

Now some associations and industrial alliances had been established in the laser sector, aiming to increase the interactions among the companies in OVC (Huofeng Net 2009; Science & Technology Department of Hubei 2010), but their real contributions were still an open question. For example, the Chief Director of the XX Optoelectronics commented that:

> 'The role of these industry associations and alliances are very limited…as many associations are chaired by retirees, who have no education background and experiences in this industry at all…Our company joined in some industry associations, or whatever they are called. However, these associations all have a very vague concept and service, so even now I am not sure what they are really about, and they have little help on this company's development' [interviewed on 11th August, 2010].

In other sectors of the optoelectronic industry, OVC was arguably just taking-off with small numbers of companies and influence. For example, the mobile communication sector in OVC really started to grow in this stage. By 2008, there were around thirty-three companies engaging in the mobile communication industry, but many were diversified into this sector very recently. In the LED sector, there were around twenty companies in OVC by 2008. However, the strongest LED clusters were still located in the coastal regions, agglomerating over eighty per cent of the companies. Shenzhen is particular, had over seven hundred companies engaging in the LED sector, contributing to around thirty per cent of the production sales in China (Chuantie et al. 2010). The optoelectronic services and entertainment, on the other hand, was still an emerging sector nationwide. Since many regions in China are standing parallel now, OVC might win a better share in this sector if its optoelectronic industry would be applied in the growing creative industry and the various established industries, such as the automobile industry.

7.2.1.3 Geographical distribution of companies' linkages

As already hinted above, the mere co-locating of the optoelectronic companies will by no means secure their interactions. Therefore the geographical mapping of a company's input-output relationship is arguably more accurate in evaluating a cluster's thickness (Hendry et al. 2000).

In this study, the surveyed optoelectronic companies were asked to indicate the shares of the different markets on their input and output (fig. 7-4). Three features emerge immediately from their replies: first of all is the crucial importance of other regions in China for companies' input and output in OVC. For example, 43.4% of the surveyed companies' depended on inputs from other regions in China, and 50.0% of their sales was secured in other regions currently. The same conclusion holds for companies' input and output distributions when they were just established on-site. The second character is the slightly increased importance of the regional and local input-output relations for the surveyed companies: the ratio of the regional suppliers (within Hubei) increased from 34.0% to 39.4%, and the ratio of the regional market grew from 35.9% to 39.5% since the companies started operation in OVC. Although these increases are small, they still represent an emerging local industry complex in the optoelectronics industry. The final feature is the marginal engagement of the surveyed companies in the international value chain. More specifically, it is found that the optoelectronic companies in OVC imported a large portion from overseas' suppliers, inferior only to their input from other regions in China, but they had the lowest sales in the international market in both time spans.

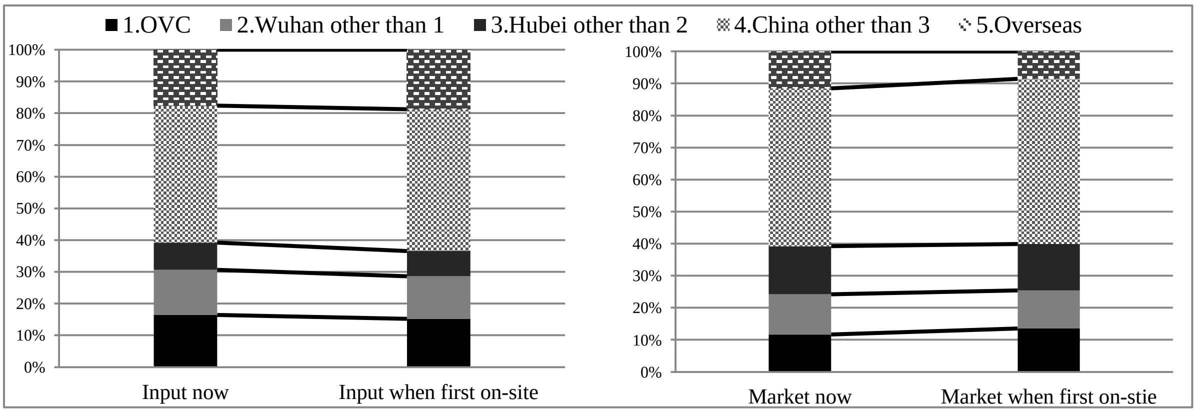


Figure 7-4 Companies' input-output distributions now and when first on-site

Note: 1. 112 valid answers for the question of input now, 80 for input when just on-site of OVC, 113 for the question of market now, and 82 for market when just came on-site;

2. Source: the author

This geographical mapping reconfirms the incomplete industrial chain in OVC, which has two immediate consequences: on one hand, the large companies had to internalize the industrial chain because of the lack of specilized suppliers locally, which however reinforced their limited demand for collaborations with other local companies. On the other hand, the bulk of the SMEs in the optoelectronic industry were degraded to backyard assembly factories for companies in other regions, especially for those in the Coastal Region of China, because there was limited demand for their products locally. Their less-embedded economic relation locally could further aggravate their political marginalization in this LIS, and finally lead to a vicious circle for these SMEs. Taken these two trends together, it is possible for some large enterprise groups to emerge in the optoelectronic industry from OVC, along with an hourglass-shaped company structure. If this happens, such super-large enterprise groups might tap into in the international value chain even before a functioning LIS get established in OVC.

7.2.2 The supporting environment of the local innovation system

7.2.2.1 Government's role in a less-developed innovation system

The learning process of the institutional environment, as conceptualized in chapter two, is twofold: internal reflecting and external reacting. For the local government, the first learning process would be found in the adjustment and expanding of its management structure. The second learning process is most strongly presented by the interactions between the government and the local companies. This section will focus on these two learning processes in turn.

7.2.2.1.1 Management structure adjustment

In April 2000, the 'OVC Construction Leading Team' was set up by the newly elected Hubei Government, headed by the Deputy Secretary of Hubei Province and comprised of many top officers from the provincial government (Pingchuan & Ying 2000). This Leading Team's successive meetings further stirred and led the orientation of OVC in its third stage. Therefore it is arguably a specially organised team supervised by the provincial government, whose main aim is to strengthen the region's leadership in this emerging LIS, or in other words, it is trying to integrate this embryonic innovative cluster onto a higher-level management hierarchy (fig. 7-5).

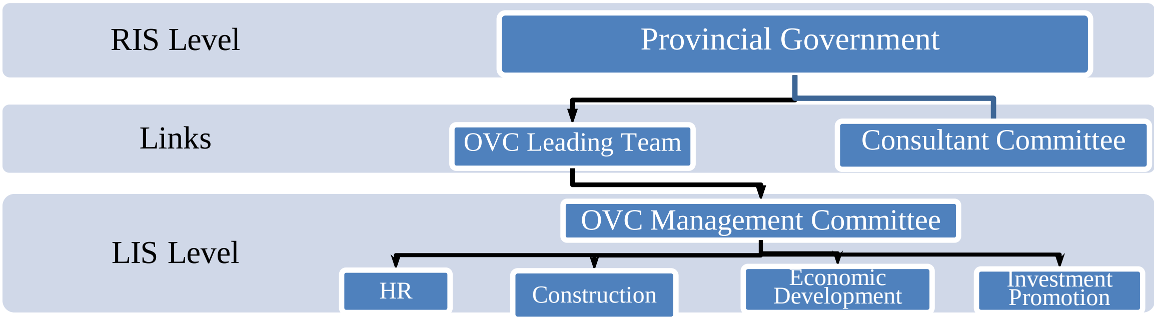


Figure 7-5 Management structure of OVC in its third development stage
Source: the author

In 2002, the Government of Wuhan delegated 241 administration approval power and 104 (reduced to 14 items later) administration fee collection right to OVC's Management Committee. In order to cater its extended responsibilities, the departments under this Committee were increased to include the Patent Transaction Office in May 2001 (Yong & Ying 2001), the Construction Management Bureau, the Economic Development Bureau, and the HR Bureau in November 2001 (WEHDZ 2005), the Investment Attraction Bureau in June 2003 (Lei et al. 2006), and the People's Court in May 2005 (Bin & Li 2005). This extended structure could be seen as an institutional advantage of OVC compared with other science parks, which was affirmed by the Officer from the Torch Centre:

> 'The criteria for a strong and well-functioned management committee lie in whether it has the following four departments: human capital, land, finance, and planning approval. A more advanced committee even has the Public Security, the Procuratorate, and the Court. If you take a look at the management committee of Z-Park, you will find it has none of the above departments; Wuhan OVC, on the other hand, has the most comprehensive structure of all the above functions' [interviewed on 20th August, 2010].

Its extended duties were followed by the improvement of the hardware of the management committee. For example, in July 2003, the Management Committee moved into its new 17-floor office block, which has an exhibition centre on the basement, and later a United Service Centre on the sixth floor (fig. 7-6). The United Service Centre, in particular, assembled six departments of the Management Committee, nine vertically managed bureaus, and five despatched bureaus of the city's government, which was complemented by the *Science & Technology Daily* as the 'innovative policy under the sunlight' (Xianghua 2003, p421), as it significantly improved the efficiency and transparency of the administration process, and thus moved beyond the old 'on-site working day'.

Figure 7-6 Office building of OVC (left) and the United Service Centre (right)
Source: the author (2010)

7.2.2.1.2 Management boundary expansion

Accompanying its political significance upgrading, OVC's coverage was also extended substantially through land entrustment. The first wave of 'land entrustment' happened at the end of the 1990s and early 2000s, pushed mainly by the 'two-hand' growth strategy of the local authorities: In October 2000, the newly elected leading team held its fourth meeting, in which the developing strategy of OVC was shifted from concentrating solely on industrial development to 'promote growth with two hands – one on industry, and the other on the New Town construction' (Ying & Pingchuan 2000). For the local authorities, the industry development was the lifeblood of OVC, but the infrastructure and physical environment was the vein and should enjoy equal priority (Rui 2001). As a result, massive physical construction started in this stage. By the end of 2000, there were twenty-one real estate construction projects underway, with a total investment of 2.77 billion YMB (Wuhan Evening 2000).

No large scale extensions, however, happened for the following half decade, which was mainly because the tight control on land usage at that time by Beijing (Haifeng 2005). However, as soon as this tight control started melting away since 2006, OVC welcomed its second ‘entrustment wave’: In 2007, a town used to belong to the Jiangxia District was entrusted to OVC. In 2008 ten villages and one community belonged to Hongshan District were delegated to OVC, which extended it to 221 km^2. The latest and largest expansion happened in 2010, after OVC was titled as the second National Innovation Model Zone. A total of 297 km^2 land was added to OVC in one-go, which doubled its coverage to 518 km^2 (Baidu 2011a) (fig.7-7, 7-8).

(Figure has been removed as third party copyright material)

Figure 7-7 Acreage of OVC
Source: Wuhan Party History Research Centre (2009); The People’s Government of Wuhan (2011); and Baidu Encyclopaedia (2011a)

(Figure has been removed as third party copyright material)

Figure 7-8 The original and new boundary of OVC
Source: Planning and Design Research Institute of Wuhan, 2006

The Chief Director of the XX Bureau of OVC provided more detail on the nature of land entrustment:

> ‘We started using this development mode (land entrustment) as early as the 1990s. The essence of this approach is to hand over planning, construction, social affairs, economic development, finance, and taxation to the Management Committee but not the NPC and CPPCC[4], since transferring the latter means adjusting the administration boundary, and needs to be reported and approved by the State Council. Actually now many science parks rely on this mode to expand their space but with different names’ [interviewed on 28th July, 2010].

Although the authority of OVC treated land entrustment as a ‘common practice’, the Director from XX Urban Planning Bureau nevertheless threw in his critical viewpoint:

> ‘I remember the first land transfer didn’t involve the social affairs; the peasants whose land was taken were left without a proper compensation, so it ended up badly. Therefore the land entrustment now is more like transferring a whole package of power to OVC. But OVC would behave overbearingly on this regard. For example, the Miaoshan area within the Jiangxia District was developing quickly at the beginning of 2000, but OVC took it for

[4] NPC: The National People’s Congress; CPPCC: The National Committee of the Chinese People’s Political Consultative Conference.

granted that Miaoshan should belong to it because they are close to each other. So when all kinds of constructions and infrastructures in Miaoshan were nearly finished, OVC jumped in to ask for delegating…What we (Planning Bureau) were busy at were planning and re-planning for its expansions at that time' [interviewed on 13th August, 2010].

Land entrustment, as it would be seen here, might not always be welcomed by all the partners. One of the negative influences was the deteriorated relationship between different local authorities. For example,

> 'Jiangxia District was of course not willing to have its land managed by OVC, so the negotiation result was that Jiangxia District could share some of the tax revenue from OVC. However, the share is limited and Jiangxia still feels this is not a win-win business. Personally, I do not think the land entrustment is a preferable way of regional co-operation. It may be too compulsive [interviewed with Director in XX Urban Planning Bureau on 13th August, 2010].

Furthermore, the expanded land had been utilised by the local authorities to develop real estate aggressively, as told by the Director in XX Urban Planning Bureau:

> 'The focus of OVC now is mainly on real estate development... which brings in money quickly – once it has money, it can wrap itself up, for example, paving a high quality road or repairing the buildings, making itself presentable' [interviewed on 13th August, 2010].

Lastly, storing sufficient land is arguably a prerequisite to keep the land price low, which in turn could attract more investment. For example, the *Wuhan Morning* once reported that OVC managed to attract ten companies relocating there within one month, and the most important reason was the low land price. In 2002, the lowest land price was around 225 YMB/m^2 in OVC, but in 2003 the price dropped by over 30 per cent to 150 YMB/m^2 on average (Tao & Ying 2003). However, suppressing land price to attract investment might trigger severe price competition between different locations and cause significant loss to the country as a whole.

7.2.2.1.3 Government involvement in the market

OECD (2008)'s review on China's NIS argued that China has evolved from a government-centred structure to company-centred. However, this does not mean that the Chinese government has been happy to withdraw from economic activities. This is especially true in Central China, where the established bureaucratic system is stronger compared with the coastal areas. Government intervening in the private sector is common in the case of OVC, which are realized through two main channels.

The first one is through drawing up industry strategy plans, which in turn will define which industrial sectors would attract more attention and support from the government. For example, in 2000, the first comprehensive development plan for OVC was announced (OVC Management Committee 2000), in which ten key construction projects were identified, all focused on the optoelectronic industry. The Eleventh 'Five-Year Plan' of OVC, on the other hand, extended its targeted industries far beyond the optoelectronic industry to cover such sectors like semiconductor, software, biomedicine, and environment protection (Changchun 2006, p11). OVC's growth target by 2010 was set to become 'the first-class science park in the world' (Xianghua & Hong 2006), which, ironically, was deferred till 2020 in its latest published industrial development strategy in 2008. This newest industry development strategy directed OVC towards 'the international hub of optoelectronic industry'. It also recommended four emerging industries, namely the energy and environment protection, biotechnology, modern equipment manufacturing, and R & D and information service as its targeted sectors in the future, with the aim to become 'the well-known industrial base in the world and especially in the Asia Pacific Region' (Dajun et al. 2008; Daolin & Lin 2008).

These changing industrial development strategies were reflected by the industrial structures of OVC. According to its 2007 annual report, for example, the industries catered in OVC covered not only the optoelectronic information (41.25% of the total industry revenue in 2006), but also the mechanical and electrical integration (16.43%), environmental protection (9.65%), new materials and energy (9.34%), and bioengineering & new medicine (6.23%) (OVC 2011). This diversified industry structure was purposely cultivated by the local authorities, as the Chief Director in the XX Bureau of OVC emphasized that:

> 'We are called the Optics Valley, but our emphasis is now on the '*valley*' but not the '*optics*', i.e. the optoelectronic industry is indeed our highly competitive industry traditionally, but by no means are we going to be confined by this industry. Other industries are welcome here as well' [interviewed on 28th July, 2010].

This diversified industrial development strategy further triggers a wider question on the proper scales for specification and diversification. On a cluster scale like OVC, a specialized industrial structure is arguably more efficient, especially when it complements the established manufacturing industries locally. However, the strategy of the local government was obviously trying to cultivate a self-sufficient LIS and minimize their chance of losing-out in the next high-tech revolution.

The second channel was directly involving in the business affairs of the endogenous companies. The local authorities had always been following the development of the key leading companies there closely. When asked for their relationships with the local governments, all interviewees from the large companies confirmed the growing support from the government, because these companies were the 'backbones' of the industry as well as this science park [confirmed by for example the R & D Directors of three largest companies in OVC]. Some criticisms, however, were heard from the smaller companies and the private companies. XX Laser, for example, hoped that the local government could provide a fair-play environment between the state-owned companies and the private ones [interview with the Sales Manager of XX on 28th July, 2010]. What is more, some drawbacks of the government's intervention were pointed out by the CEO of the Wuhan XX Laser:

> 'The laser companies in Wuhan are raised in captivity…The city and region's governments have always been looking after their laser companies dutifully, and there are lots of preferential policies available. So the laser companies in OVC are used to turning to the government for financial and other supports when facing difficulties' [interviewed on 9th July, 2010].

The establishment of the joint venture – HUST Unity Lesser – vividly reflects the deep involvement of the local governments in the economy. The promoter of combining HUST Laser, Chutian Laser, and Unity Laser was in reality the local authority (Shanghai Stock 2011), whose earliest effort could be dated back to 2002 (Tianming 2007). Chutian Laser, however, was not happy with the proposal and thus dropped out. Unity Laser, on the other hand, hoped that establishing a joint venture with HUST Laser (state-owned) would deepen its political background. Therefore a joint venture was finally formed between these two companies in 2007 [interview with the CEO of XX Laser on 13th August, 2010]. However, the Secretaries of China Optics & Optoelectronics Manufactures Association revealed that: 'the local government had used its administration power to order this cooperation, but we heard that the effect is not that promising' [interviewed on 4th August, 2010]. As suspected, in 2011 there was news that the cooperation was not successful, and the divorce between these two partners was just a matter of time (Shanghai Stock 2011).

In summary, the local government of OVC interacted with the private sector through designing industrial development plans and cultivating a favourable environment for the local companies. However, its involvement in the economic affairs had arguably exceeded the acceptable baseline. Similar situations would also be found in the interface between the local government and the knowledge institutes. However, because the local government had devoted more effort on cultivating the brand of Optics Valley and attracting investment, motivating these knowledge institutions had gradually become its second priority, which will be discussed next.

7.2.2.2 The HEIs and RIs

7.2.2.2.1 The good and the bad of the knowledge resources

As China's reform on the education and the research systems getting deepened in this stage, more HEIs and RIs in OVC took a liberal attitude towards spin-offs and part-time staff. For example, the Head of the Land Resources Management Department in HUST believed that:

> 'It is a personal choice for the staff to take part-time job on the market, and the university should not bother controlling. As long as one finishes the due tasks and assigned work by the university, he or she is free to do whatever they like to do. What is more, HUST itself has many university-run enterprises, and many staff involved in them'. For example, the HUST High-tech Group CO. Ltd. was established in 2000 as the sole investor of the university-owned companies' [interviewed on 5th July, 2010].

In reality, HUST also established the National Technology Transfer Centre in 2001, which aims at promoting cooperation between enterprises and the university (Qiping & Xia 2009; HUST 2011b). The R & D Office of HUST was established in 2008 and is headed by the Deputy President of the university. Its main tasks involve promoting enterprise-university cooperation, designing motivation measures, and cooperating with international partners (HUST 2011c) (fig. 7-9).

(Figure has been removed as third party copyright material)

Figure 7-9 Production & research cooperation management structure of HUST
Source: The National Technology Transfer Centre, HUST (2011b)

However, some problems remain to be solved if OVC wants to fully utilise its local knowledge storage. The first problem relates to the curriculum design and the specific courses run by the universities. As discussed in previous chapters, most of the competitive universities in Hubei are managed centrally, and the design and change of curriculums needs the approval of the Ministry of Education (MOE). As a result, many courses and subjects run by the local HEIs are not updated and can not meet the demand of the industry. The Head of the Land Resources Management Department in HUST remarked on this:

> ‘HUST is only responsible for the tasks and requirements of MOE...the curriculum designed by HUST have to take into account the overall situation of China, not only those of Wuhan and Hubei. The structure of the departments and courses in HUST are relatively stable for the past decades, and of course we could not be influenced so easily by the existence of an optics valley here’ [interviewed on 5th July, 2010].

The second problem is the lack of entrepreneurship education in HEIs. Even by 2011, there were no specifically designed courses on entrepreneurship and enterprise-running in the Chinese universities, although some basic and general education on management, accounting, law, and finance are provided. According to an earlier survey of forty enterprises in OVC, 76.4% of the employees had a lower than average education in economics and 81.9% had little knowledge in management. Moreover, 94.4% of the entrepreneurs knew little about international business operations, international financing, and trading regulations, while 54.1% knew nothing at all about basic international business practices (Guang 1995a). Such a situation is worrying because the quality of the local entrepreneurs depends to a large extent on their knowledge accumulation, a large portion of which is arguably gained through their college education. This situation might be more alarming in Hubei because it has a higher unemployment rate than the national level since the mid-1990s (National Bureau of Statistics of China 2011). Therefore, incorporating entrepreneurship education in the HEIs and encouraging graduates to set up their own companies are very much needed.

The third obstacle relates to the declining R & D standards in many HEIs and RIs. As discussed before, many research institutes in Hubei were reformed from non-profit institutions to companies, and therefore before 2008, there were actually no dedicated R & D institutes focusing on optoelectronic technology, except for some small research centres and laboratories hosted by the local HEIs. Furthermore, the profit-oriented reforms in HEIs and RIs have argueably reduced the high R & D standards they used to keep. Many interviewed companies had expressed their concerns on this matter, saying that ‘the moral standards of HEIs are now declining in China, and they are just places for cheating’ [interview with the sales manager of XX Optoelectronics on 15th July, 2010], and that ‘it will take us at least ten more years to commercialize the R & D results from the labs’ [interview with the CEO of Wuhan XX Laser on 9th July, 2010].

The final shortcoming is OVC’s difficulty in attracting and retaining human resources. According to the three nationwide *Graduate Surveys* organised by MOE, Beijing, Shanghai, Guangzhou, and Shenzhen were always the top choices for graduates. Hubei, on the other hand, was far less attractive compared with these ‘hot locations’ for talent (Yuchun 2008). This perception was confirmed by all the companies interviewed regardless their sizes. Actually this weakness was perceived by many interviewed companies as the biggest disadvantage of OVC.

7.2.2.2.2 Government & knowledge sources

The relationship between the government and the knowledge institutions in OVC used to be very close. In this stage, however, the attention of the local authorities had shifted to attract MNCs and the subsidiaries of the leading domestic companies, and thus their time reserved for scientists and professors was reduced.

One significant exception in this stage was the establishment of the National Laboratory for Optoelectronics in 2008. The idea of setting up a number of national level research laboratories based on some prestigious HEIs was proposed by MOST in late 2002. On hearing the news, the local authorities of OVC backed-up HUST strongly to compete for the quota: Besides HUST, other partners, such as the WRI, Wuhan Physics & Mathematics Research Branch of the National Academy of Science, the 717 Research Institute of the National Marine Group, were convened together by the provincial government as the knowledge support for this Laboratory (Jing & Qianjin 2003; WNLO 2011). The physical construction of this laboratory started in 2003, and by now it had made some achievements on technology diffusion. One case in point was a LED producer called XX Optics. This company established its first producing line inside the laboratory in order to save sunk-investment. After launching its product successfully on the market, this company later moved out of this laboratory to the newly established Liufang Industry Park [interview with the Deputy Director of XX Optics on 15th July, 2010]. Except this promising example, however, this laboratory had fewer achievements in commercializing the R & D results from the laboratory compared with the prestigious ITRI in Hsinchu, since ‘the market feasibility is not a precondition for accepting a research project in our laboratory’ [interview with the Deputy Director of this laboratory on 28th July, 2010]. Furthermore, when this field work was conducted in 2010, this laboratory was still under trial operation with many officers empty. This Deputy Director admitted that:

> ‘Our laboratory has not done very well in establishing linkages with the industries, because I think the pilot stage is still missing here…we have been trying different approaches to fulfil this gap, but all were blocked by the difficulty of establishing the incubating function here. This function needs capital support from various sources…we do not have investment from any venture capital but relying on loans from some rich individuals or companies. However, it is hard to keep functioning if we only depend on the private capital. If the government and the venture capital funds would join in, the situation might get much better’ [interviewed on 28th July, 2010].

The contradictory attitude of the local government before and after winning the quota triggers the speculation that, while the local government had devoted much effort in applying for a national level research laboratory to locate in OVC physically, it had less passion for improving the soft environment of the lab afterwards.

7.2.2.3 Other sectors

7.2.2.3.1 Finance and venture capital

In the financial sector, two channels were relied on heavily by the local government to assemble capital. The first one was through organising forums and exhibitions, and the other was setting up venture capital.

A series of forums called the 'Capital Market and High-tech Industrialization' and later the 'International Expo of Optoelectronic Technology' were organised in this stage. In July 2000, the first Forum was jointly organised by the MOST, Hubei and Wuhan governments, and Shanghai Stock Transaction Centre. Many banks and venture capital firms signed cooperation contracts with the Management Committee on spot. The third forum was co-organised with the first International Expo of Optoelectronic Technology in June 2002, which had a more international-oriented theme (WEHDZ 2005). These forums and Expos were organised under the belief that 'exhibition economy' would not only boost the reputation of OVC internationally, but also effectively match investors with companies. The influences of these exhibitions were increasing, although the scale and reputation of Wuhan's Expo was still lagging behind those held in Japan and Germany (Hong & Yongxin 2002).

The second way was establishing state-controlled investment service centres or venture capital. According to the government's design, the venture capital system in OVC would include: 1) the Investment and Financing Trust Funds, 2) Enterprise Funds and, 3) Government Seed Funds (Xinhua News Agency 2000). By 2007, there were fifteen venture capital companies in Wuhan with one billion YMB investment capitals in total. Seventy-five per cent of their fund, however, came from the state capital. In the case of OVC, there were only four venture capital companies by 2007, which were the East Lake Innovation, Wuhan High-tech Investment, HUST Enterprise Investment, and the Wuhan University Enterprise Investment, all of which were state-controlled (Zuohui et al. 2007). As told by the CEO of Wuhan XX Investment, this company had supported five companies went public by 2010 and three more were waiting for its engagement [interviewed on 7th July, 2010]. Therefore, it is a safe argument that the state capital had been supporting the venture capital sector in OVC for all these years. Central China's general lack of attraction to venture capital is arguably one of the main reasons. Other reasons would be found in the small scale of companies, low technology sophistication, unfamiliarity with the practices of the financial market, the relatively conservative attitude of managers, as well as the global economic depression since 2008 (Nianwu 2007; Xuege 2007; Siwei 2008).

7.2.2.3.2 Service sector

In this stage, a functioning and independent service sector was still missing in OVC. Therefore the local government had to fill this market gap and acted as a mediator between the companies and other system components. For the leading companies in particular, the local authorities put a lot of attention on their development, either holding forums and meetings with their managers frequently, or personally visiting these companies from time to time. Having got to know the difficulties facing these companies, the government would negotiate on their behalf with other actors, such as the finance and public media. This proactive role of the government was confirmed by many interviewees. For example, the R & D Director of one of the largest companies in OVC commented on the relationship with the Management Committee, saying that:

> 'I think the service of the OVC government is not bad. I am in charge of applying for R & D project fund in this company, and the Committee is always very supportive. Moreover, the government has a lot of communications with us, as there are always some survey questionnaires need to be filled and some meetings need to be attended. We can tell them directly about our difficulties during these meetings' [interviewed on 7th July, 2010].

Besides functioning as a mediator, the local government had also started to realize the importance of industry alliances in strengthening the cooperation between companies, and consequently promoted their development. The first industry alliance in OVC was called the FTTX Industry Alliance, which was established in 2006 and led by Fibre Home (Sunhua 2006). In 2008, this alliance was acknowledged as the national-level industry alliance and comprised of over thirty domestic companies throughout China (Yang 2008). In 2009, ten more pilot industry alliances were approved by the Government of Hubei (Wuhan Party History Reserach Centre

2009). The role of the local government in selecting members, motivating HEIs and RIs, as well as providing all kinds of support was crucial on the formation stage of these industrial alliances.

Overall, the local government of OVC had been the leader and engine for this LIS's growth. Although Beijing is gradually withdrawing from direct market interventions, as shown by OECD's (2008) report, the authorities in less-favoured regions, however, are still assuming some of the market functions and taking a dual-role: one as the game player, and the other as the game referee. Figure 7-10 below illustrates a typical IS in less-favoured regions.

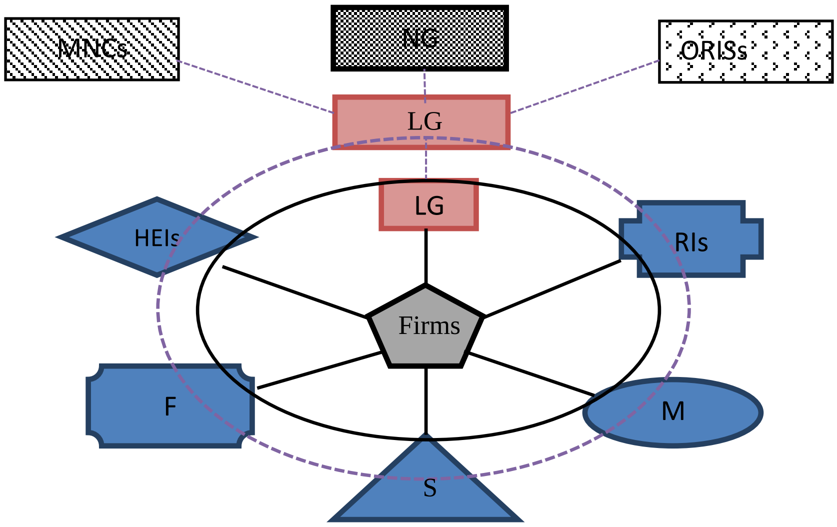


Figure 7-10 Structure of the innovation system in a less-favoured region

Note: 1. Private sector; HEIs; Research institutes; Finance sector; Media; Service sector; Local government; Central government; MNCs; Other RISs; Market interactions; Administrative interactions

2. Source: the author

7.3 Learning between innovation systems

An innovation system is not closed. Every individual component in this system has closer or looser linkages with the components from other innovation systems. The changes in one unit may or may not trigger a domino effect in others; however, some corresponding adjustments are very likely to happen, no matter the adjustment is merely awareness, a ripple, or even a revolution.

Learning among the LISs within a region is relatively easier compared with that between RISs, because there are fewer direct competitions between different cities and towns within one regional administration boundary. For example, OVC on its third development stage was strong enough to act like a growth pole for its surrounding areas. In 2006, OVC signed a cooperation framework with Xiaogan High-tech Park, aiming to cooperate with each other in technology and industry development, incubating, and human capital exchange (Renfeng 2006). In September 2008, an agreement was settled on constructing the OVC-Xianning Industry Park, which was designed to provide services and supplementary products to the major industries in OVC (Zeping & Weiming 2009). These co-operations not only enhanced the interactions between the LISs, but also promoted the economic development of the involved partners.

The learning between the RISs in China used to be highly superficial, as discussed in chapter five. However, as the economic integration and linkages between regions grow, more regional governors realize the importance of learning from each other. For example, the Wuhan Software Industry Base was jointly established between OVC and Dalian Software Park in 2006 (Zuohui et al. 2006), which would be difficult in the 1990s as the approval from Beijing was a precondition. What is more, various industrial associations are emerging now in China. The National Optics & Optoelectronics Manufactures Association, for example, has become one of the communication platforms between companies in different RISs [interview with the Secretaries of this association on 4th August, 2010]. However, the most common formats of learning between RISs are still on-site visiting and/or joint activities (WEHDZ 2005; Changchun 2006; 2007; 2008; 2009)

On the national level, cooperation between OVC and other countries is also growing in this stage. One case in point was the Sino-British Science Park jointly established by OVC and the city of Manchester. The history of this science park would be traced back to 2002 when the Mayor of Manchester visited OVC (Hong & Yuanjun 2002). After two years' negotiation, this plan was finally realized in 2004 (Lingyun & Hui 2004). Another example was the partnership established between the International Laser Association in Russia and the Wuhan Laser Society in November 2006. The deal included the permission of exporting CO_2 laser transmitter from Russia, the technology of which was still missing in China. More importantly, the two partners agreed to establish a Sino-Russia Laser Processing Technology Research Center with the technology support from Russia (Daolin et al. 2006; Jiulong 2006). This cooperation is crucial for China's optoelectronic industry, because many developed countries still restrict their technology export to China, especially in some strategic areas, such as the laser and the numerical control technologies. The aim of US, for example, was to 'impede China's technology advance in laser sector at least twenty years behind US,' as remarked by the Sales Manager from XX Laser [interviewed on 28th July, 2010].

On the other hand, the strategy of the Chinese government is to promote the self-innovation capabilities of this country, whose importance has also been realized by more and more domestic companies. The latest political upgrading of OVC to the 'National Self-innovation Model Zone' in December 2009 was a reflection of the Central Government's intention. For the local authorities, on the other hand, the promotion of OVC as the second Model Zone after Z-Park had been regarded as the start of a new chapter in OVC's history, since this title brings in significant autonomy in policy making [interviews with the Directors in the Economic Development Bureau, Investment Promotion Bureau, and the Strategy Research Institute of OVC in 2010]. The real effect of this upgrading, however, might take a longer time to be appraisable and thus is out of the scope of this study.

7.4 Summary

Along with winning the brand of 'Optics Valley', significant growth was achieved by OVC in this stage, but shortcomings were also noticeable. In the private sector, industrial chains in the optoelectronic communication and laser sectors were strengthened, but other sub-sectors were arguably just taking shape. Regarding the tangible linkages between companies along the industrial value chain, it was found that companies in this science park did not pick their proximate firms as the first-choice business partners. This was partly resulted from the relatively high product similarities among companies, and partly from the integrated organisational structure of many large and leading companies here. Regarding the intangible interactions and cooperation, it was found that informal interactions between employees were highly active but were mainly internal in nature. Formal interactions, on the other hand, were less noticeable.

In the public domain, the local government of OVC started to pay attention to both the hardware and the software construction of this LIS. Land entrustment was inherited by the new Leading Team of OVC. However, there was a growing passion of the local government for real estate development instead of industrial promotion. Therefore the continuously expanded boundary of OVC might only provide the local authority sufficient land to sell cheaply. For the software construction, the management structure of OVC was further tightened onto the provincial level through the imposed Leading Team. However, the efficiency of both the Leading Team and the Management Committee was significantly improved in this stage. Another noticeable change was the increasing independence and autonomy of the local authorities in orienting OVC's growth direction, even when it came to the foreign investment and regional cooperation. A functioning LIS is arguably emerging in OVC along with the decentralization process of China.

The knowledge institutes in OVC no longer attracted the same amount of attention from the local authorities, but an active role of the local governments in the financial and service sectors would be identified. Moreover, other forms of organizations were emerging quickly in this stage, such as the industrial alliances and various kinds of associations and societies. Although their structures and services were less professional and their contributions were still small, these self-organised institutions still represented a promising power in this less-favoured region, and they surely signalled a strengthened innovation system in OVC. Nevertheless, the LIS of OVC represented a 'dual-track' system that was actively constructed and promoted by the local governments, with the latter gradually gaining in autonomy from the NIS along time.

Chapter 8 Current profile of OVC

The previous three chapters reviewed the growth trajectory of OVC, aiming to answer the first three questions raised in the introduction: 1) how OVC was born, 2) what its growth trajectory looks like, and 3) the power redistribution between different layers of innovation system. This and the next chapters will embark on the last research question of this study, namely the current profile of OVC and its synergy, with the original survey data as the main input. More specifically, two databases will be utilised: the first one is the author's face-to-face questionnaire survey conducted between May and September 2010 (referred to as database 1 subsequently), and the second one is the 2010 annual survey of all the registered optoelectronic/electronic companies provided by the Management Committee of OVC (referred to subsequently as database 2).

In this chapter, three out of the five dimensions in the four-quadrant conceptual model will be covered, which are: 1) the internal resources of the companies; 2) their technology characters and; 3) their economic performance. What is more, two previous studies on the UK science parks will be included as benchmark: The first one was published by Monck and his colleagues (1988). Their study covered a total of 284 matched companies both on- and off-science parks in the high-tech sectors. The second one was the survey conducted by Westhead and Storey (1994), which compared the on- and off-park high-tech companies based on a cohort group between 1986 and 1992, and also a new sample of companies collected in 1992. A preliminary summary of the characters of the companies in OVC will end this chapter.

8.1 The general profile of companies

8.1.1 Ownership and organisational structure

Among the surveyed companies in database 1, 22 were state-controlled companies and 10 were collective-controlled ones. Totally they accounted for 23.2 per cent of the sample size. 99 companies were private-controlled, and the remaining 7 companies were either foreign-controlled (6 companies) or invested by partners from Hong Kong, Macao, and Taiwan (1 company) (thereafter referred to as foreign-controlled for simplification). Comparing this ownership distribution with other data sources, it was found that the state/collective controlled companies were over-represented in database 1 than those from database 2, the overall company profile in OVC, and the national average (tab. 8-1). This is to be expected because the surveyed companies in database 1 were in a more strictly defined optoelectronic sector. The importance of this high-tech sector in turn requires the dominance of the state capital. Moreover, the lack of foreign investment in OVC compared with the national average reconfirms the inferior position of Central China in competing with the coastal regions for attracting FDI.

Table 8-1 Number and percentage of companies with different ownership

(Table has been removed as third party copyright material)

Note: 1. Data were based on the 2006 report of OVC (2007);
2. Data were from Torch Centre (2009a).

Table 8-2 below shows the management structure of the companies, or the commonly discussed 'ownership' in western studies. Among the 130 companies answered this question, 73 (56.2%) were single-plant independent companies, within which only 2 had traded before relocating to OVC. 11.5 per cent of the companies were head-offices of multi-plant companies, and the rest 32.3 per cent were branches or subsidiaries of other companies. Comparing these results with those based on the UK science parks, it was obvious that OVC had the highest percentage of companies belonging to the category of subsidiary and branches, which might reflect its attraction for established companies to take advantage of the preferential policies. Compared with Monck et al.'s (1988) study, it was found that OVC had a relatively higher level of start-ups than the UK science parks. This is understandable given that the UK science parks normally adopt stricter criteria on accepting companies. In OVC, on the other hand, the physical space is enormous, thanks to the continuous land entrustment, and the policy is inclusive; therefore the threshold for starting up a company is significantly lower.

Table 8-2 Management structure of companies in comparison

(Table has been removed as third party copyright material)

Note: 1. The data in UK 1988 were from Monck et al. (1988, p106);

2. The data in UK 1986 and 1992 were from Westhead & Storey (1994, p35);

3. In Westhead and Storey's (1994) study, the division was only made between 'independent' and 'subsidiary' companies.

Another way to explore the organisational structure is to check a company's position in an enterprise group. In database 2, there is a question asking the companies' positions in an enterprise group if applicable. The two pie charts below show the results from the two databases. It seems that in general, around 10 to 15 per cent of the optoelectronic companies in OVC belonged to an enterprise group, which equalled to 22 companies in database 1 and 62 companies in database 2.

Figure 8-1 The organisational structures of companies in database 1 and 2

Source: the author

A closer look at the ownership types and organisational structures of the companies reveals some more interesting relationships: first of all, 45.5% of the state/collective-controlled companies belonged to a company group, which was significantly higher than the percentages of both the private (5.1%) and the overseas (28.6%) controlled companies. A plausible reason for this difference is once again the strategic importance of the optoelectronic industry. On the other hand, the overseas-controlled companies should have had a high percentage belonging to a company group, as long as their parent companies are well established and internationally influential. However, the finding here contradicts with this expectation, which might indicate that the foreign-controlled companies in OVC were mainly established by returnees. XX Inc. is just a case in point. Its head office was established in San Jose, California in 2001, but it chosen Wuhan to locate its R & D and manufacturing facilities in the same year [interviewed on 8th July, 2010]. However, a word of concern is that the scale and scope of this 'reverse brain drain', as discussed in chapters six and seven, was still too small to be influential in OVC.

8.1.2 Age and size distributions

Using the same age classification as in Monck et al. (1988) and Westhead and Storey's (1994), the age distribution of the surveyed companies is summarised in table 8-3 below. Comparing the patterns in different data sources, it is found that Westhead and Storey's (1994) follow-on sample in 1992 exhibited a typical pyramid-shape with the firms of less than 4-year's old dominant. In comparison, the survey results in this study as well as from Monck et al.'s (1988) shown that companies in the 4-9 years age group accounted for the bulk of the on-park companies. Moreover, significantly more companies from OVC belonged to the 4-9 years age group, while fewer existed over 26 years. Furthermore, it was found that over half of the optoelectronic companies in OVC were established between 2001 and 2006, when OVC was on its accelerated development stage after being titled as the first National Optoelectronic Industry Base. So it could be argued here that the institutional opportunities brought by this national brand had encouraged the potential entrepreneurs to start their businesses.

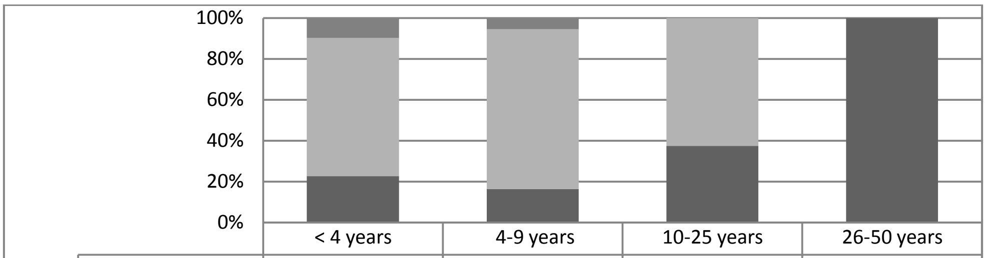
Table 8-3 Age distribution of companies in comparison

Age	Database 1		Database 2		UK1988[1]		UK1992[2]	
	No.	%	No.	%	No.	%	No.	%
1. < 4 years	31	22.5	111	20.2				
2. 4-9 years	73	52.9	294	53.5				
3. 10-25 years	32	23.2	140	25.5				
4. 26-50 years	2	1.4	4	0.7				
5. > 50 years	0	0.0	1	0.2				
Total	138	100	550	100				

Note: 1. The data for UK science parks 1988 were from Monck et al. (1988, p106);

2. The data for UK science parks 1992 were from Westhead & Storey (1994, p35);

Furthermore, significant age differences existed between the optoelectronic companies with different ownership: all the long-established companies in OVC were state/collective controlled, which affirms the previous historical review of OVC. What is more, the foreign-invested companies were all younger than ten years, which reflected the very recent engagement of OVC in the international value chain.



	< 4 years	4-9 years	10-25 years	26-50 years
Overseas & HMT	3	4	0	0
Private	21	57	20	0
State & Collective	7	12	12	2

Figure 8-2 The percentage of different ownerships in each age group

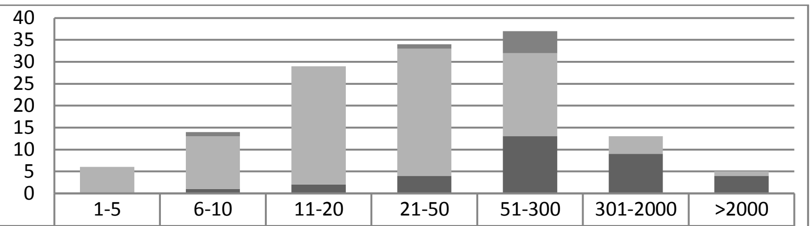
Note: 1. $\chi^2 = 14.393$, d.f. = 6, significance level = 0.026, reject H_0

2. Figures in the table refer to the numbers of companies in that ownership falling into the individual age group.

3. Source: the author

Regarding the employment size of the surveyed companies, it was found that small companies with less than 20 employees accounted for 35.5 per cent of the sample, and companies belonged to the 21-50 sized group accounted for another 25 per cent. Therefore it seems that SMEs dominated OVC. The relationship between these SMEs and the local big companies thus determines whether OVC represents a ‘hub-and-spoke’ industrial cluster or a satellite cluster (Markusen 1996). Referring to the discussions in last chapter, especially the phenomenon that the bulk of companies’ input-output relations were out of Hubei, and that SMEs were marginalized in this local innovation system, the speculation here is that OVC functions more like a satellite cluster now.

Regarding the relationship between companies’ size and their ownership (fig. 8-3), it is clear that the state/collective-controlled companies and the foreign-invested companies tend to be larger, whereas the majority of the private-controlled companies fall into the category of SMEs. This is understandable in China if one takes into consideration the attractiveness of both the foreign-invested and the state-controlled companies. The former is competitive in the labour market because of their generally higher salaries, whereas the latter is attractive for their better welfare. What is more, these large state/collective-controlled companies in OVC are normally the well-established companies in the optoelectronic industry, the resources they can assemble are therefore far ahead of other companies, especially the private ones.



	1-5	6-10	11-20	21-50	51-300	301-2000	>2000
Overseas & HMT	0	1	0	1	5	0	0
Private	6	12	27	29	19	4	1
State & collective2	0	1	2	4	13	9	4

Figure 8-3 Number of companies in different size groups according to their ownership

Note: 1. For companies' size differences grouped by their different ownerships: $\chi 2 = 47.607$, d.f. = 12, significance level = 0.000, reject H0.

2. Source: the author

8.1.3 Geographical coverage

Confined by time and finance, this study was not successful in surveying a matched sample of off-park companies as Monck et al. (1988) and Westhead and Storey (1994) managed. However, analysing the influence of agglomeration is still possible and meaningful in this study. It is possible because companies' registered postcodes were recorded in the questionnaire, which helps to mapping the surveyed companies geographically. It is meaningful because of the large coverage of OVC and its 'parks within park' development mode. These themed parks were generally located in separate places and accepting companies with different standards, therefore they might cultivate diversified sub-cultures within OVC.

Depending on: 1) the density of companies clustered in a specific postcode, 2) the author's field work diary and local knowledge, and 3) the development history of OVC, two clusters with more than 20 companies each were identified. The first cluster comprised of 85 companies with the postcode of 430074, which accounted for 61.6 per cent of the surveyed companies (thereafter will be referred to as the 'old cluster'). This cluster emerged mainly on the foundation of Guandong and Guannan industry parks, the two earliest industry parks in OVC. Moreover, as the traditional centre of OVC, this cluster was also blessed with well-developed urban facilities and the strongest HEIs and RIs of Hubei.

The second cluster had 28 companies with the postcode of 430223, which accounted for 20.3 per cent of the sampled companies (thereafter will be referred to as 'newer cluster'). This cluster was located in the south of OVC, where the latest development and extension of this science park happened since 2000. What is more, this cluster emerged mainly on the base of the United University Science Park (UUSP) of OVC, which was a joint initiative of four universities in the new century. The physical layout of this UUSP is unique, as each university has their self-managed park separated from each other, although all are within walking distance (fig. 8-5). The remaining companies accounted for 18.1 per cent of the surveyed companies, and they were scattered all around OVC with no identifiable cores, so this group was treated as a benchmark against which the effect of clustering was tested statistically in this and the following chapters.

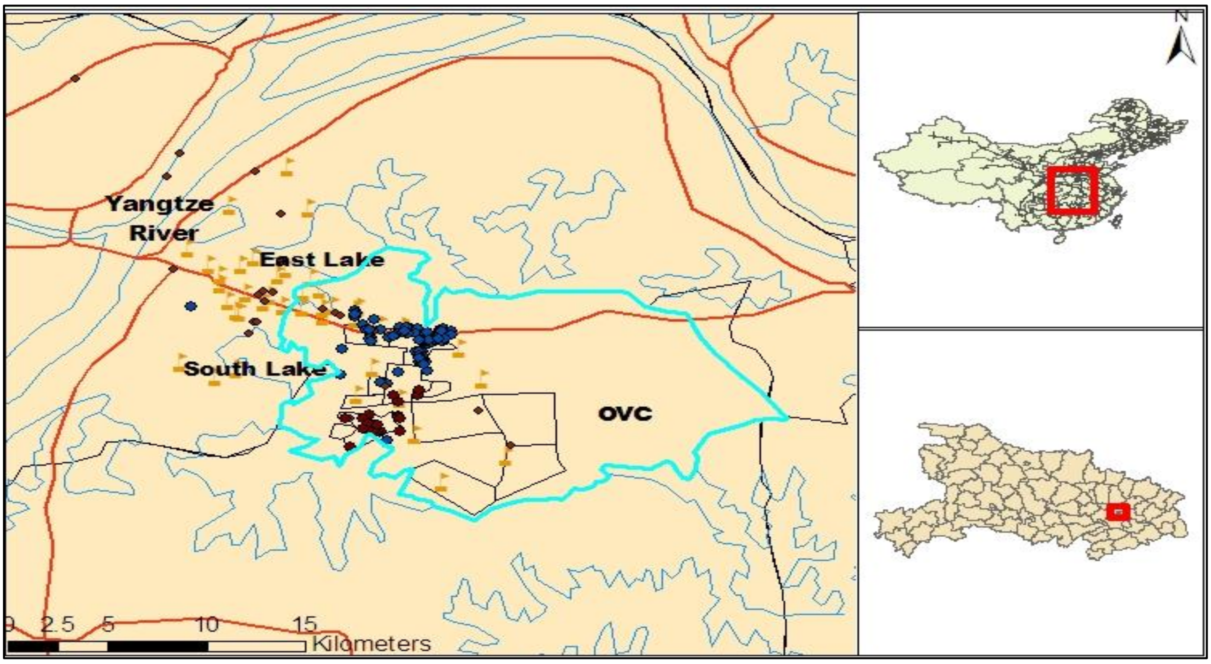


Figure 8-4 The geographical distribution of surveyed companies

Note: 1. Firms in the older cluster; Firms in the newer cluster; scattered firms; HEIs & RIs; OVC boundary; Main roads; Rivers & lakes

2. Source: the author

Figure 8-5 Wuhan Technology University science park and HUST University science park
Source: the author (2010)

Companies belonging to different geographical groups exhibited highly diversified patterns regarding their ages, sizes, and ownership types. For companies' age distributions (tab.8-4), it was found that the scattered companies were generally older, while companies agglomerated in the older cluster were dominated by young firms. However, given that this cluster grew up on the bases of the two oldest inside parks, the relatively young age of its companies is thus puzzling. One plausible interpretation would be that it took ten years for this cluster to start attracting companies, a phenomenon that has already been noticed by Castells and Hall (1994b). The newer cluster, on the other hand, was dominated by start-ups as expected, because this cluster benefited from OVC's very recent extension, and the UUSP only took shape since 2000. However, it is interesting to find that this newer cluster had more companies falling into the 10-25 aged category, which might be attributed to the first generation spin-offs from HEIs or RIs. These spin-offs used to locate on the campus, but they were encouraged to relocate onto the UUSP when its physical construction was finished (Lingyun & Ying 2003).

Table 8-4 Cross tabulation analysis of companies' geographical location and age

Geography		Age group				Total
		<4 years	4-9 years	10-25 years	26-50	
Scattered	Count	1	15	9	0	25
	% within scattered	4.0%	60.0%	36.0%	.0%	100.0%
430074	Count	19	49	15	2	85
	% within 430074	22.4%	57.6%	17.6%	2.4%	100.0%
430223	Count	11	9	8	0	28
	% within 430223	39.3%	32.1%	28.6%	.0%	100.0%
Total	Count	31	73	32	2	138
	% within location	22.5%	52.9%	23.2%	1.4%	100.0%

Note: 1. $\chi2$ = 14.695, d.f. = 6, significance level = 0.023, reject H0.

2. Source: the author

Regarding the relationships between companies' sizes and their geographical distributions (fig.8-6), It was found that for the scattered companies, a higher than the average percentage (36% compared with the average level of 26.1%) falling into the medium sized group, ranging between 51 and 300 employees. The older cluster, in comparison, had the highest percentage of companies in the small sized category, which might imply that SMEs value the urban facilities and the agglomeration economies the most. The younger cluster, on the other hand, had significantly more companies in the large-sized group (28.6%) with over 300 employees. This is a very puzzling finding if one takes into consideration its newer existence and the younger age of its companies. One speculation is that companies in this cluster might have a higher growth rate and thus higher demand for human resources than their peers in other two geographical groups. Another plausible reason might be that the few older companies in this cluster were significantly larger and thus disturbed the size distribution.

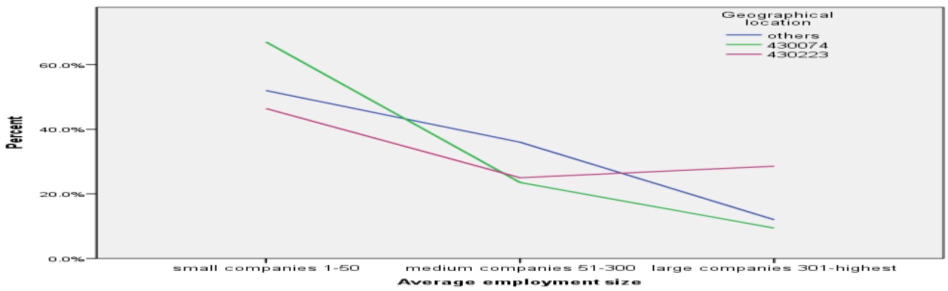


Figure 8-6 The percentage of companies in the three clusters with different size divisions
Source: the author

Regarding companies' geographical locations and their ownership, some interesting findings could be noticed by comparing the patterns shown in figure 8-7 below. First of all, there was a higher percentage (35.7%) of state/collective-controlled companies locating in the newer cluster as compared with the average level (23.9%), which might derive from their closer relation with the HEIs. Secondly, the foreign-invested companies tend to locate outside the officially established parks. Last but not least, the percentages of the private-controlled companies all went beyond 60 per cent in the three geographical groups, with the older cluster boasting the highest of 75.3 per cent. So it seems that the private sector in this region already started to grasp the market, technological, and institutional opportunities in the optoelectronic sector, although the state capital was still over-represented in OVC.

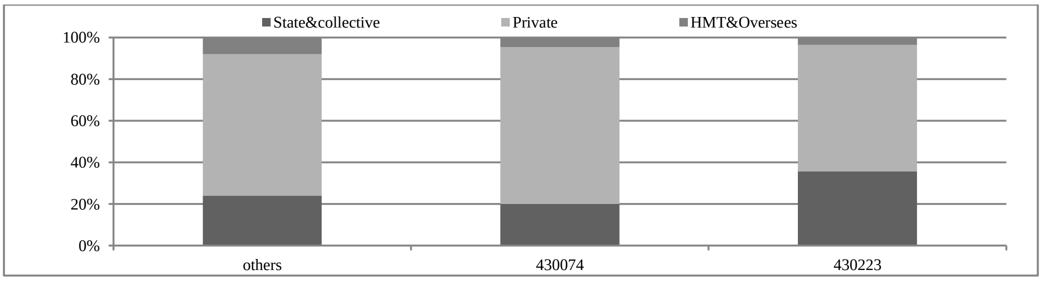


Figure 8-7 Percentage of companies in the three clusters falling into different ownership

Note: 1. $\chi 2$ = 3.414, d.f. = 4, significance level = 0.491, accept H0.

2. Source: the author

8.2 Technology characteristics of companies

One of the most widely used indexes for evaluating firms' innovation commitment is their R&D activities (Baysinger et al. 1991; Acs et al. 1994; Dixon & Seddi 1996). Although there are shortcomings related with the R & D indexes, especially when the company is just established (Agrawal 2001; Battaggion & Grieco 2007), or the innovation is processed through a learning-by-doing and/or learning-by-using manner (Arrow 1962; Malerba 1992; Lundvall & Johnson 1994), their wide availability and high comparability still make R & D input and output by far the most widely used indicators. Therefore this study also utilised these indexes to assess the innovation activities of the optoelectronic companies.

8.2.1 Sector coverage and main activities of companies

Database 2 had two questions asking companies to identify the technology code and the industrial sector they belonged to according to their main activities and products, which help to map companies' sector coverage. However, because companies would only choose the most applicable technological and industrial codes from the drop-down list, the survey results in database 2 were different from those obtained by Monck et al. (1988) and Westhead & Storey (1994), the latter of which allowed for multiple answers.

Regarding companies' industrial sectors, it is found that OVC had a wide coverage along the optoelectronic industry chain, ranging from the optoelectronic machinery, optoelectronic processing, electronics, communication, optoelectronic equipment, to consumer electronics, software, and R & D service. Nevertheless, the bulk (23.9%) of the surveyed companies were engaging in the ‘Optoelectronic devices and other electronic component manufacturing’ (code: 4059), whereas most of the other sectors were covered by less than five companies in the surveyed sample.

The main technology sectors engaged by the surveyed companies are summarised in table 8-5 below. One third of companies identified themselves in the technology area of ‘Optoelectronic components and products’ (code: 107), which reflected the strong position of OVC in the upstream of the industry chain in general. The second largest technology area was the ‘Other optical electromechanical integration technology’ (code: 407), which was mentioned by 21.7 per cent of the surveyed companies. This feature might derive from the increasing linkages between the optoelectronic industry in OVC and the traditional machinery industries in Wuhan and Hubei. The third largest technology sector identified by 15.2 per cent of the companies was the ‘Communications equipment’ (code: 109), which was to be expected because of the strong position of OVC in the optical communication sector in China. All in all, it could be argued that the manufacturing base of OVC was relatively strong in the optoelectronic sector, but its information technology was lagging behind its manufacturing activities, which might become a bottleneck for this industry’s future development.

Table 8-5 Technology sectors of surveyed companies

Technology code	Technology area	Frequent	Per cent
101	Computer	3	2.2
103	Information processing equipment	3	2.2
104	Computer networking products	2	1.4
105	Computer software products	10	7.2
106	Microelectronics, electronic components	15	10.9
107	Optoelectronic components and products	50	36.2
108	Radio and television equipment	1	.7
109	Communications equipment	21	15.2
110	Other electronic and information technology	3	2.2
407	Other optical electromechanical integration technology	30	21.7
Total		138	100.0

Source: the author

8.2.2 Economic activities of companies

As emphasized by Monck et al. (1988), the analysis on companies' technological characters should be made one step further to inquire their main economic activities on the premises. Therefore in the author's questionnaire, companies were asked whether they had any R & D activities on-site. Moreover, the changes of companies' activities between three time spans were covered in the survey, which were: 1) companies' current activities; 2) their activities when started operations in OVC and; 3) their expected activities in three to five years' time.

Table 8-6 below shows the economic activities of surveyed companies grouped by their geographical locations. In general, it can be seen that around ten per cent of companies had basic research, and around half of surveyed companies declared they had applied research and developmental activities. The majority of companies (over 80%) had manufacturing and sales on-site. Comparing the figures between companies in different locations, significant differences would be found between companies' research activities (rows one and two). Moreover, higher percentages of companies in the scattered group and in the newer cluster had basic and applied research when the survey was conducted. The companies in the older cluster, on the other hand, had higher than the average level engaging in product development and manufacturing/sales, which might be explained by the dominant 'learning-by-doing' nature of companies there.

Table 8-6 R & D activities of the surveyed companies disaggregated by location

Activity	All firms		Scattered		430074		430223	
	Current	Arrival	Current	Arrival	Current	Arrival	Current	Arrival
1. Basic research	15 (10.9)	16 (11.6)	5 (20)*	2 (8.0)**	5 (5.9)*	7 (8.2)**	5 (17.9)*	7 (25.0)**
2. Applied research	65 (47.1)	48 (34.8)	12 (48)	8 (32.0)	36 (42.4)	29 (34.1)	17 (60.7)	11 (39.3)
3. Product develop	81 (58.7)	52 (37.7)	14 (56)	6 (24.0)	51 (60.0)	33 (38.8)	16 (57.1)	13 (46.4)
4. Process develop	71 (51.4)	48 (34.8)	12 (48)	5 (20.0)	43 (50.6)	33 (38.8)	16 (57.1)	10 (35.7)
5.Manufacturing/sales	113 (81.9)	110 (79.9)	18 (72)	16(64.0)**	70 (82.4)	68 (80)**	25 (89.3)	26(92.9)**
Total firms	138	138	138	138	138	138	138	138

Note: 1. figures are numbers of mentions; figures in parentheses are percentages of responses in each column. Not all figures in parentheses sum to 100 because of rounding errors;

2. * significant difference on 90 per cent level; ** significant on 95 per cent level;

3. Source: the author

Regarding the changes of companies' R & D commitment, table 8-7 below shows that: 1) the scattered companies had increased both their R & D activities and the standard manufacturing/sales currently compared with when they just started businesses in OVC. However, their R & D activities were expected to shrink in the next three to five years' time, while the manufacturing/sales were expected to expand. 2) The companies in the older cluster showed an opposite trend against the former. While their basic and applied research decreased after they established in OVC, a higher percentage of companies had expected an increase in all R & D activities than the average level. 3) In the newer cluster, a decline in the basic research was found in both time spans, while the product development and the manufacturing/sales were expected to increase by the majority of companies.

Table 8-7 Changes in activities over time disaggregated by locations

Activity	Scattered		430074		430223	
	Current	In 3-5 years	Current	In 3-5 years	Current	In 3-5 years
1. Basic research	+	-	-	+	-	-
2. Applied research	+	-	-	+	+	-
3. Product develop	+	-	+	+	-	+
4. Process develop	+	-	-	+	+	-
5. Manufacturing & sales	+	+	+	-	-	+

Note: 1. 'Current' refers to changes between current activities and when arrival, and 'In 3-5 years' refers to expected changes of companies' activities in 3-5 years' time compared with now;

2. '+' means above-average increased activities in percentage
'-' means static or declined activities in percentage;

3. Source: the author.

The above trend very likely reflects the life cycles of the companies surveyed: companies in the scattered group were generally older, whose products were more standardised. Therefore increasing turnover and market share were their priorities. In contrast, companies in the older cluster were dominated by those aged four to nine, which were in their growth stage, and thus tended to focus more on improving their products in order to either compete with the established companies or occupy the niche market. R & D activities are therefore valued highly by these entrepreneurs. The bulk of companies in the newer cluster, in comparison, were less than four years old, so technological innovations are supposed to be their main competitive advantages.

However, the declining R & D activities showed in the last two columns contradicted with this common wisdom. This is explainable if one takes into consideration that most of the companies in this cluster were either university spin-offs or university-controlled, so they might already had high R & D inputs before communalizing them, or even directly inherited the intellectual properties from their parent institutes when they were established in OVC.

When looking at the relationship between companies' R & D activities and their ownership, a clearer pattern shows up (tab.8-8). Generally speaking, higher percentage of state/collective controlled companies and the foreign-invested ones were engaging in the R & D activities than the private ones. For the latter in particular, around a half declared that they had research activities and eighty-six per cent had development activities. What is more, only fifty-seven per cent of foreign-invested companies had manufacturing and sales on-site, which was much lower than the average level of eighty-two per cent in OVC.

Table 8-8 R & D activities of the surveyed companies disaggregated by ownership

Activity	All firms		State		Private		Overseas	
	Current	Arrival	Current	Arrival	Current	Arrival	Current	Arrival
1. Basic research	15 (10.9)	16 (11.6)	6 (18.2)**	7 (21.2)	6 (6.1)**	8 (8.2)	3 (42.9)**	1 (14.3)
2. Applied research	65 (47.1)	48 (34.8)	20 (60.6)*	15 (46)**	40 (40.8)*	27 (27.6)**	5 (71.4)*	6 (85.7)**
3. Product develop	81 (58.7)	52 (37.7)	21 (63.6)	14 (42.4)	54 (55.1)	33 (33.7)	6 (85.7)	5 (71.4)
4. Process develop	71 (51.4)	48 (34.8)	21 (64)**	14 (42.4)	44 (45)**	30 (30.6)	6 (85.7)**	4 (57.1)
5. Manufacturing & sale	113 (81.9)	110 (79.9)	27 (81.8)	26 (78.8)	82 (83.7)	80 (81.6)	4 (57.1)	4 (57.1)
Total firms	138	138	138	138	138	138	138	138

Note: 1. figures are numbers of mentions; figures in parentheses are percentages of total responses in each column;

2. Not all figures in parentheses sum to 100 because of rounding errors;

3. * Significant different on 90 per cent level; ** significant different on 95 per cent level;

4. Source: the author

Changes of companies' R & D activities grouped by their ownership were presented in table 8-9 below. It was found that the state/collective-controlled companies had increased all their activities since their establishment except for the basic research, which was expected to increase in the next three to five years. The private companies had reduced their basic research, which was expected to be continued. In contradiction, the foreign-invested companies showed a declined trend in product development and an increased trend in basic research, which might be interpreted as their transform from simply adapting products to China's market to relying more on the domestic R & D resources, although this trend was less noticeable in the previous qualitative analyses.

Table 8-9 Changes in activities over time disaggregated by ownership

Activity	State & collective		Private		Foreign-invested	
	Current	In 3-5 years	Current	In 3-5 years	Current	In 3-5 years
1. Basic research	-	+	-	-	+	+
2. Applied research	+	-	+	+	-	+
3. Product develop	+	-	+	+	-	-
4. Process develop	+	-	-	+	+	-
5. Manufacturing & sale	+	+	+	+	-	+

Note: 1. 'Current' refers to changes between current activities and when arrival, and 'In 3-5 years' refers to expected changes of companies' activities in 3-5 years' time compared with now;

2. '+' means above-average increased activities in percentage

'-' means static or declined activities in percentage;

3. Source: the author.

8.2.3 R & D input of companies

The R & D input of companies in OVC, measured by their R & D spending and R & D employment ratios at the end of 2009, shows a clear pattern of polarization between the surveyed companies (fig. 8-8). For example, the average R & D spending ratio of the surveyed companies was 21 per cent, but there was a high standard deviation of 0.93 among companies. The average R & D employment ratio of the surveyed companies was 18 per cent, with a moderate standard deviation of 0.28, which means companies' R & D employment ratio was less polarized compared with their R & D spending.

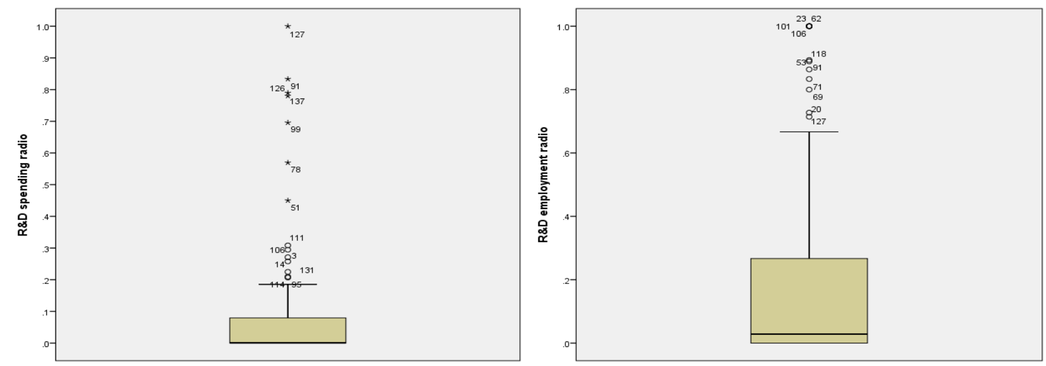


Figure 8-8 Boxplots of R & D spending and employment ratios of surveyed companies

Note: 1. Outliers with over 100 per cent ratio were disregarded;

2. Source: the author

A detailed breakdown of companies' R & D spending ratio is shown in table 8-10 below. On one end of the spectrum, it was found that almost half (49.6%) of the surveyed companies had no R & D spending, and 62.3% had a lower R & D spending ratio than the provincial average (2.5%). In comparison, a higher percentage of companies in the UK's science parks had invested on R & D. On the other end of the spectrum, it showed that 21.1% of the surveyed companies having an R & D spending ratio higher than 10%, and six companies in OVC even spent more on R & D than their annual revenue in 2009, which confirms the polarization of companies' R & D input. All in all, it seems that the R & D expenditure ratio of the surveyed companies had a very similar pattern to the 1992 survey conducted by Westhead and Storey (1994). Moreover, a general decline in R & D spending was found when comparing the high figures in Monck et al.'s (1988) study with Westhead and Storey's (1994) survey and the author's more recent study on OVC.

Table 8-10 R & D expenditure ratio of on-park companies

Science park		R & D expenditure as percentage of revenue								Total
		0	1-10	11-20	21-40	41-60	61-80	81-100	>100	
1.database1	No	66	39	8	7	2	3	2	6	133
	%	49.6	29.3	6.0	5.3	1.5	2.3	1.5	4.5	100.0
2.UK88[1]										
3.UK92[2]										

Note: 1. Data from Monck et al. (1988, p143);

2. Data from the 1992 new sample of Westhead & Storey (1994, p103)

The detail of companies' R & D employment ratio is presented in table 8-11 below. The bulk (49.3%) of the surveyed optoelectronic companies in OVC had no R & D employees at all, while the second highest percentage of R & D employment ratio was in the 21-40 per cent category. Again the results of this study were closer to the one conducted by Westhead and Storey (1994), both of which witnesses a shrinkage in companies' R & D employment scales compared with those found in Monck et al. (1988).

Table 8-11 R & D employment ratio of on-park companies

Science park		R & D employee as percentage of employment							
		0	1-10	11-20	21-40	41-60	61-80	81-100	Total
1.database1	No	68	15	12	21	8	4	10	138
	%	49.3	10.9	8.7	15.2	5.8	2.9	7.2	100.0
2.UK88[1]									
3.UK92[2]									

Note: 1. Data from the on-park companies survey in Monck et al. (1988, p143);

2. Data from 1992 new sample of on-park companies in Westhead & Storey (1994, p102)

8.2.4 R & D output of companies

Two indexes were used in this study as evaluators for companies' R & D output, which were: 1) companies' patent counts and 2) companies' new product counts. Patent count is one of the most widely used indicators for innovation achievement, although there are shortcomings associated with it. The situation might be even worse in OVC, if one recalls the comment from the CEO of Wuhan XX Laser, who pointed out the reluctance of the companies in this science park to apply for patents [interviewed on 9th July, 2010]. In order to account for the possible drawbacks of patent counts, companies were also asked to number the new products and/or new services they had ever brought to the market.

Within the 138 surveyed companies, 39 companies (28.3%) had been granted patents in previous years, and 44 companies (31.9%) had applied for patents in 2009. The relationship between companies' geographical locations and their total granted patents is presented in figure 8-9 below. Generally speaking, companies in the two clusters had better performance regarding their granted patents than the scattered ones: 80 per cent of scattered companies had no patents by now compared with 77.6 per cent in the older cluster and 46.4 per cent in the newer cluster. Companies in the newer cluster had a particularly outstanding performance here.

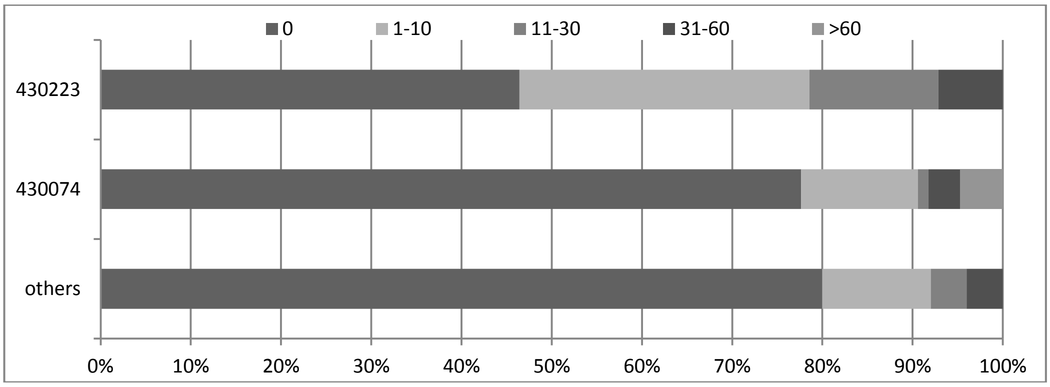


Figure 8-9 Total granted patents of the surveyed companies disaggregated by locations

Note: 1. $\chi^2 = 19.679$, d.f. = 8, significant level = 0.012, reject H_0.

2. Source: the author

Regarding the relationship between companies' ownership and their patent counts (fig. 8-10), it was found that the state/collective-controlled companies were by far the leaders in the number of granted patents. This finding is very interesting as it contradicts with many previous studies, which tend to find a lower efficiency of the state-controlled companies (see Xu & Wang 1997; Clarke & Du 1998; Wei et al. 2002). This contradiction might be explained on one hand by the specific industry sector chosen by this research; and on the other hand by the generally older age of the state/collective-controlled companies. The second interesting feature was the poor performance of the foreign-invested companies in OVC. This is against the previous findings on the high R & D commitment of foreign-invested companies. This paradox might result from the R & D orientations of these overseas controlled companies, i.e., mainly adopting standardized technologies to the Chinese market in their earlier activities (Cui 1998). On the other hand, this contradiction might also derive from the weak patent protection system in China, which may deter MNCs applying for patents in China (OECD 2008).

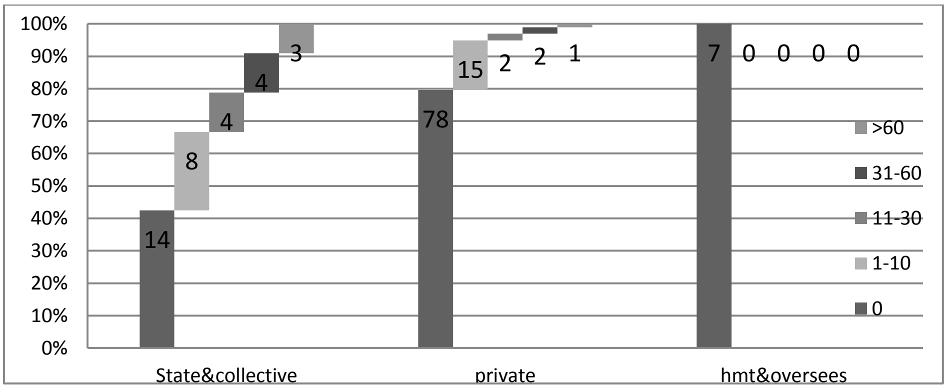


Figure 8-10 Total granted patents of the surveyed companies disaggregated by ownership

Note: 1. $\chi^2 = 25.928$, d.f. = 8, significant level = 0.001, reject H_0.

2. Source: the author

Cross tabulation was utilised to check the relationship between companies' R & D input and output (tab.8-12). A clear inverted-U shaped relationship shows up between these two variables. Regarding the efficiency of companies' R & D expenditure, it was found that a company spending one to ten per cent of its annual revenue on R & D had the highest possibility of obtaining at least one patent (65.8%). However, this possibility generally dropped as companies spending more on R & D. A similar trend was found between companies' R & D employment ratio and granted patents. Generally speaking, a company with no more than forty per cent of its human resources engaging in R & D was more likely to hold at least one patent, but the possibility declined quickly as companies' R & D personnel ratio went above this threshold.

Table 8-12 Relationship between companies' R & D input and output

Patents granted (>0)	R & D expenditure and employment ratio								Total
	0	1-10	11-20	21-40	41-60	61-80	81-100	>100	
R & D spending	5.3	65.8	10.5	7.9	2.6	2.6	0.0	5.3	100
R & D employment	5.1	23.1	20.5	28.2	12.8	2.6	7.7	0.0	100

Note: 1. Figures refer to the percentages of companies having at least one patent in previous years in each row, disaggregated by the R & D input levels;

2. Source: the author

The second index used to evaluate companies' R & D output was new product/service counts. Companies were asked to number their introduced products/services that were either new to their company or to the domestic market since they started business on OVC. On average, the number of introduced new products/services to the company was the highest of 8.35, while the number of introduced production lines that were new to the industry was the lowest of 0.76. Furthermore, no clear relation between companies' new product counts and their geographical locations could be observed (tab.8-13). But companies in the old cluster seemed to have better performance in introducing products/services that were new to the companies. This may again imply the 'learning-by-doing' and 'learning-by-using' innovation natures of the firms in this cluster.

Table 8-13 Relationship between companies' new product counts and their locations

Geography location		New products/services		New production lines	
		To the company	To the industry	To the company	To the industry
1. Scattered	No.	9	8	8	3
	%	37.5	32.0	33.3	12.0
2. 430074	No.	41	24	32	8
	%	52.6	30.8	41.0	10.3
3. 430223	No.	9	8	10	3
	%	36.0	32.0	40.0	12.0
Total	No.	59	40	50	14
	%	46.5	31.3	39.4	10.9

Note: 1. 'No.' refers to the number of companies had new product/services and production lines;

2. '%' refers to the percentage of companies having new product counts on each row;

3. Source: the author.

Significant relations, on the other hand, did show up between companies' new product counts and their ownership (tab. 8-14). In general, the state/collective controlled-companies were the best performers in launching new products/services and production lines, while the private companies had the worst performance in innovation counts. This is to be expected given that the private companies in OVC were generally not so keen on R & D activities, which has been shown by both the qualitative and the quantitative analyses. In comparison, the foreign-invested companies had done well in bringing new products/services and production lines to the whole industry. This in turn could be a benefit to OVC if companies here are interacting with each other on a frequent basis, which however, has not been highly noticeable in the foregoing qualitative study. The interactions between different innovation actors will be turned to again in the next chapter.

Table 8-14 Relationship between companies' new product counts and their ownership

Geography location		New products/services		New production lines	
		To the company	To the industry	To the company	To the industry
1. State & collective	No.	19	14	18	8
	%	61.3	45.2	58.1	25.8
2. Private	No.	38	23	31	5
	%	41.8	25.0	34.1	5.4
3. Overseas	No.	2	3	1	1
	%	40.0	60.0	20.0	20.0
Total	No.	59	40	50	14
	%	46.5	31.3	39.4	10.9

Note: 1. 'No.' refers to the number of companies had new product/services and production lines;

2. '%' refers to the percentage of companies having new product counts on each row;

3. Source: the author

The relationship between companies' R & D input and output, as represented by their new product/service counts, is presented by figures 8-11 and 8-12 below. In general, the results here have confirmed the foregoing analysis with patent counts as index (tab. 8-12). More specifically, both results showed that there is an inverted-U shaped relationship between companies' R & D input and output. The tentative conclusion here is that around ten per cent R & D spending ratio and around thirty per cent R & D personnel ratio seem to be the most productive levels in the case of OVC.

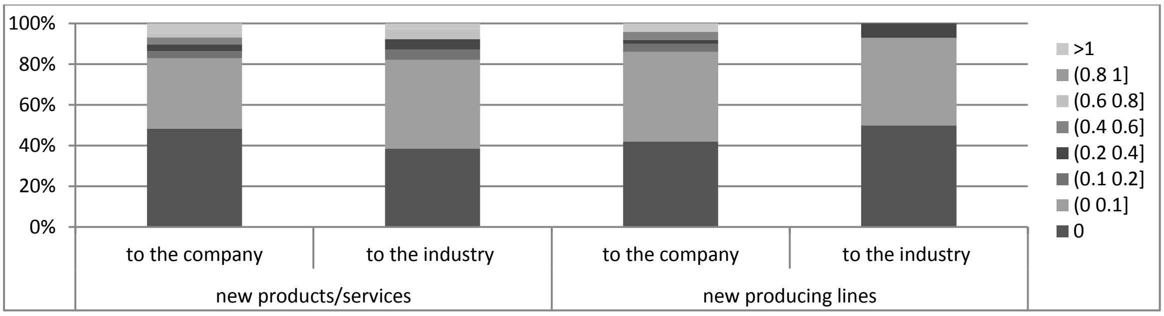


Figure 8-11 Firms with new product count disaggregated by their R & D spending ratio

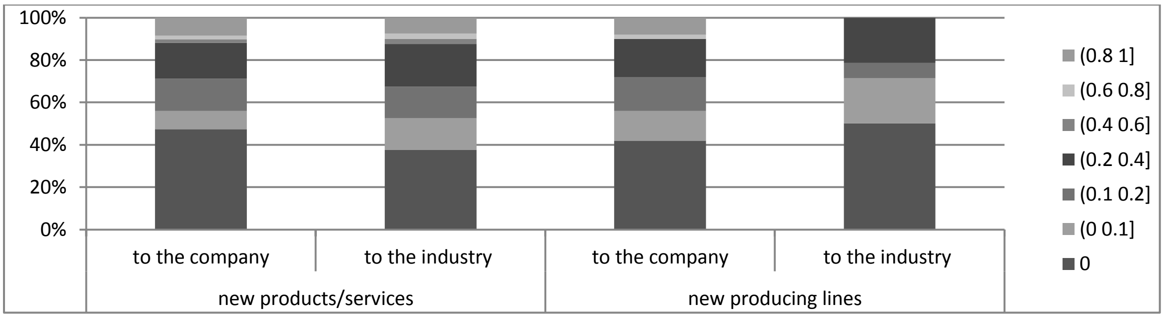


Figure 8-12 Firms with new product count disaggregated by their R & D employment ratio

Note: 1. Only companies with at least one new product count were included in the calculation;

2. Source: the author

8.3 General economic performance of companies

In order to analyse companies' general economic performance, three indexes from database 2 were chosen, which were: 1) companies' total revenues; 2) companies' industrial output values and; 3) sum of import and export values. Because these indexes are highly standard statistics that are collected by the National Statistics Bureau annually, it is possible to compare companies' performance in this research with the science parks' average levels. In what follows, a macro-level comparison between the various LISs, RISs, and NIS will be presented first. The result in turn will help to posit OVC against the RIS and NIS it is embedded in, as well as against other LISs. Then the analysis will concentrate on the companies' performance in OVC and try to identify some influential factors for their performance.

8.3.1 Performance comparison between different levels' innovation systems

It is argued in this study that the local, regional, and national level innovation systems are closely linked with each other. A multi-level interaction and two-way influential relationship between them are more realistic. On the other hand, the power struggles and the emergence of grassroots governance in China imply that different levels' innovation systems tend to have different levels of fitness and synergy, a phenomenon that has not been fully explored before. Therefore, this section will be devoted to uncovering the fitness of the different levels innovation systems in China.

The LIS in this analysis is represented by the fifty-four national-level science parks acknowledged by the Central Government by 2009. The province or municipality that hosts these science parks will be treated as approximate for the RIS, while the NIS will be analysed by the national average data. The fitness of different levels' innovation systems is going to be approximated by their industry productivities per employee, because the two indexes: 1) the average employees of enterprises, and 2) industrial output values, are among the few limited indexes that are available on all the three geographical levels. Moreover, the data on individual science parks need to be agglomerated on their regional level in order to simplify the comparison. Productivity comparisons between the NIS and RIS, and between LIS and RIS, are presented in figure 8-13 below.

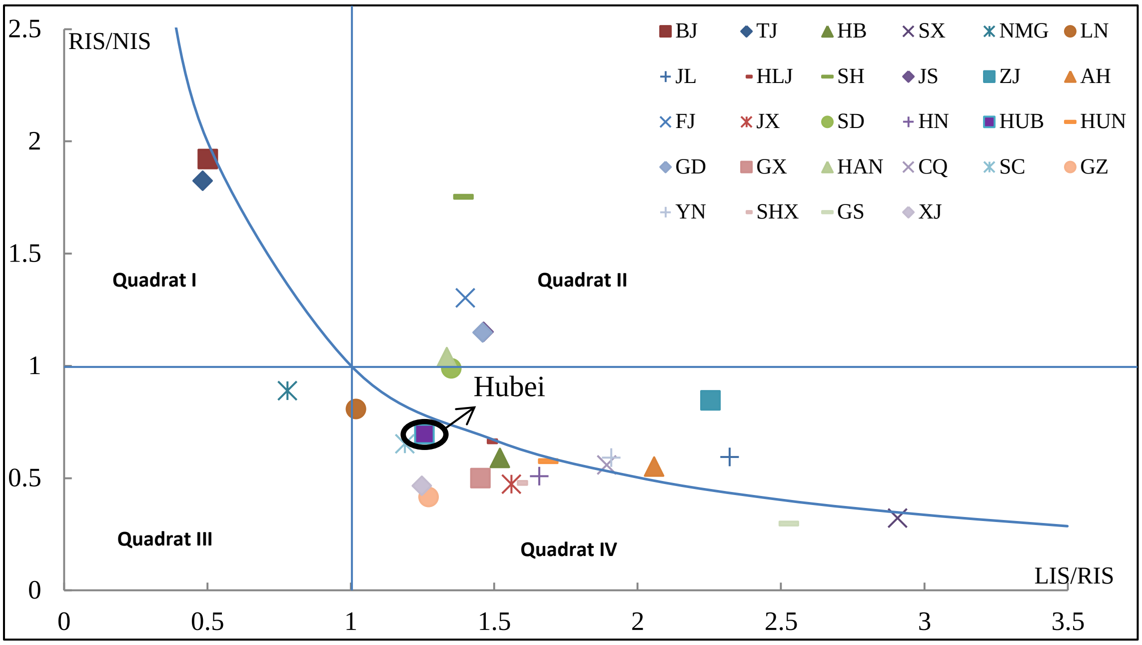


Figure 8-13 The relation between national, regional, and local innovation systems
Source: the author

Three reference lines were added in the figure: 1) the vertical line starting on the point of (1.0, 0.0) indicates the position where the LISs have the same productivity as their RIS. Any point falling on the left of this line means this LIS is less productive than its RIS, and verse via for a point falling on the right; 2) the horizontal line starting at the point of (0.0, 1.0) indicates the position where the RIS has the same productivity as the NIS. Any point falling above this line means the RIS is more productive than the NIS, and verse via for a point falling below this line; 3) the curve indicates the position where the LISs have the same productivity as the NIS. Any point falling on the upper right of this curve means the LISs are more productive than the NIS, and verse via for a point falling on the lower left of this curve.

Regarding the specific results presented in figure 8-13, it shows that: 1) Regions falling on the upper left corner (quadrant I) means the RIS is more efficient than both the NIS and its LISs. Beijing and Tianjin were in this group. 2) Regions falling in the upper right corner (quadrant II) have a more efficient RIS compared with the NIS, but their LISs, represented by their hosted science parks, are the best fitted systems. Shanghai, Fujian, Jiangsu, Guangdong, and Hainan were the five regions in this category. 3) Locating on the lower left side of the chart (quadrant III) means the NIS is the best fitted and the LISs are the worse fitted in rising innovation synergies. Only Inner Mongolia fell into this quadrat, which might reflect the growing powers of the local and regional innovation systems in China. 4) Falling in the lower right corner of this chart (quadrant IV), which most of the regions did, means their RIS functions worse than both the NIS and their LISs. In order to compare the efficiency between NIS and LISs in a region, the third reference line is needed. As it turns out, OVC in Hubei Province was still less productive than the NIS (fell under the curve), even though it had overtaken the region in systematic fitness.

A tentative conclusion from the above analysis is that, the science parks established in the vast lagging regions in China have already shown a positive sign of improving the efficiency of LISs out of their poorly functioned RISs. However, China's NIS still exerts the most influential effect on many less-favoured regions and their science parks. In the case of OVC, the preliminary speculation is that companies here generally perform better than the provincial average, thanks to their better fitted innovation environment. However, they may not be so outstanding compared with the national average level, especially with the ones located on the science parks in coastal regions.

8.3.2 The economic performance of surveyed companies

Against the fitness comparison between different levels' innovation systems, this section will concentrate on examining the surveyed companies' economic performance. What needs to be pointed out at the beginning is that the collected sample in this study was high-tech optoelectronic companies, and hence they might have above-average performance than the OVC average.

Table 8-15 below summarises the basic economic indexes of: 1) the surveyed companies, 2) OVC in average, 3) the national-level science parks in average, and 4) the acknowledged high-tech companies outside science parks. The last four columns show the average figures, and it would be found that in general, the economic performance of the companies in OVC indeed fell behind the national-level science parks on average; on the other hand, the surveyed optoelectronic companies in this study did have a better performance than OVC as well as the national-level science parks in all the five indexes. What stands out surprisingly was the superior achievement of the off-park high-tech enterprises in all the economic indexes. This might result from the different survey coverage between the on-park and off-park companies: for the former, statistics were calculated on the base of all the on-parks companies, whereas the latter only included the qualified high-high ones. Nevertheless, the significant differences in economic achievements between the on- and off-park companies in China still leads one to doubt the standards of accepting companies by these national-level science parks.

Table 8-15 Summary of companies' economic performance

Index (Million YMB)	Surveyed companies					OVC AVE[1]	SP AVE[2]	Off-park AVE[3]
	N	Min	Max	Medium	Mean			
1.Revenue	138	0.0	10241.9	9.28	216.00			
2.Industry product	138	0.0	9211.72	8.74	216.60			
3.Profit	138	-198.16	448.46	0.02	11.16			
4.Added value	138	0.0	1777.44	2.80	50.30			
5.Export (Million USD)	138	0.0	270.96	0.0	5.58			

Note: 1. OVC AVE: the averages of OVC companies in 2008, from MOST (2009a);

2. SP AVE: the averages of the 54 national science parks in 2008, data from STS (2011b);

3. Off-park AVE: the averages of all the entitled high-tech enterprises located outside the 54 national science parks in 2007, data from STS (2011b).

Table 8-16 below explores companies' performance according to their geographical locations. The average figures show that companies in the older cluster yielded the highest scores in all four indexes. However, it was also this group of companies that had the largest differences between its medium and average figures, which infers to the noticeable diversities of companies locating within this cluster. In comparison, the scattered companies had the worst economic performance in all three indexes. This might be read as another confirmation of the external economies existed in the two clusters, echoing the former findings in companies' R & D output.

Table 8-16 Summary of companies' performance in different locations

Geographical location	Economic performance (Million YMB)							
	Revenue		Industry output		High-tech product sales		New product sales	
	Medium	Mean	Medium	Mean	Medium	Mean	Medium	Mean
1. Scattered	11.27	92.13	8.93	73.46	0.0	34.07	0.0	21.92
2. 430074	4.67	286.25	3.39	287.34	0.0	238.28	0.0	57.80
3. 430223	30.22	113.33	34.56	129.65	0.0	68.00	0.50	43.75
Total	9.28	216.00	8.74	216.60	0.0	166.73	0.0	48.45

Note: 1. One-way ANOVA text showed the between-groups mean differences were not significant;

2. Source: the author

The relationship between companies' economic performance and their ownership is summarised in table 8-17. It is very clear that, on average, the state/collective controlled companies had taken a lead in all four economic indexes. This pattern was explainable given the higher R & D commitment of the state/collective controlled companies as discussed in the foregoing sections. The average performance of the private companies ranked the second, but their lowest medium figures means that there were significant divergences among the private companies regarding their economic performance. The foreign-invested companies showed the worst performance on average among the three groups, which was puzzling again if one recalls their higher involvement in R & D activities. On the other hand, the inferior economic performance of the foreign-invested companies finds its echoes in their R & D output as well as the previous qualitative analysis, which would result from the low efficiency or even reluctance of these companies to transfer their knowledge.

Table 8-17 Summary of companies' performance with different ownership

Ownership	Economic performance (Million YMB)							
	Revenue		Industry output		High-tech product sales		New product sales	
	Medium	Mean	Medium	Mean	Medium	Mean	Medium	Mean
1. State/collective	78.39	779.17	97.47	770.14	24.50	644.83	0.32	181.48
2. Private	3.87	40.15	2.81	44.07	0.0	17.34	0.0	6.90
3. Overseas	14.50	22.98	14.50	22.39	0.0	4.29	0.0	2.96
Total	9.28	216.00	8.74	216.60	0.0	166.73	0.0	48.45

Note: 1. One-way ANOVA text showed all four between-groups-mean differences were significant on 95 per cent level;

2. Source: the author

8.4 Summary

This chapter has focused on analysing the activities and performance of the surveyed optoelectronic companies locating on this science parks. First of all, it summarised the basic profiles of the companies covered in the survey, with companies' geographical locations and ownership as the two most important variables. Secondly, this chapter examined the R & D activities of companies. From company's self-identified R & D activities, it was found that around one third of the surveyed companies had research activities, over a half had developmental activities, and around eighty per cent had manufacturing functions. Regarding companies' R & D output, it was found that the companies in the two clusters had better performance than the scattered ones in the two indexes, so did the state/collective-controlled companies. The overseas-invested companies, on the other hand, did not stand out on their R & D output, although they tent to introduce more products/services and production lines that were innovations to the whole industry.

Thirdly, this chapter focused on the general economic performance of the surveyed companies. The relative position of OVC as a LIS against its RIS and NIS was illustrated first. Against this backdrop, it was found that the optoelectronic industry in OVC was relatively competitive judged by its companies' better performance. Moreover, the companies in the two clusters were more competitive than the scattered ones on various economic indexes, but the significant polarization within them was also noticeable. Furthermore, the state/collective-controlled companies took the lead again in economic performance, while the foreign-invested companies fell behind surprisingly. The low R & D output and economic performance of the foreign-invested companies echoes the previous qualitative analyses and led to the tentative conclusion that, while the potential contributions of the foreign-invested companies would be enormous in OVC, especially when it comes to upgrade the technology sophistication of the endogenous companies through knowledge diffusion and interaction, their actual performance is nevertheless not outstanding so far due to: 1) the strategic nature of the optoelectronic industry; 2) the small number of the foreign-invested companies in OVC; 3) their limited integration with the local economy and, 4) the poor protection on the intellectual property in China.

Chapter 9 Companies and their institutional environment

This chapter will build on the previous descriptive analyses by relying on a more rigorous statistical toolkit. The rest two dimensions of the conceptual model, namely the relationship between companies' entrepreneurship levels and their institutional environment, as well as the determinants of companies economic and innovation performance will be the focuses here.

9.1 Entrepreneurship level of companies in OVC

In the theoretical model, an established company's entrepreneurship is constructed on two capabilities: internal resource exploitation and external resource exploration. The former refers to maximizing the potential of its hardware, software, wetware, and orgware, while the latter stands for companies' capabilities in resource seeking, constantly learning, and flexibility to the changing market. The questionnaire used in the survey was designed to cover both dimensions, although it is admitted that a clear-cut distinction between these two capabilities is difficult. More specifically, companies were asked to rank the relative importance of nineteen entrepreneurship criteria on a five-scale division, ranging from 'not important at all' (scored as '0') to 'very important' (scored as '4'). These criteria were further grouped on three themes: 1) the reasons for setting up this entity; 2) self-identified comparative advantages and; 3) capabilities in resource mobilization. Theme one and two aimed at capturing companies' capability in grasping the external opportunities and resources. Theme three, on the other hand, tried to cover companies' capabilities in maximizing their internal resources. What is more, three characteristics of the entrepreneurs, namely the highest education level of the manager, his or her previous working experiences, and age were also collected in the survey, as it is well documented that the entrepreneurs or the entrepreneur team would significantly influence the company's strategic decisions (Alvarez & Busenitz 2001; Casson 2005). In what follows, the factors covered by each theme will be discussed in more detail.

Six factors were included under the theme 'reasons for setting up this company', which were: 1) the huge potential market demand; 2) reduced cost of production; 3) technology breakthrough; 4) favourable policy environment, 5) institutional adjustment, and 6) personal preference. Factors 1) and 2) evaluate the market conditions; factor 3) refers to the technology factor, while factors 4) to 6) take account of the institutional opportunities. Table 9-1 summarises the basic statistics of the six items from the company survey. As it shows, three out of the six listed factors had an average ranking above '2' – the threshold level – which means they are of some importance in triggering the establishment of the surveyed companies. The other three factors, on the other hand, were less important for the surveyed companies. Moreover, by comparing the means of the six items, it is obvious that the potential market demand was the single most important factor responsible for the establishment of the company (averagely ranked as 3.37). This factor was closely followed by the technology breakthrough (ranked as 2.86) and the favourable political environment (ranked as 2.60). This result on one hand shows that 'market pull' is crucial in stimulating the latent entrepreneurship. On the other hand, the similar importance and co-appearance of the market, technological, and the institutional opportunities sheds light on the importance of their complementarity for triggering entrepreneurial sparks, which has been illustrated in chapter two.

Table 9-1 Reasons for setting up the companies

Factors	N	MIN.	MAX.	MEAN	DEV.
1.Market demand	129	0	4	3.37	1.083
2.Reduced cost	128	0	4	1.76	1.429
3.Technology breakthrough	130	0	4	2.86	1.357
4.Favourable policy	130	0	4	2.60	1.417
5.Institutional adjustment	130	0	4	1.77	1.553
6.Personal preference	128	0	4	1.97	1.557
Summary item statistics	6	1.74	3.37	2.38	0.44
Cronbach's Alpha	0.64 (6)[5]				

Source: the author

Surprisingly, the factor of production cost was not so important for the surveyed companies (averagely ranked as 1.76). This might be derived from the high-tech nature of the optoelectronic industry, as the technology know-how is the most important input instead of the

[5] Cronbach's α (alpha) is commonly used as a measure of the internal consistency or reliability test. Although a minimum of 0.7 is required as a rule of thumb, the appropriate degree of reliability depends much on the case itself, especially in social studies (Cortina. J. M. (1993). What is coefficient alpha? An examination of theory and applications. *Journal of Applied Psychology*, 78, 98- 104)

traditional production factors. The factor of 'institutional adjustment' was defined in this survey as 'the negative by-products of China's reforming process, such as the abolishment of the permanent employment, and the large scale employment cut-down'. These negative factors are all widely-cited stimulators for triggering entrepreneurship, because they break the risk-rewarding balance of the latent entrepreneurs (Monck et al. 1988; Feldman et al. 2005). Against this common wisdom, however, these disruptive institutional adjustments were not proved to be the constructive 'push' factors as compared with the positive political environment in China. This comparison in turn confirms the value of China's incremental reform practice. The last factor, 'personal preference', was also ranked as less important by the surveyed companies, which reflects the general lack of entrepreneurial spirit in China as found in previous studies (Watkins-Mathys & Foster 2006).

Seven items were included to reflect companies' comparative advantages, which were: 1) accurate market assessment; 2) constantly improving quality and/or lowing price; 3) new products or services; 4) sufficient production and R&D capital; 5) sufficient human capital; 6) leading technology; and 7) flexible to the political environment. Items 1) to 3) mean to evaluate a company's market performance. Items 4) to 6), on the other hand, reflect a company's technology level. The last factor, factor 7), aims to obtain a sense of the companies' social capabilities. Table 9-2 below summarises the basic statistics.

Table 9-2 Companies' self-defined competitive advantages

Factors	N	MIN.	MAX.	MEAN	DEV.
1. Accurate market assessment	129	0	4	3.16	1.130
2. Improving quality, lowing price	129	0	4	3.08	1.190
3. new products or services	129	0	4	2.84	1.345
4. Sufficient producing and R&D capital	129	0	4	1.86	1.362
5. Sufficient human capital	129	0	4	2.18	1.422
6. leading technology	129	0	4	2.84	1.391
7. Flexible to the political environment	129	0	4	2.04	1.394
Summary item statistics	7	1.84	3.16	2.57	0.29
Cronbach's Alpha	0.79 (7)				

Source: the author

By observing the mean scores, it can be found that all items except one were ranked by the surveyed companies as their important competitive advantages. More specifically, factors 1) to 3) yielded the highest rankings by the surveyed companies. And because these three factors evaluate a company's market capabilities, their high scores might reflect the market-oriented competition strategy of the optoelectronic companies in OVC. The following three factors aim to capture a company's technology capability. As it turns out, although the surveyed companies did not think their internal R & D resources were sufficient enough to be ranked as a strong competitive advantage (1.86 for 'finance' and 2.18 for 'human resources'), they nevertheless were more confident about their technology standards (2.84 for 'leading technology'). The lack of R & D resources was confirmed by many surveyed companies. The CEO from one small optoelectronic company told the author that, it was very hard for them to borrow money from the bank because of their small size (Guoqiang 2010). What is puzzling here, however, is the imbalance between companies' weak R & D resources and their high technology sophistication (at least the surveyed companies thought they had). Given that the bulk of the surveyed companies were SMEs, this paradox could be explained by their 'learning-by-doing' style, which has been pointed out in previous chapters. Another plausible explanation was the prevalence of 'borrowed ideas', i.e., many surveyed companied did not have formal R & D activities in-house but depend on diffused knowledge from somewhere else. Therefore the crucial questions are how they borrow ideas and from where, which the author will get back to later. The social capability of established companies, grasped by their flexibility to the changing political environment, just managed to cross the threshold level of '2', which might be explained by the reduced importance of the governance environment once a company gets onto the business track. This inference was confirmed by several interviewees, who believed that the government should cultivate a stable environment for the companies to compete with each other, instead of intervening directly: 'The more hands-free, the better', as remarked by the CEO from XX Electronics [interviewed on 18th July, 2010].

The above two themes were tailored towards one side of a company's entrepreneurship, i.e., its external exploration capabilities, although the second theme has already touched on companies' internal exploitation capabilities. The remaining six factors, on the other hand, were indexes designed exclusively for evaluating an entrepreneur's ability to mobilize and maximize the company's internal potentials. More specifically, the interviewees were asked to rank the relative importance of: 1) providing on-site training to employees, 2) providing off-site training to employees, 3) communicating/knowledge sharing, 4) regular job rotating, 5) staff secondment with other companies, and 6) cultivating an innovation culture within their companies. Their average scores are summarised in table 9-3 below. It is very obvious that on-site training was the single factor that ranked as relatively important (above 3) by the surveyed companies. Moreover, sharing knowledge between employees and cultivating an innovative culture inside the companies were also acknowledged by the companies (ranked above 2). These informal knowledge diffusions within the companies thus shed light on how and where these SMEs get innovative ideas from. In comparison, the surveyed companies had put the least effort on more formal activities, such as purposely organised off-site training (ranked 1.17) and secondment with other companies (ranked 0.70). The capital constraint identified above could explain part of this. However, the fear of disclosing their core technologies might also discourage their interactions with other companies. Therefore, it seems that the optoelectronic companies in OVC were making an effort to mobilize their internal knowledge, but this was confined within their organisational boundary and under the acceptable financial threshold.

Table 9-3 Companies' internal entrepreneurial efforts

Factors	N	MIN.	MAX.	MEAN	DEV.
1. Importance of providing on-site training	129	0	4	3.26	1.099
2. Importance of providing off-site training	129	0	4	1.17	1.306
3. Importance of commutation/knowledge sharing	129	0	4	2.85	1.341
4. Importance of regular job rotating	129	0	4	1.20	1.313
5. Importance of staff secondment	129	0	4	0.70	1.170
6. Importance of innovation culture cultivating	130	0	4	2.62	1.517
Summary item statistics	6	0.70	3.26	1.96	1.14
Cronbach's Alpha	0.76 (6)				

Source: the author

All in all, based on the survey results, the tentative conclusion regarding the entrepreneurial characteristics of the optoelectronic companies in OVC can be summarised as: strong in seeking for market opportunities, but weak in leading technology advance; strong in noticing and coping with market changes, but weak at assembling R & D resources; strong in informal and internal knowledge circulating, but weak at formal and external learning and cooperation.

One of the main questions raised in the theoretical chapter is what the relation looks like between a company's internal resources and its entrepreneurship level. The author's tentative hypothesis has been that there might be an 'S-shaped' relation between these two factors. Moreover, it is assumed that a company needs a minimal level of internal resources to sustain its entrepreneurship, and also a minimal level of entrepreneurship to stir its willingness to exploit these resources. However, reducing the dimensions of the above nineteen indexes is necessary to obtain a clear pattern, which will be the focus of the next section.

9.2 Entrepreneurial indexes and influential factors

Exploratory factor analysis is a widely used method in social studies for identifying the underlining latent variables that structure the large amount and sometimes seemly unrelated variables. The basic idea behind factor analysis is that, factors representing the same dimension are likely to correlate with each other significantly, thus it avoids the danger of arbitrary weight allocation that used to relate with composite variable construction (Jae-on Kim & Mueller 1978; Basilevsky 1994). Fagerberg and Srholec (2008), for example, utilised the method of principal component analysis on 25 indicators of 115 countries collected between 1992 and 2004. After running the programme, they obtained four capability indexes that reflect different dimensions of a national innovation system. This in turn enabled them to compare the 115 countries through these four dimensions.

Principal component analysis is the default method in most of the statistical analysis software, such as SPSS and SAS. Anna and Osborne (2005), on the other hand, pointed out that the principal component analysis calculates components by using all the variances of the included variables, while factor analysis distinguishes between the shared variance of a variable and its unique and error variance, and therefore only the shared variances appear in the solution. Since the entrepreneurial indexes collected in the questionnaire already have a pre-designed relation structure by the author, it seems that factor analysis is preferable to principal component approach, although pretty similar results were obtained by these two methods. Therefore in what follows, only the result of factor analysis is reported.

The principal axis factoring method was chosen for the factor analysis here, because the strong relations between the nineteen entrepreneurship indexes violate the assumption of multivariate normality (Fabrigar et al. 1999). The scores assigned to the nineteen entrepreneurial indexes by the surveyed companies, as well as the three personal features of the entrepreneurs were included as indicators. Orthogonal rotation (varimax) was applied in order to ensure that the resulting factors were uncorrelated. In the preliminary analysis with all the pre-mentioned indexes in, the Kaiser-Meyer-Olkin (KMO) measure gained a result of 0.77 ('good' according to Field, 2009), which verified the total sampling adequacy for the analysis. Moreover, the KMO values for individual items were all above the threshold of 0.5 (Field, 2009), except for the three indicators of the entrepreneurs' characteristics. Moreover, the resulting community table (omitted here) indicates that the three personal features were badly represented by the principal components extracted (lower than 30%), and thus had very low factor allocations in the final extraction factor matrix.

By deleting these three variables, the total KMO increased to 0.80 and every individual factor's KMO also improved to over 0.60, well above the acceptable threshold of 0.5. An explorative test was run to obtain eigenvalues for each component. As it turned out, six components had eigenvalues over Kaiser's criterion of 1, but these component factors lacked clear meanings. By observing the scree plot (fig. 9-1), it is obvious that after the first three components, there comes the inflexion. Given the relatively smaller sample size (less than 250) and the lower average communality score, Kaiser's criterion may not be accurate. Therefore, only three components were retained in the final result, which in combination explained 40.0% of the variations. The factor scores for the retained three entrepreneurial indictors were estimated by the method of Bartlett Factor Scores, because this method provides an unbiased result (DiStefano et al. 2009).

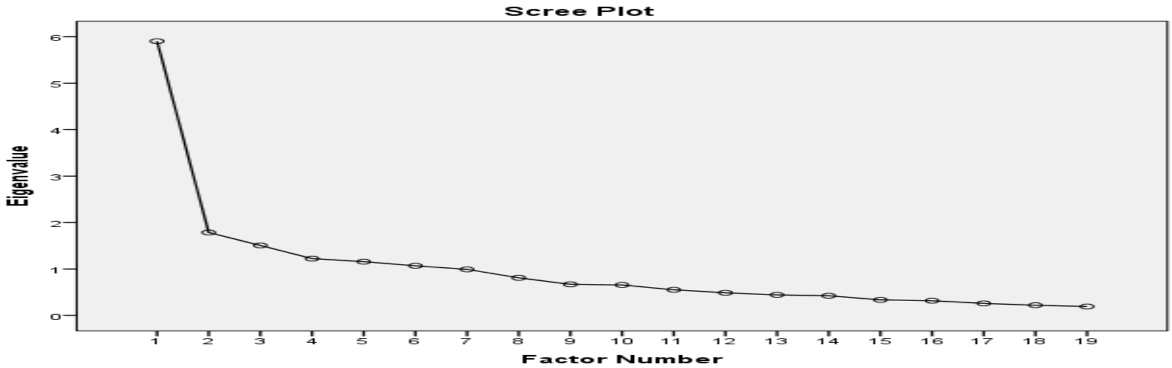


Figure 9-1 Scree plot of the eigenvalue in factor analysis

Source: the author

Table 9-4 below shows the factor loading after rotation. It was found that indexes such as human resources, R & D capital, and leading technologies were clustered together, which would be assigned a component name as the 'technological oriented entrepreneurship'. This bunch of indexes reflects not only companies' exploration for the cutting-edge technologies, but also their effort in boosting the innovative atmosphere inside the companies. Indexes such as market assessment and potential market demand were clustered together on the other hand, all of which reflect a company's market exploration capability. Therefore this component factor was named as 'market oriented entrepreneurship'. The last component kept in the final model mainly comprises of such indexes like system reform, personal preference, and staff training, which indicate the companies' reaction to the internal and external institutional environment. Therefore, the third component was titled as 'institutional oriented entrepreneurship'. All in all, the result of the principal component analysis shows that a company's entrepreneurship is by no means a single-dimensioned phenomenon. The external market, technological, and institutional opportunities require different skills of the companies to grasp. These skills, in turn, need to be cultivated and polished purposely, and ideally, balanced with each other. An entrepreneur not only needs to conceive the different opportunities, but also needs to identify what kind of capabilities he or she has, and what skills are still missing for the company. The three dimensions of a company's entrepreneurship thus can be seen as three pillars for sustaining its competitiveness, whichever is missing or weak would very likely lead to a low performance of the company.

Table 9-4 Factor analysis on companies' entrepreneurship

Factor	1.Technology	2.Market	3.Institutional
1 Sufficient human capital	0.848		
2 Sufficient production and R&D capital	0.700	0.324	
3 Leading technology	0.522		
4 Cultivating an innovation culture	0.488		
5 Potential market demand		0.371	
6 Mature technologies		0.325	
7 Favourable policies		0.549	
8 Accurate market assessment		0.403	
9 Flexible to the political environment	0.340	0.482	0.380
10 Improving quality, lowing price		0.496	0.312
11 New products or services		0.473	0.310
12 Communication/knowledge sharing	0.330	0.490	
13 Providing on-site training		0.376	
14 Lowing cost			0.539
15 System reform			0.526
16 Personal preference			0.491
17 Providing off-site training	0.421		0.624
18 Regular job rotating			0.605
19 Staff secondment	0.496		0.740

Note: 1. Three factors were retained which explain 40% of the total variance;

2. Extraction method: Principal Axis Factoring; Rotation method: Varimax with Kaiser Normalization; number of observations: 190; Factor coefficients below 0.3 were suppressed;

3. Source: the author.

A company's internal resources are also multi-faced. Following the distinction between firms' hardware, software, wetware, and orgware introduced by Romer (1991) and Lundvall (2006), the total capital of a company is adopted to represent its hardware and software; the total employment size of a company is chosen as the index for a company's wetware; while the number of employees with a higher than college degree is utilised as index for a company's orgware.

Table 9-5 summarises the correlations between the three entrepreneurial components and companies' internal resources. Against the original hypothesis, the correlation scores did not support the strong relations between company's entrepreneurship and their internal resources, except for the technological oriented entrepreneurship. More specifically, the technological oriented entrepreneurship of a company was related with its wetware (employment size) on the 99% significant level, and modestly correlated with its hardware, software (total capital), and orgware (skilled labour radio) on the 95% significant level. All the correlation scores also showed the expected positive direction. Figure 9-2 exhibits the relations between companies' technological oriented entrepreneurship and internal resources in more detail. It can be seen that the assumed positive relationship between these two variables are confirmed to some degree, except the pair between companies' technological oriented entrepreneurship and its orgware, where a U-shaped relationship is noticeable.

Table 9-5 Correlations between company's internal resources and entrepreneurship

	Employment	Total capital	Skilled labour	Institution	Technology	Market
Employment	1	.748**	.921**	-.038	.236**	.022
		(.000)	(.000)	(.667)	(.007)	(.806)
Total capital	.748**	1	.750**	-.031	.220*	.089
	(.000)		(.000)	(.730)	(.012)	(.318)
Skilled labour	.921**	.750**	1	-.006	.192*	-.002
	(.000)	(.000)		(.951)	(.031)	(.980)
Institution	-.038	-.031	-.006	1	-.091	-.042
	(.667)	(.730)	(.951)		(.305)	(.635)
Technology	.236**	.220*	.192*	-.091	1	-.068
	(.007)	(.012)	(.031)	(.305)		(.447)
Market	.022	.089	-.002	-.042	-.068	1
	(.806)	(.318)	(.980)	(.635)	(.447)	

Note: 1. Figures show the Pearson correlation scores and their significance in the parentheses.

2. ** Significant at the 0.01 level; * Significant at the 0.05 level (2-tailed).

3. Source: the author

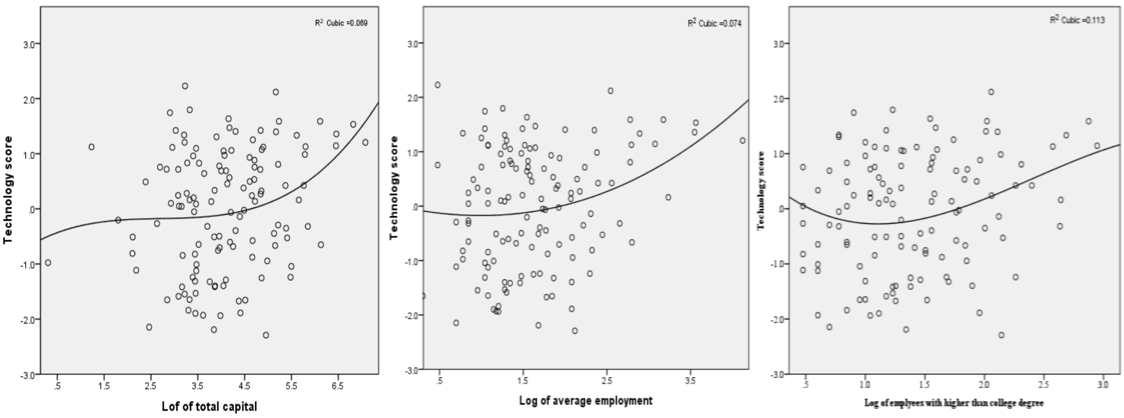


Figure 9-2 Scatter plots of firm's technological entrepreneurship and internal resources

Source: the author

In contrast, a company's institutional and market oriented entrepreneurship were not significantly correlated with its internal resources. What is more, the correlations between a company's institutional oriented entrepreneurship and its internal resources even showed negative signs, which echo the hypothesis discussed in chapter 2 on the negative relationship between companies' entrepreneurship and international resources. This could be partly explained by the growing bureaucracy of a company as it grows larger, which in turn hampers its entrepreneurship. For a company's market oriented entrepreneurship, it was found to be positively related to its hardware, software, and wetware. However, this dimension was negatively related with its orgware, which would possibly result from the more cautious attitude of highly educated employees when facing market uncertainties and risks. This in turn will reduce the efficiency in decision making, and possibly lead to the missing of a valuable market opportunity.

In summary, it is shown from the above discussion that, a company's entrepreneurship is not a mono-dimensional characteristic as it used to be treated. Accordingly, the relationships between companies' entrepreneurship levels and internal resources are not straightforward. Statistical analysis here shows that all three possible relationships between the above two factors raised in chapter 2 have found their justifications. However, only a company's technological oriented entrepreneurship significantly related with its internal resources. The reasons, on one hand, would be derived from the imperfect indicators for company's internal resources; on the other hand, a company's institutional environment might exert stronger influences on companies' entrepreneurship, which will be discussed in what follows.

9.3 Institutional opportunities and company's entrepreneurship

One of the main arguments in this study, which is also one of the main contributions, is that the institutional opportunities, besides the market and technological opportunities, have a reciprocal effect on companies' entrepreneurship and performance. This section will therefore take a closer look at these relations and is aiming to solve three questions: 1) how do the optoelectronic companies value their institutional environment? 2) What do the relations look like between the institutional opportunities and the company's entrepreneurship? And 3) are these relations robust statistically, and if so, to what level?

9.3.1 The institutional environment in companies' view

Regarding the interactions between the knowledge institutes and the private enterprises, limited formal and long-term cooperation would be identified throughout the history of OVC, a problem that has been noted several times in previous chapters. This thin interaction largely remains today, as pointed out by all the SMEs interviewed. In the questionnaire, the surveyed companies were asked to rank the relative importance of different actors in leveraging their innovation capabilities on a five-scale division (tab. 9-6). It can be seen clearly that the customers' needs were by far the most important stimulators for companies' innovation activities. This observation was confirmed by the CEO from XX Laser, who reflected that the feedbacks from their customers were the sole source directing their innovations [interviewed on 9th July, 2010]. Companies' competitors and suppliers were also ranked above the threshold level of '2'. The inference is twofold here: on one hand, the surveyed optoelectronic companies in OVC tent to closely monitor their peer companies in order to keep themselves up-dated; on the other hand, the 'learning-by-using' model, which represents the knowledge diffusion along the industry chain, was prevalent in OVC as well. In comparison, the importance of the local HEIs were ranked as 'just-so-so', and the public institutions were ranked as 'less important' on average. The weakness of the local private service sector was confirmed by the survey, which echoes the previous findings presented in chapters five to seven.

Table 9-6 Importance of different actors for companies' innovation capabilities

Actors	Value Number	Mean value
Customers	129	**3.61** - relatively to highly important
Competitors	129	**2.65** - normal to relatively important
Suppliers	128	**2.47** - normal to relatively important
HEIs	129	2.02 - normal
Public Organization/RIs	128	1.65 - less important to normal
Private Service sectors	128	1.27 - less important

Note: 1. 0-Not important at all, 1-Less important; 2-just so-so, 3-with some importance, and 4-very important;

2. Source: the author

The author also took one step further to explore the format, frequency, and importance of the different interactions between companies and the local HEIs. Figure 9-3 shows the results.

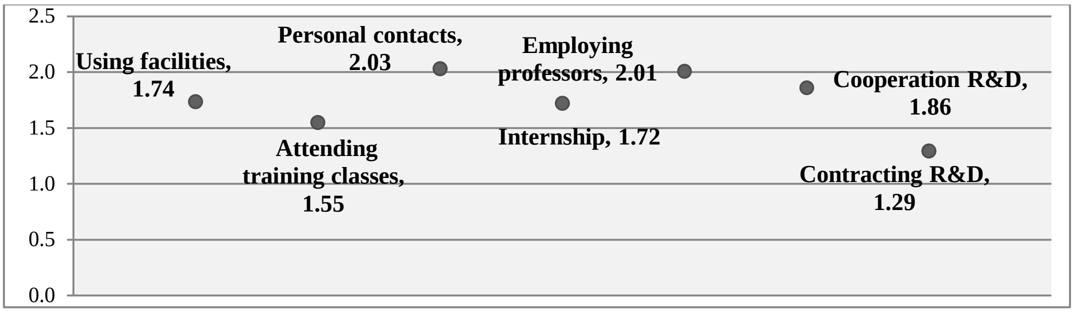


Figure 9-3 Importance of different interaction formats with the local HEIs

Note: 1. 0-Not important at all, 1-Less important; 2-just so-so, 3-with some importance, and 4-very important;

2. Value answers for 'Personal contacts' were 130; for all the others were 129;

3. Source: the author.

The foremost feature to notice in figure 9-3 is that all the interaction channels with the local HEIs were ranked relatively low by the surveyed companies. However, slightly higher weights were allocated to the informal interactions, such as the personal contacts (2.03) and employing part-time staff (2.01). Given that many first generation optoelectronic companies were spin-offs from the local HEIs, the result here is to be expected. Formal R & D cooperation and contracting research were less important for companies (lower than 2), so did the facility sharing and attending public training courses. The findings in this study are largely in the same vein as those from Vedovello's (1997; 2000). In the latter's studies, the informal interactions between the private sector and the knowledge institutions were also the most important format of networking. The difference, on the other hand, mainly lies in the importance of these interactions in general.

The above results show that a close partnership and trust relationship are far from established between the optoelectronic companies and the knowledge institutes in OVC, which reinforces the conclusion in the foregoing qualitative analyses. So it is tentative to say that the local authorities of OVC, at least till the current stage, are the most important glue sustaining the entire institutional structure. In order to check this speculation, companies were asked to evaluate the supportiveness of the governments on different layers, and the results are presented in table 9-7.

Table 9-7 Supportiveness of the governments on different layers

Ranking	**OVC**		**Hubei**		**China**	
	No.	%	No.	%	No.	%
0 – Not supportive at all	5	3.9	11	8.5	9	7.0
1 – Less supportive	27	20.9	15	11.6	14	10.9
2 – Just so-so	52	40.3	27	20.9	19	14.7
3 – relatively supportive	29	22.5	45	34.9	50	38.8
4 – Very supportive	16	12.4	31	24.0	37	28.7
Total	129	100.0	129	100.0	129	100.0

Source: the author

As it turns out, 45 companies (34.9%) agreed that 'the Management Committee of OVC is highly efficient and flexible' (sum of ranking above 2); while 76 (58.9%) agreed that 'the Hubei government is very supportive in innovation'. The consent percentage increased to 67.5 per cent (87 companies) with the Central Government's supportiveness on innovation. So it seems that the surveyed companies were more satisfied with the efforts of the higher level governments on promoting innovations, which is interesting yet puzzling, since the on-site Management Committee is gaining responsibilities now for the all-round development of OVC, and it is very keen on fostering the growth of this innovation system. Three plausible explanations could be offered here: First, the heavy government intervention may not be perceived positively by the private sector. Secondly, the local companies were so used to the incubating environment cultivated by the government that they tended to have an even higher expectation. Thirdly, the biased treatment of the institutional actors towards the big companies and the SEMs might have irritated the latter. On the other hand, the 'transforming pains' of the local institutional environment might shed light on this regard as well. As described by the Sales Manager of XX Laser, the various high-tech zones in the coastal region represent the complete format of reformation, which resemble the cooperative science parks on many standards. The ones in West China have just started reform and therefore most of China's socialism characteristics persist there. The Central China's institutional atmosphere is somewhere between these two: there are increasing liberalities learnt from the west, which however rub up against the persisting bureaucracy culture [interviewed on 28th July, 2010]. What this struggle leads to, as it is obvious here, could either be a blessing or a bottleneck for this innovation system's future development.

A more direct question regarding the competitiveness of the NIS, RIS, and LIS was included in the survey (tab. 9-8). For the LIS, the surveyed companies marginally agreed that 'there are many cooperation opportunities locally' (average scored 2.12), and that 'OVC has reached a leading position in China currently' (average scored 2.28). However, OVC's weak international linkage was widely acknowledged by the surveyed companies. Regarding the RIS, the relatively lagging situation of Hubei province in China was confirmed from the survey, as companies were reluctant to agree on the statement that 'Hubei holds a leading investment environment in China'. What is more, the support that Hubei gained from the NIS was only marginally acknowledged by the local companies, although Beijing has declared its intention on 'Central China uprising' since 2008. The common feeling was that the actual benefits obtained by Hubei and OVC were far less than what the Central Government had promised, or in the words of the R & D Director from XX Optics, was 'big thunder but tiny rain' [interviewed on 30th June, 2010].

Table 9-8 Agreement of companies on the situations of different layers' innovation systems

Statements	**No.**	**Mean score**
LIS of OVC: many cooperation opportunities	129	2.12
LIS of OVC: leading position in China	129	2.28
LIS of OVC: tapping into the global chain & gaining on importance	129	1.95
RIS of Hubei: leading investment environment in China	129	1.72
NIS of China: increasing preferential policies to Hubei	129	2.05

Note: 1. 0-Not agree at all, 1-Less agree; 2-just so-so, 3-agree a little bit, and 4-totally agree;
2. Source: the author

9.3.2 Institutional opportunities and company's entrepreneurship levels

Because it is plausible to say that a company will rank its institutional environment according to its perception of the available institutional opportunities, these rankings could thus be used as indexes for the abstractive term of 'institutional opportunity'. This approximation will in turn enable the statistical analysis on the relations between institutional opportunities and the company's entrepreneurship level, which is the focus of this section.

In the questionnaire, there were several questions designed to obtain companies' opinions towards their institutional environment and opportunities, therefore the first task here is to organise these estimates in a way that a coherent and well-covered indexes for institutions could be established. Based on the methodology review in chapter two, the actor-centred approach was experienced here. More specifically, the seventeen indexes on institutional opportunities were firstly grouped according to whether they were related with: 1) HEIs and RIs, 2) governments, and 3) institutional environment in general. Moreover, Cronbach's Alpha tests were used to check the internal coherence of the three sub-groups, and the result shown that all three classifications passed the acceptable threshold of 0.6. Secondly, the mean scores were calculated for each group to represent the average rankings for the three actors. In the last step, Pearson's correlation analyses were relied on to check the relations between these average scores and the three entrepreneurship components obtained from the above factor analysis.

Table 9-9 Correlations between companies' entrepreneurship and institutional opportunities

	Institution score	Technology score	Market score	Government ranking	institution environment	HEIs ranking
Institution score	1	-.091	-.042	.254**	.400**	.206**
		(.152)	(.318)	(.002)	(.000)	(.010)
Technology score	-.091	1	-.068	.484**	.347**	.474**
	(.152)		(.224)	(.000)	(.000)	(.000)
Market score	-.042	-.068	1	.277**	.302**	.108
	(.318)	(.224)		(.001)	(.000)	(.112)
Government	.254**	.484**	.277**	1	.755**	.478**
	(.002)	(.000)	(.001)		(.000)	(.000)
Institution environment	.400**	.347**	.302**	.755**	1	.393**
	(.000)	(.000)	(.000)	(.000)		(.000)
HEIS	.206**	.474**	.108	.478**	.393**	1
	(.010)	(.000)	(.112)	(.000)	(.000)	

Note: 1. Figures show the Pearson correlation scores and their significance in the parentheses.
2. ** Significant at the 0.01 level; * Significant at the 0.05 level (1-tailed).
3. Source: the author

Table 9-9 summarises the results. As it turns out, the three institutional opportunity indicators were all positively and significantly related to companies' entrepreneurship components, except for the pair between companies' market oriented entrepreneurship and their average ranking for the local HEIs and RIs. This result in turn confirms the linkage between industry and research in OVC was incomplete and fragile.

Compared with the weak correlations found in last section between the companies' entrepreneurship components and their internal resources (Quadrant I), the above results on companies' entrepreneurship and institutional opportunities (Quadrant IV) are very encouraging. It seems that a company's awareness of the available institutional opportunities could spark its market, institutional, as well as technological oriented entrepreneurship. This in turn provides preliminary confirmation of the earlier hypothesis that the external institutional environment has a stronger influence on companies' entrepreneurship level. In order to further explore the relations between the institutional opportunities and the companies' entrepreneurship components, scatter plots of the average ranking for institutional environment and companies' entrepreneurship components are shown in figure 9-4 below.

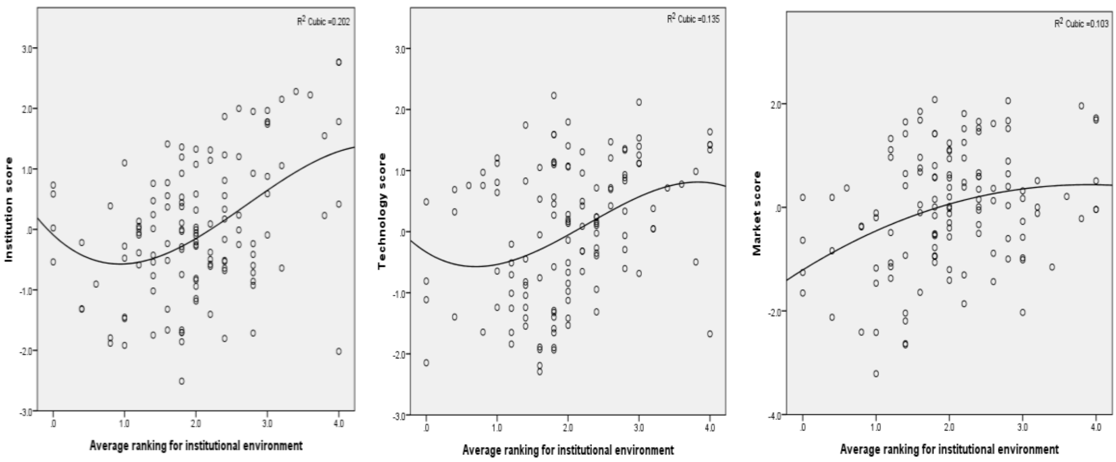


Figure 9-4 Institutional environment ranking and companies' entrepreneurship components
Source: the author

In a sketch, the relationship between companies' institutional environment and their entrepreneurship components resembles a 'U-shaped' curve, except their market-orientated entrepreneurship. A closer observation reveals that when the institutional environment was evaluated as somewhere between 'less supportive' and 'just so-so' by the companies (scored between 1 and 2), one unit improvement in institutional environment would yield an increasing return on companies' entrepreneurship level. When the institutional environment was ranked as 'supportive' (scored above 2), the same unit improvement in the institutional environment, on the other hand, would only get a declining return in companies' entrepreneurship, which resembles the classic 'diminishing marginal effect' in the economic analysis. This pattern is very puzzling, because it is expected theoretically that the entrepreneurship of a company will continuously increase when more opportunities are available (Radosevic 2007). Two tentative explanations would be offered here: the first one is inspired by the classical economic explanation on diminishing returns, which will not be elaborated here. The second explanation, on the other hand, is derived from the reality: OVC, as the political focus of the governments from different levels, must be the foci of various kinds of incentives as well. These preferential policies and incentives, on one hand, are opportunities for the local companies, but their large number and possible inconsistence would also add to companies' searching and filtering costs, especially when these opportunities are scattered, unrelated, and even contradicting with each other. As a result, a company might revert back to its 'comfort zone' comprised of its familiar and/or easily accessible opportunities, and rarely search for new ones. This situation is most vividly described by the Secretary from the Tsinghua University Science Park:

> 'We now provide special training courses focusing on policies. As you know, Z-Park is the first National Self-innovation Model Zone in China, and therefore there are thousands of newly-added policies every year targeting on this zone. However, it could also become very tricky and time-consuming for a company to decide which one suits its special conditions. In order to deal with this situation, we now have a specialized team, focusing solely on collecting, classifying, and up-dating these policies. Moreover, we organise regular forums to explain these policies, and help companies to apply for the proper ones to meet their needs, such as seeking financial support. Now this service is highly valued and demanded by our tenants' [interviewed on 19th August, 2010].

Based on these observations, the conclusion here is that the institutional opportunities, especially the purposely cultivated ones by the public agencies, would be more efficient in leveraging the companies' entrepreneurship if they are well organised, easily accessible, and compatible with each other.

9.4 Explanatory factors for companies' performance

By now, the four quadrants of the conceptual model have been fully discussed one-by-one: Chapters five to seven reviewed the development history of OVC, which meant to outline the power struggles in the institutional environment (Quadrant III), as well as the relationship between the private sector and other innovation actors (Quadrant II). Moreover, the reactions of the private sector to the various opportunities created intentionally or unintentionally by the power redistributions also received due attention in these chapters (Quadrant IV). Against these documentary analyses, chapter eight explicitly examined the internal resources of the companies, their innovation capabilities and performance (Quadrant I). This chapter follows on the previous one and quantitatively tested the influences of companies' internal resources (Quadrant I) and institutional opportunities (Quadrant IV) on their entrepreneurship. This section will build on the foregoing discussions and examine the influences of: 1) companies' entrepreneurship components, 2) internal resources, and 3) external resources and opportunities on their performance.

Confined by data availability, the annual productivity of the companies will be used as the dependent variable for companies' general economic performance, and whether a company had new product sales or not in 2009 was chosen as indicator for its innovation capability. Because the first indictor is a continuous variable and the second one is a binary variable, two models based on the ordinary least square (OLS) regression and the binary logistic regression are utilised here. The explanatory variables include: 1) the companies' entrepreneurship components, 2) the companies' internal resources, 3) the external economies and opportunities[6] and, 4) company's characteristic variables, i.e., age (continuous various), location (dummy variable), and ownership (dummy variable).

The comprehensive model to be estimated takes the following format:

[6] The two variables of external economies and the institutional opportunities were condensed here because they are supposed to influence the companies' performances indirectly through the companies' internal resources and their entrepreneurship. Controlling the number of the variables included could reduce the potential problem of multicollinearity.

$$\text{Productivity/Innovation capability} = \alpha_0 + \alpha_1\text{Age} + \alpha_2\text{Location} + \alpha_3\text{Ownerhsip} + \alpha_4\text{Entrepreneurship} + \alpha_5\text{Internal resources} + \alpha_6\text{External economies \& Opportunities} + e$$

Where: Productivity is the annual industry revenue per employee, and innovation capability is whether or not the company had new product sales at the end of 2009. Age is the integral number of years since companies' establishment in OVC. It is of potential importance because companies' knowledge and resources tend to increase as it is growing older. Location is represented by dummy variables indicating the scattered companies, companies in the older cluster, and in the newer cluster, which have been classified in chapter 8 based on companies' postcode. It is admitted here that no comparable data with off-park companies were available in this case study. Nevertheless, comparing the performance between 1) companies in and out of a cluster, and 2) companies in the older and newer cluster is still useful in term of evaluating the effect of geographical proximity. Companies' ownership is also evaluated by dummy variables referring to state & collective, private, and foreign controlled. Entrepreneurship components are the three factors extracted in the factor analysis, which represent companies' institutional, technological, and market oriented entrepreneurship (min: -4; max: 3). Companies' internal resources will be represented by their total asset, employment size, and high-quality employee in common logarithm term, which are continuous data collected for 2009. The composite indicators for the governments, HEIs, and the general institutional environment (IE) are chosen as measures for companies' external resources and institutional opportunities (min: 0; max: 4); and e is the error term.

So the extended format of the regression model is:

$$\text{Productivity/Innovation capability} = \beta_0 + \beta_1\text{Age} + \beta_2\text{Location} + \beta_3\text{Ownerhsip} + \beta_4\text{Institutional entrepreneurship} + \beta_5\text{Technologcial entrepreneurship} + \beta_6\text{Market entrepreneurship} + \beta_7\text{Asset} + \beta_8\text{Employment} + \beta_9\text{ High-quality employee} + \beta_{10}\text{Government} + \beta_{11}\text{HEIs} + \beta_{12}\text{IE} + e$$

The OLS regression model is evaluated first. Using the model of OLS might suffer from two potential problems: the first one is endogeneity, which refers to the loop of causality between the independent and dependent variables. In order to test the presence of endogeneity, the two-stage Least Square Model analysis was used by introducing instrumental variables for the entrepreneurship components, whose results in turn were checked against the Durbin--Wu--Hausman test (Ben 2008). Overall, it was found that endogeneity was not a problem in this analysis. The second potential problem relates to the collinearity between the independent variables (Ender et al. 2003). In order to check whether it exists or not, the collinearity diagnostics test provided by SPSS is employed, which displays the 'tolerance' and the variance inflation factor (VIF) values for each predictor. A less than 0.10 value of tolerance may deserve further investigation. In this study, the tolerances found in the estimates ranged from 0.16 to 0.98, meaning that no serious multicollinearity occurred, and thus the OLS regression is appropriate here.

Table 9-10 below shows the regression results on companies' productivity. The four groups of independent variables were entered into the model sequentially, and the significance of the model's overall fitness change (F-value change) was used as the criterion for whether to keep the variable in the next step or not.

Regarding the characteristic variables, it was found that the companies' ownership had a significant influence on the model's overall fitness, thus it was kept in. Regarding the influence of companies' geographical location, the negative sign of the older cluster means that the companies agglomerated in the older cluster had worse economic performance compared with the scattered companies on average. In comparison, the companies located in the newer cluster had better performance on average compared with the scattered ones, as showed by its positive coefficient. However, the dummy variables of companies' geographical locations did not significantly contribute to the model's overall fitness.

Table 9-10 OLS regression analysis on companies' economic performance

	Characteristic variables			Entrepreneurship			Internal resources			External economies			Final
A. Characteristic variables													
1.Location[2]													
Older cluster	-.198	-.178	-.181										
Newer cluster	.087	.028	.024										
2.Ownership[3]													
State & collective		.436	.439	.409	.405	.460	.395	.170	.178	.187	.188	.176	.178
Private		-.004	-.003	-.029	-.024	-.023	.111	.149	.131	.129	.130	.119	.131
3.Age			-.021										
B. Entrepreneurship													
4.Institutional				.003	.003	.010							
5.Technological					.010	.013							
6.Market						.133**	.129**	.067	.081**	.083*	.083*	.081*	.081**
C. Internal resources													
7.HQ Employee[4]							.223*	-.327**	.418**	.418**	.416**	.437**	.418**
8.Assets								.535***	.626***	.623***	.623***	.606***	.626***
9.Employment									-	-.963***	-	-	-
D. External economies													
10.Government										.010	.004	.035	
11.IE											.008	.008	
12.HEIs												-.044	
R-square	.029	.100	.100	.067	.067	.112	.144	.431	.564	.565	.565	.568	.564
F change	1.972	5.03**	.012	.002	.024	6.01**	3.76*	58.6***	35.2***	.030	.010	.798	
N	138	138	138	128	128	128	126	126	126	125	125	125	125

Note: 1. * p<0.10, ** p<0.05, *** p<0.00;

2. Category variable with the scatter companies as reference;

3. Category variable with the overseas controlled companies as reference;

4. Refers to the high-quality employee with at least a college degree;

5. Source: the author.

Step two added in companies' entrepreneurship, and it is found that companies' market oriented entrepreneurship had a significant coefficient and its presence also significantly improved the model's overall goodness of fit. Nevertheless, it seems that all the entrepreneurship components are positively related with companies' economic performance.

In step three, the variables of companies' internal resources were added in, which increased the model's overall goodness of fit (R-square) significantly from 0.11 to 0.56. What is more, all three indexes had significant coefficients at the 95% level. However, what went against the conventional wisdom was the negative coefficient of companies' total employment. This might derive from the declining efficiency of companies as they grow larger. The external factors were added in the model in the last step, but all three variables did not improve the R-square significantly. The signs of the three variables were also worth noting: while the supportiveness of the governments and the overall institutional environment showed a positive influence on companies' productivity, the knowledge resources nevertheless had a negative coefficient. This result thus reconfirms the decisive role of the local government in OVC's competitiveness, while an active and supportive role of the knowledge institutes remains to be seen.

The final model, as shown in the last column of the above table, contains companies' ownership, market entrepreneurship, employment size, high-quality employee, and the total assets of a company in the following format:

Productivity = 0.570 + 0.178State & collective +0.131Private + 0.081Market entrepreneurship + 0.418 HQ Employee + 0.626 Asset -0.966 Employment + e

Several comments could be made based on this regression result:

1. Regarding the influence of companies' ownership, it shows that the state/collective ownership would increase companies' productivity by 0.178, and the private ownership would increase companies' productivity by 0.131 compared with the foreign-controlled companies. This thus shows the limited contribution of the foreign controlled companies in OVC in this stage;
2. For companies' entrepreneurship level, it is found that one unit increase of the companies' market entrepreneurship would boost their productivity by 0.081, although it is admitted here that its influence is still very low statistically. The more important contribution here, on the other hand, is the decomposition of the entrepreneurship factor, as the previous studies used to treat this factor as a 'black box'. The analysis here shows that different entrepreneurial components might contribute to companies' performance differently. In the case of the optoelectronic companies in OVC, their entrepreneurship deficit in the

technological and institutional dimensions might become an obstacle in their opportunities seeking activities and thus influence their economic performance;

3. Companies' internal resources are by far the most robust determinants on companies' economic performance. One unit increase of high-quality employee and asset would increase companies' productivity by 0.418 and 0.616 respectively, whereas one unit increase in companies' total employment tend to reduce their productivity by 0.966. This result thus contradicts with Hendry et al.'s (2000; 2006) conclusion in that over-employment of the surveyed companies would result in declined productivity of its employees. The special context of China might count here, as the Chinese companies generally lack a well-defined evaluation and monitoring system internally;
4. The roles of companies' external economies and opportunities in contributing to their productivities were much less noticeable in this study compared with companies' internal resources. Echoing the previous review on OVC's growth history, it is argued here that the optoelectronic companies in OVC are still mainly relying on their internal resources for survival, and may not be aware of or lack initiatives to explore their potential entrepreneurship as well as their external environment.

The binary logistic regression on companies' innovation capabilities is processed in what follows, and table 9-11 summarises the regression results. The same method of model selection illustrated before is utilised again in order to detect the contribution of individual variables. The Omnibus tests of model coefficients were adopted as criteria for variable selection.

Step one focuses on the characteristic variables. As it turns out, all three characteristic variables significantly contributed to the model's goodness of fit, and in total they could explain 15.4% to 22.1% of the variance. This implies that older companies in OVC had better innovation performance, while companies in the two clusters surpassed scattered ones in their innovations. In step two, the three entrepreneurship components were entered into the model. Contrary to the previous regression, it is found that companies' technologically oriented entrepreneurship significantly contributed to the model's overall fitness. Step three added in companies' internal resources, and both companies' total asset and high-quality employees were found improving the model's overall fitness significantly. All three variables nevertheless had a positive coefficient towards companies' innovation performance.

Table 9-11 Binary logistic regression of companies' innovation performance

	Characteristic variables			Entrepreneurship			Internal resources			External economies			Final
A. Characteristic variables													
1.Age	1.527**	1.282**	1.629**	1.535**	1.537**	1.542**	1.094	.583	.432	.655	.732	.745	.732
2.Ownership[2]													
State & collective		.732	.486	.528	.446	.466	-.068	-.023	.009	.099	.145	.196	.145
Private		-.599	-.725	-.870	-.799	-.810	-.352	.238	.253	.348	.430	.449	.430
3.Location[3]													
Older cluster			.131	.349	.363	.386	.294	.231	.235	.216	.245	.228	.245
Newer cluster			1.448**	1.360*	1.377*	1.375*	.813	.901	.848	1.015*	1.046*	1.035*	1.046*
B. Entrepreneurship													
4.Institutional				-.094	-.078	-.071							
5.Technological					.185*	.186*	.167	.199	.188	.317	.353	.317	.353
6.Market						.067							
C. Internal resources													
7.Assets							.844**	.282	.208	.403	.509	.551	.509
8.HQ Employee[4]								1.441**	.867	1.348**	1.30*	1.234*	1.30*
9.Employment									.738				
D. External economies													
10.Government										-.415	-1.04**	-1.11**	-1.038**
11.IE											.768*	.771*	.768*
12.HEIs												.115	
-2 Log likelihood	158.33	149.15	141.27	128.29	127.60	127.48	118.33	113.07	112.	109.61	106.75	106.58	106.75
Omnibus tests	6.00**	9.18**	7.88**	.22	.70*	.11	8.77**	5.26**	.61	1.50	2.85*	.18	39.56***
N	138	138	138	128	128	128	126	126	126	125	125	125	125

Note: 1. * p<0.10, ** p<0.05, *** p<0.00;

2. Category variable with the overseas controlled companies as reference;

3. Category variable with the scatter companies as reference;

4. Refers to the high-quality employee with at least a college degree;

5. Source: the author

The most interesting results show up in the last step, when the external factors were added in the model. First of all, the model's overall fitness was significantly improved when the general institutional environment factor was added in: the -2Log likelihood was reduced to 106.75, and the total factors would explain 27.1% to 39.3% of the variance. Secondly, both the factors of government supportiveness and the institutional environment turned out to have significant coefficients in the regression model, which is very encouraging compared with the previous regression results. Last but not least, the governmental factor was found having negative influence on companies' innovation capabilities now.

The final model, as shown in the last column of the above table, contains companies' age, ownership, location, technological entrepreneurship, high-quality employee, the total assets of a company, the supportiveness of the governments, and the general institutional environment in the following format:

Log odds of having new products = -5.699 + 0.732Age + 0.145State & collective +0.430Private + 0.245 Older cluster + 1.046Newer cluster + 0.353Technological entrepreneurship + 1.300HQ Employee + 0.509Asset -1.038Supportiveness of government + 0.768General institutional environment

Or:

Odds of having new products = 0.003 + 2.080Age + 1.156State/collective +1.538Private + 1.278Older cluster + 2.847Newer cluster + 1.424Technologcial entrepreneurship + 3.669HQ Employee + 1.663Asset + 0.354Supportiveness of government + 2.156General institutional environment

Observing the regression result on companies' innovation performance and comparing it with the foregoing OLS regression on companies' general economic performance, the following conclusions could be generated:

1. Regarding the results of the binary logistic regression, it shows that allowing for other factors, one unit increase of a company' age would make it 2.1 times more likely to have new product sales. Being a state/collective-owned company is 1.2 times more likely to have new product sales compared with the foreign-controlled companies, while being a private-controlled company is 1.5 times more likely to have new product sales compared with the foreign-controlled ones. Companies located in the older cluster are 1.3 times more likely to have new product sales compared with the scattered companies, while locating in the newer cluster is 2.8 times more likely to have new product sales compared with the scatter

companies. One unit improvement of a company technological entrepreneurship would make it 1.4 times more likely to have new product sales. For one unit increase of the high-quality employees and asset, the company is 3.7 times and 1.7 times more likely to have new product sales respectively. One unit increase of the government involvement would however reduce the likelihood of a company to have new product sales by 2.9 times. On the other hand, one unit improvement of the institutional environment could increase the possibility of a company to have new product sales by 2.2 times;

2. Compared with the regression results on companies' general economic performance, it seems that more 'soft factors', such as locating in a cluster and the institutional environment, turned out to be crucial towards the innovation capabilities of the companies;
3. Physical proximity is working here. What is more, the performance of the companies located in the newer cluster, no matter regarding their revenues or innovation capabilities, have surpassed both the scattered companies as well as the companies located in the older cluster. This might be attributed to the fact that significantly more university-run enterprises are located in the newer cluster, which tend to have a higher R & D resources and commitment;
4. Companies' technological oriented entrepreneurship has replaced their market oriented entrepreneurship as an important factor for their innovation capabilities. This result justified again the value of decomposing the different dimensions of entrepreneurship. On the other hand, it shows that a company should try to develop its all-round entrepreneurship in order to increase its competitiveness;
5. The institutional environment is important in the general performance of the high-tech companies, but more so in their innovation activities. However, the role of the government is highly paradoxical: it showed a positive role towards improving the companies' general performance but turned out to have a negative influence on companies' innovation capabilities, which might be explained by the frequently incompatible goals between the governments and the private sector. What is more, it seems that the various preferential policies provided by the government might work well on boosting companies' revenues, but not so efficient on leveraging their innovation capabilities.

9.5 Summary

This chapter has focused on the companies' entrepreneurship and its interactions with companies' internal resources (Quadrant I) and external opportunities (Quadrant IV). Factor analysis has been utilised to analyse companies' entrepreneurship. Three components were abstracted from the nineteen indexes, which were the institutional, the technological, and the market oriented entrepreneurship. The hypothesis on a strong relation between companies' internal resources and their entrepreneurship, however, was not confirmed uniformly by analysing the correlations between these components. However, the technological oriented entrepreneurship did have significant relations with companies' internal resource, and the scatter plots showed both the positive and the U-shaped relationships between these two variables.

Regarding the influence of institutional opportunities, this study has taken an actor-centred approach focusing on governments, the general institutional environment, and the knowledge resources. Correction analysis has shown that all three institutional opportunity indicators had significant and positive relations with companies' entrepreneurship components, except the pair between companies' market-oriented entrepreneurship and the knowledge resources. What is more, a 'diminishing marginal effect' of institutional opportunities was identified by observing the scatter plot between the two factors.

The influential factors on companies' general and innovation performance were explored at the end of this chapter. Comparing the two regression results, it was clear that the 'soft factors' of the companies' institutional environment were more crucial for the companies' innovation capabilities. Regarding the different components of companies' entrepreneurship, it was found that companies' market-oriented entrepreneurship had significant influence on companies' general performance, while their technological-oriented entrepreneurship was more crucial towards their innovation achievements. Therefore, this study has shown the necessity of differentiating and targeting on different entrepreneurial components. Moreover, the value of distinguishing between companies' general performance and their innovation capabilities has been justified in this study, as they require different stimulators from the interested parties.

Chapter 10 Genesis and dynamics of science parks and policy implications

As stated in the introduction, the primary aim of this research has been to *explore* and to *describe* the birth, the growth, and the dynamics of a local innovation system (LIS) in a less-favored region in China, drawing support from a concrete example of a science park in Central China, where the power adjustment and redistribution are prominent. In order to reach this aim, the theoretical foundations adopted in this study have moved beyond the linear model of innovation that dominates the science park literature: Here the theoretical framework comprises: 1) innovation system (IS) theory, which is regarded as the most comprehensive viewpoint on the innovation process (Mothe & Paquet 1998); 2) the resource-based view of the firm, which complements the former on the micro-level analysis and; 3) entrepreneurship theory, which helps to bridge the former two strands. Together these three theories comprise the three pillars of the four-quadrant conceptual framework proposed in chapter two. This framework has been tested first through reviewing the famous science parks in the world, and then empirically through a single case study in Central China. It is time now to reflect on the conceptual framework, and to lay out the preliminary findings and arguments gained through the foregoing qualitative and quantitative analyses.

10.1 What do we know about Science Parks?

10.1.1 There is no single way of constructing an innovation system

Similar to the conclusions of previous studies on high-tech clusters (Belussi 1999; Braunerhjelm & Feldman 2006; Owen-Smith & Powell 2006) and technopoles (Castells & Hall 1994b), there seems to be no single way of building an IS, because a nation's institutional tradition, economic position, and cultural setting could all influence the particular route that its LISs take to generate. This conclusion seems straightforward for many readers, but it may be not so easy to follow in practice. The existence of some advanced innovation systems has unintentionally compelled people to 'think-alike' and 'behave-alike'. In other words, these functioning ISs are assumed to be based on some universal formulas, which once decomposed to their basic ingredients, would provide the right recipe for others to follow (Perry 2004). However, reviewing the six science parks worldwide in chapter three shows that, significant contributions to their regions/countries could be reached through totally different genesis routes: While Silicon Valley in the US and Cambridge in the UK represent the spontaneous type, which are recommended by many scholars as the most desirable mode (Belussi 1999; Cooke 2001; Fromhold-Eisebith & Eisebith 2005); the birth of Sophia Antipolis in France (Hilpert & Ruffieux 1991; Chorda 1996) and Hsinchu in Taiwan (Lin 1997; Mathews 1997) were on the other hand the results of strong public involvement. Nevertheless, all four science parks are now the leading innovation hubs in their host regions and even the world.

Besides the influence of the national environment, a region's particular setting could also affect how its LISs are born. The contrasts between Z-Park in Beijing and OVC in Wuhan have vividly illustrated this point. Z-park emerged at grassroots level as shown in chapter three, and was strongly supported by its local authority, especially at a time when severe political and economic disturbances happened in the late 1980s. In comparison, the seeds of OVC were planted by the local authority as a response to the national call for high-tech development. Moreover, the local and regional governments of OVC had a much more reserved attitude towards the emergence of this LIS, which had resulted in OVC missing its 'early-mover' advantage.

Therefore it is obvious that the intertwined institutional settings on the national, regional, and local levels could co-influence the way its LIS is built. As a result, the four-quadrant model of an innovation system is constructed and presented divergently in different regions and countries, led and powered differently towards their growth targets. So it is argued here that trying to compare which route is superior to the other – 'bottom-up' or 'top-down' – is misleading, as they are just reflections of a particular economic and institutional composition in a specific place and time.

10.1.2 A local innovation system is continuously changing

Using the four-quadrant model to analyse science parks, their continuously changing nature also becomes obvious. This dynamic is sustained by the interactions within and between the four quadrants. Furthermore, the leader of this system, its growth engine, and its relative efficiency in achieving goals are also far from static. A longer time-span is therefore required to trace the dynamic of these factors.

Chapters five to seven have illustrated this point through an extensive review of OVC's birth, departure, and accelerated growth. The leader of this LIS has been the local authority for the most part of its traceable history. Various political incentives, such as public investment, government funds, and large projects, were the engine for its growth. Under the push of the government, the efficiency of this system to assemble resources within a short period of time and to trigger the enthusiasm of the potential entrepreneurs was relatively high at the beginning. However, this high efficiency was not sustainable in the long run, especially when the internalization and decentralization processes are becoming obvious in China: on one hand, the open-door policy has accelerated China's transformation from a planned economy to the market economy, where resource allocation is increasingly realized through the market mechanism. MNCs not only compete for the domestic market share, but also attract increasingly more capital, resources, and most importantly, talent away from the home-grown companies. On the other hand, decentralization has allocated more power to the regional and local governments, which unavoidably aggregates regional competitions. These concurrent changes are in turn out of the control of OVC's local governments, who find themselves losing the capability in assembling resources and controlling human capital. This gradually undermined government intervention, however, may provide valuable opportunities for private companies to take over the leading role in this LIS. Nevertheless, companies' current growth incentive is still 'benefit-centered', which is inferior to the desire for constantly innovating and upgrading. Moreover, the bulk of OVC's companies are functioning as self-sufficient units with limited interactions with each other, which is low in innovation productivity compared with those in a networked system.

All these deficiencies further confine the efficiency of OVC in competing with other innovation systems.

10.1.3 The particular genesis mode of a local innovation system would influence its growth trajectory

In their edited book on Cluster Genesis, Braunerhjelm and Feldman (2006, p3) suggested that 'any agglomeration can, in principle, be accounted for in terms of some initial seeding event – what matters most is what happens next'. What has been implicitly suggested by these authors, therefore, is that the particular genesis route of a cluster has little to do with its following development trajectory. However, what has been found in this study is that the genesis mode of a LIS would very likely help to shape its growing dynamic afterwards.

There are at least two channels through which the genesis of an innovation system could influence its growth. First is the institutional heritage (Martin 2010). As pointed out in the beginning of this section, different genesis formats are distinctive features among the LISs in different countries/regions, which in turn are derived from the divergent national and regional institutional environment. In other words, in what kind of format and through what particular approach a LIS is born is by no means an isolated phenomenon, but is embedded deeply within its wider social and cultural background. This institutional environment, in turn, is inherited to a great extent by the following generations, and thus continues its influence on the growth of this LIS. The birth of the Cambridge Science Park, for example, experienced a burdensome debating, lobbying, and plan-revising process, which was resulted from the locals' pride in their countryside landscape, the laid-back attitude of the university, as well as the conservatism of the Planning Committee (Segal Quince Wicksteed 2000). These institutional factors would still be observed in Cambridge Science Park's later development: many companies located in Cambridge were happy with a 'leisure-styled' working environment, with few exhibiting comparable ambitions as their US competitors (Segal Quince Wicksteed 2000). The case study of OVC provides another example on this point. Originally conceived and promoted by the governments, the following growth of OVC is heavily influenced by the political factors. Many local optoelectronic companies were so accustomed to political protections that when facing difficulties, their first reaction was not to reflect on what they were doing wrong, but to seek government aid.

The second channel is through the power distribution and redistribution. The particular genesis route of a LIS is accompanied by a specific combination of its system leader, growth engine, and relative efficiency, which in turn defines the initiative power distribution between the different actors within the system. The following growth of this system, however, is highly likely to experience either modest or dramatic adjustments on these three factors and the corresponding power redistributions. Just like breaking through the unfitted shell is essential for a caterpillar to transform into a butterfly, an innovation system also needs to break the established yet sometimes poorly fitting power structure for a better growth. This adjustment process has been illustrated by figure 3-13 on the changing positions of the six science parks, as no single one had managed to retain its original power structure between its leading force and dynamic engine. In the case of OVC, the pro-reform party leaders in Beijing were the actual promoters for its genesis around the mid-1980s. However, the power transfer from reformers to hardliners later witnessed the termination of OVC's growth. When China's reform got back on track in mid-1990s, the leading role of OVC was gradually transferred to the regional government as OVC took its departure (chapter six). Along with the accelerated growth of this LIS in the new century, the expanded private sector is trying to take the leadership role (chapter seven). Nevertheless, the local government is still reluctant to transfer its power but plays a dual-track role here.

Taking the above three findings together, there seems to be no definite answers to the question of how to build an innovation system. The most important considerations emerging from this research are the continuity of the system genesis and its construction process, because of the strong institutional influence and the various obstructions in power redistribution. A dramatic trajectory shift is possible but difficult, which is influenced by many spatial and temporal factors as well, to which the following finding will address.

10.1.4 Less-favored regions can build local innovation systems from scratch

In their study on *Technopoles of the World*, Castells and Hall (1994b) pointed out that it was still the metropolitan centers that proved most attractive for high-tech industries; they nevertheless were optimistic of the possibility for technopoles to be built on less-developed areas. The findings in this study support theirs in that a less-favored region, such as Hubei Province in Central China, could construct its LIS from scratch, which is even becoming functional after almost three decades' development.

However, a word of caution here is that while this possibility exists, it becomes increasingly more difficult for the less-favoured regions to get on board this 'high-tech train'. For the 'early movers', such as Silicon Valley and Cambridge, their success could be largely attributed to their specific international environment – the wartime demand; and the particular resources they got hold of – a worldwide prestigious university (Hall & Markusen 1985; Segal Quince Wicksteed & partners 1985; Massey et al. 1992). The followers of their models however, are vast in number but only a few have achieved substantial success, among which Sophia Antipolis and Hsinchu are noteworthy examples of interactive science parks. The latters' exceptional growth speed, as compared with the above spontaneous science parks, should be mainly attributed to the unrivaled political attention, power, and resources they could assemble, since both were labeled as of 'national interest' by their Central Government (Castells & Hall 1994b; Kung 1995; Hu 2008). All of these favorable factors, i.e., the war-time economy, the proximity of the most prestigious research institutes, the focus of the Central Government on a single project, and the concurrent IT revolution, are difficult to reproduce nowadays. In the case of OVC, it had missed the valuable early-mover advantage in the 1980s, along with the attention from Beijing. Approved as a national-level science park with twenty-five others, OVC has been facing severe competition since the day it was officially acknowledged. Moreover, compared with the larger number and higher reputation of HEIs and RIs around Z-Park, OVC is humbled by its knowledge foundation. All these factors make it more difficult for OVC to catch up with Z-Park, let along the global innovation hubs.

In saying that, the author still believes that there is hope for less-favored regions. Based on the study of OVC, two factors are crucial for approaching and finally realizing this hope. The first factor is related to the balance between endogenous and exogenous companies. Focusing on attracting FDI might be a short-cut for a LIS to reach the threshold of scale economy, such as in the cases of Sophia Antipolis and Hsinchu; but there is also danger of retreating into some kind of 'branch economies' (Phelps 2009). For the development of OVC, on the other hand, the home-grown companies were, and continuously are the backbones of its economic growth. This endogenous growth model, however, may not necessarily come out of OVC's spontaneous effort, but was arguably 'forced' by the fact that around ninety per cent of the FDI are agglomerated along the coastline without any intention to move inland (Broadman & Sun 1997). Changes are observable now in the balance between endogenous and exogenous companies because of the growing reputation of OVC worldwide, and the strong promotion of the local authority. These growing foreign investments are arguably building on the existing endogenous force. However, an effort on melting these endogenous and exogenous forces is still urgently needed.

The second crucial factor is time. This factor has been emphasized by Castells and Hall (1994b), but is arguably more important for less-favored regions. Three temporal spheres are worth noting, which are: 1) the time of entry; 2) the time of adjustment; and 3) the time of just being there. Regarding the first dimension, the shortened technology cycle and the continuously emerged new sectors provide opportunities for less-favored regions. Entering the market when a sector is in its embryonic stage is widely recommended (Freeman & Soete 1997; Freeman & Louca 2001), whereas another possibility is when crisis happens in an established sector. However, entering the market when established industries are facing a downturn is promising only if attention is paid to the adjustment of the established products or technologies, which relates to the second crucial dimension of time – the time of change. OVC for example, entered the fibre and cable sector in late 1980s when the international market was in demand of cheaper mass-produced products; it later successfully entered the LCD/OLCD market in late 1990s when there was a worldwide shrinkage in the fibre and cable sector; now OVC is diversifying its industrial structure to many emerging sectors, such as the optoelectronic machine integration, which is worthy of applause because it bridges the strong industry of OVC with the long-established machinery industry of its host region. When China's machinery industry is on the junction of modernization, OVC's strategy adjustment might win it a new catch-up opportunity. Through these adjustments and changes, OVC manages to survive for almost three decades, even when facing fierce competitions from both the domestic and the international players. The benefits of 'just being there', in the case of OVC, are arguably its growing experience, extended knowledge storage, specialized resources, and confidence in international cooperation, which illustrates the importance of the third temporal dimension, namely the value of persistency and continuity in constructing an innovation system.

In summary, the findings in this study still lead towards the optimistic side regarding the question of where an innovation system can be built. Less-favored regions could build and nourish a functioning innovation system if due attention is paid to the balance between endogenous and exogenous factors on one hand, and the temporal factor on the other. However, it is also pointed out that the difficulties accompanying this system construction process are increasing now for late-comers. Therefore a deeper understanding of the micro-level innovation dynamics is very much needed. The following two findings will elaborate on this.

10.1.5 Entrepreneurship is both a micro and a macro phenomenon

As shown in the above discussions, change is one of the central issues when trying to answer the questions of how and where a LIS can be built. On a more abstract level of theorizing, the factor that underlies any changes during the system construction process is arguably entrepreneurship, both on the micro and on the macro levels.

Micro-level entrepreneurship would derive from both the private and the public sector. Chapter nine quantitatively analysed the surveyed companies' entrepreneurship, and the results shown that there were at least three dimensions of companies' entrepreneurship, which are market, technological, and institutional oriented. Different types of entrepreneurship would in turn help the companies to sense and grasp the related market, technological, and institutional opportunities by either mobilizing their internal resources or cooperating with external partners. This chain-activity of sensing opportunities, triggering entrepreneurship, mobilizing internal resources, and/or seeking external resources are simplified in quadrants I, II, and IV of the four-quadrant model. For the public sectors, entrepreneurship is exhibited during their 'self-reflecting' and 'external-reacting' processes showed in quadrants III and IV of the conceptual framework. In reality, public entrepreneurship is exhibited by their engagement in market activities that both innovative and risky (Albert & Jamie 2009). In the context of China and many other Asian countries, public entrepreneurship is very noticeable and sometime crucial in motivating the whole system (Wan & Dong 1992; Yangtze Daily 2000; Felker 2003). In the case of OVC, for example, the first generation companies in this science park were part-spin-offs from the local HEIs and RIs, the latter of which not only controlled the stock of the companies, but were also directly or indirectly engaged in their daily operations, and thus showed a strong university entrepreneurship. The local government, on the other hand, facilitated the establishment of the first entrepreneur incubator in China, held various exhibitions, and sustained the bulk of the venture capital, all of which represent a strong government entrepreneurship.

This micro-level entrepreneurship, through its demonstration effect and the institutional learning process, would collaboratively shape the macro-level entrepreneurial culture of the whole region. The six science parks reviewed in chapter three, for example, exhibited very different 'system spirits', ranging from Silicon Valley's 'aggressive system', to Cambridge's 'leisure-styled system', and then Bangalore's 'follower system'. OVC, like the Z-Park in Beijing, represents an 'imitator system' that mainly relies on imported technologies and incremental improvement. Changing a system's overall entrepreneurship is possible, like what are happening in Hsinchu and Bangalore, but this is by no means an easy and quick process, as it depends on the collective awareness and reactions on the micro level.

10.1.6 Learning is confined by the power structure of an innovation system

Learning is another key concept in the dynamic of an innovation system. Unlike the idea of entrepreneurship, which emphasizes originality and transformation; the idea of learning stresses on awareness of the differences, open-minded, and accumulation. Because interaction is one of the most important channels for learning to happen, the various constrains on interactions from the spatial, temporal, and cultural dimensions would also influence the learning process (see for example Boschma & Lambooy 1999; Florida 2000; Martin & Sunley 2006; Chaminade & Vang 2008).

What is added by this research, on the other hand, is a clearer route through which the learning process on different levels and in different domains could influence the dynamic of an IS. It would either originate from enterprises' seeking for external resources and opportunities, or derive from the self-reflection and/or external-reaction of the institutional domain. Furthermore, the established power structure within the system would significantly determine the trigger, the orientation, the intensity, and the speed of this interactive learning process. Illustrated by the four-quadrant model, these different power structures would be reflected by: 1) which quadrant(s) initializes the learning loop; 2) whether the majority of the learning happens within the same system or between systems; 3) the average intensity of learning activities of an IS compared with others, and 4) how long it takes for the learning activities in one quadrant to trigger changes in the others.

In the case of OVC, a representative cultivated IS, learning initialized by the public sector has arguably inspired other sectors and directed the growth trajectory of the whole system. For example, learning the early experience of Zhongguancun encouraged the local authority to start its own science park project; learning from the growth of Hsinchu Science Park and particular the promising optoelectronic industry significantly led the reorientation of OVC towards this particular sector; learning the growing importance attached to innovation by the Central Government has promoted the local authority to compete for the title of 'Innovation Model Zone'. What is missing in OVC, however, is a strong learning culture within the private sector, and between the private and public domains. This weakness is mainly a result of the fact that the private sector in OVC has been subordinated to the public forces for the most part of OVC's growth history, although they are now gradually gaining on importance and experience in leading the economic growth of OVC.

All in all, the foregoing two conclusions have tried to explore the underlying factors that powering any system construction process. It becomes obvious that both entrepreneurship and learning activities are micro-level behaviors but have macro-level collective effects. These effects are shaped by the power structure of an IS and are changing over time. A deeper understanding of their micro- to macro-level transformation and vice versa is desired for answering the questions of where and how to build an IS. This deeper understanding is also highly relevant for explaining the contributions of science parks to their local economy. The last two findings will turn to this point explicitly.

10.1.7 Science Parks have an economic value to their regions and nations

Similar to the conclusion reached by Monck and his colleagues (1988), there is no doubt that the six reviewed science parks in general and OVC in particular have achieved significant economic growth and contributed to their hosted regions or nations. In the case of OVC, its economic scale and job creation have already been discussed in chapter seven. Here the focus will be on its deadweight effect and technology diffusion.

The deadweight effect of OVC is arguably more significant than its absolute job contribution, because first of all, the first generation spin-offs or part-spin-offs from the knowledge institutes were mainly encouraged by the construction of this science park, as discussed in chapter five. Secondly, the decision to build a United University Science Park had further facilitated the spin-off processes and agglomerated a growing number of companies, where a new and a highly competitive cluster is forming as showed in chapters seven to nine. Thirdly, although for many surveyed companies, locating on this science park was mainly because they were operating on the site before OVC was even established, none of them had the intention to move out of this science park as shown in the survey. The strategy of the leading companies here, such as YOFC and Fibre Home, was to establish subsidiaries and branches in other regions, especially the coastal regions and even overseas, but retain their R & D centers and head offices in OVC. Fourthly, outside companies interviewed without exception expressed their desire to move onto this science park, because of the latter's convenient transport, advanced infrastructure, specialized service sectors, as well as preferential policies. All these pieces of evidence justify that the deadweight effect of OVC had become substantial.

Regarding the technological diffusion of OVC, two channels could be identified: the first one is the R & D effort of the on-park companies. For example, chapter eight showed that over half of the surveyed companies on OVC had some sort of R & D activities. Moreover, the average R & D spending and employment ratios of the surveyed companies were higher than both the national and the regional average levels. These relatively strong R & D activities of the on-park companies would in turn build on the knowledge storage of their host region, and narrow the learning gap of its local companies for cutting-edge technologies. The second channel has been found in the growing embeddedness of OVC into the region's established industrial structure, which in turn would upgrade the technology standards of the traditional industries in Wuhan and Hubei. Chapter six, for example, documented the stories of many state-owned companies getting revitalized from the edge of bankruptcy. Their re-birth was realized either through establishing joint ventures with the on-park companies, or through modernizing their facilities with the advanced products provided by the optoelectronic companies.

10.1.8 'Hard' targets of Science parks are relatively easy to assess and achieve, but not so for its 'soft' aims

Although OVC represents a great economic progress, a final word of caution is still needed regarding its soft environment and its systematic synergy.

OVC's growth trajectory has shown that this LIS is mainly induced by policy incentives and preferential offers. The private sector is growing in influence and power to lead this IS, but it lacks the experience in cooperating with each other, especially with the knowledge institutes; the local authority had nourished this IS, so it is reluctant to withdraw from the stage; the strongest HEIs located in OVC are still managed and coordinated by the Central Government, which reduces their sensitivity and responsibility to the local requirements; the implanted optoelectronic industry by now has not been fully integrated into the region's industrial foundation, neither has it established a complete industrial chain locally, which leaves OVC relying on other regions in China for both inputs and sale; the growing number of ISs in China with similar industry focuses are competing with OVC for market share; its hinterland location, relatively low international presence, and lack of experience in dealing with FDI further confine OVC in becoming a leading industrial hub in China. All these 'soft' weaknesses, however, are hidden underneath the 'hard' economic glory of OVC. What is more, finding efficient measures to counter these systematic shortcomings is even more challenging.

Chapter nine assessed the performance of the on-park companies on two indexes: hard economic achievement as represented by their revenue per employee, and soft innovation capabilities as represented by new products sales. The results showed that, for companies' hard economic achievement, their internal resources influenced the strongest; while for their innovation capabilities, the institutional environment contributed significantly. This qualitative analysis reinforces the above argument in that, the factors contributing to the 'soft' targets of science parks might be different from those contributing to their 'hard' economic achievements.

All in all, it seems that some of the targets set by the Chinese government on its science parks, such as becoming a base to develop the high and new technology industries; a radiator for diffusing high technologies and products to traditional industries, and an experimental zone for institutional reform and innovation, have been modestly achieved by OVC. However, other designed functions, such as acting as a demonstration center for science-industry linkage; a school for cultivating high-tech enterprises and entrepreneurs; and a new community that embodies modern socialism, have proved more difficult to reach in a short period of time.

10.2 What policies can do

As declared at the beginning of this chapter, the fundamental aim of this study has been to explore but not to provide political prescription. However, since many public sectors on different levels have been deeply involved in the construction of science parks, especially in developing/transitional countries and regions, and since many of the foregoing discussed findings have direct or indirect implications for policies, it seems necessary here to conclude with a separate section on these implications and to shed light on the relevance of this study for various interested bodies.

Two levels of policy implications can be generated from this research, which are relevant for the Central Government and for the regional and local governments respectively.

10.2.1 Recommendations for the Central Government

10.2.1.1 Pay attention to integrated policy making

As explained theoretically by the layered innovation system model in chapter two, and empirically by the growth trajectory of OVC, the construction of science parks should not be treated as an isolated project. Their development, on the other hand, is intertwined within multi-dimensional and multi-layered environment. On the dimensional level, it is obvious that various industrial promotion policies, such as identifying the laser sector as one of the strategy sector in the national Five-Year Plan; the regional preferential policies, such as Central China Uprising Strategy; the science & technology development policies, such as reducing the public funds in HEIs and promoting the privatization of the research institutions, all affect the growth path of OVC and other science parks in China. Regarding the different layers' co-influence, it is obvious that decisions of Beijing could be interpreted and executed differently on the regional and local levels, which in turn will also affect the specific growth route of their science parks. Therefore it is important on the state level to provide an integrated policy framework, which would be used as a guideline for coordinating industrial development, as well as serve as a reference for the lower-level policy making. In this regard, the National Planning Policy

Framework of the UK might provide a good example. In comparison, the current policy making process in China is still separated among different Ministries on the state level. The various Ministries, in turn, tend to preserve their privileges and thus have little conversation between each other. No guidelines are available by now for the local governments when different interpretations emerge.

10.2.1.2 Walking to the front of the international playground through 'two legs'

As discussed in chapters three and nine, China is facing two obstacles in its tango onto the international market. Without proper solutions, the growth of its science parks would also suffer. The first challenge is the remaining hostile or cautious attitude of many western countries towards China. The most direct influences of this obstacle are arguably the constrained export of high-tech products to this country and the confined international market access. This export constriction in turn limits the learning channels of the Chinese companies from the world leading innovators, and restricts it from smoothly upgrading on the global value chain (Gereffi 1999; Chaminade & Vang 2008). The second obstacle is the follower and imitator's strategy followed by many domestic companies. Although the Chinese Government has started to pay attention to the importance of endogenous innovation capabilities, the weak legal system and poor executive power on protecting patent and intellectual right still leave loopholes for companies to 'borrow' from others. For example, over half of the surveyed optoelectronic companies in OVC did not have any R & D spending at all, as they mainly relied on decomposing and copying the imported technologies and products. Therefore the concern of Beijing should be twofold: improving its relations and cooperation with other countries on one hand, and strengthening its legal system and thus forcing the domestic companies to upgrade their innovation capabilities on the other.

10.2.1.3 Adopt local-based policy making framework and procedure

Science parks in China are delegated to their host cities or regions from the very beginning. This is most convincingly shown by the changing industrial structure of OVC towards homogeneity with its host region, and the dominant role of the regional government throughout OVC's growth history. This is a desirable approach given the huge diversity between different regions in China (Si-ming & Wing-shing 2000). The same recommendation is arguably applicable in other countries as well, because every space tends to have a unique combination of resources, economic structure, institutional setting, and history, which in turn will reflect on their LISs and hard to be fully appreciated at the state level. Therefore the Central Government should follow and encourage a local-based policy making process by giving more power to the local levels regarding the daily practice of science parks.

10.2.1.4 Pay attention to the coherence of policies

This recommendation may seem most relevant at the start of the science park practice in China, when the country's economic and political atmospheres were unstable. However, it is argued here that the importance and the complexity involved in making a coherent policy framework is increasing nowadays. In the case of OVC, for example, one of the main reasons for it to miss the 'early-mover' advantage could be attributed to the dramatic political retrogression during the 1980s. As reviewed in chapters three and five, this was a time when the pro-reform orientation and the relatively tolerant political atmosphere were replaced by tight economic regulations. Now almost four decades have passed since China initialized its reform and open-up, which is accompanied by an increasingly stable economic and political environment. As a result, the chances for China to witness another large scale economic crisis and dramatic policy reorientation are minimal. Nevertheless, the increasingly synchronous economic fluctuations between China and the global economy, and the continuously emerged disturbances both domestically and internationally all add to the difficulty of evaluating and keeping a coherent political framework. Therefore it should remain a concern of the Central Government.

10.2.1.5 Pick the winners but also add requirements

As mentioned before, the management of the science parks in China has been traditionally organised on the regional level. The main role of the Central Government, on the other hand, is confined to picking winners in various national projects. Although this 'winner-picking' policy has been widely criticized for its potential on intensifying regional competition (Orsenigo 2001), it nevertheless helps to motivate the local government and flatten the highly centralized power hierarchy in the country (Shaomin et al. 2000). Therefore 'winner-picking' still has its temporary value in many developing/transitional countries like China. However, the Central Government could and should do more than just pick winners in order to cultivate a functioning LIS, such as promoting the coordination between science parks in different regions, strengthening the cooperation between private sector and the knowledge institutions, and inducing companies to rely on self-innovation capabilities. Therefore adding these pre-requisites when deciding which science park(s) could win the national projects and titles is highly desirable.

10.2.2 Recommendations for the regional and local governments

For the regional and local governments, their involvement in science park constructions is more direct in many countries and thus the findings from this study also seem more relevant. In particular, four implications for regional and local governments emerge from this study:

10.2.2.1 Prepare for long-term commitment

This is the most straightforward recommendation given that time is a crucial element in the growth of science parks. In reality, however, this is not so easy to follow because first of all, the political focus normally changes along with the power transfer. This is justified in chapter seven by the shifted target of OVC in the new century from concentrating solely on industrial growth to paying more attention to hard environment construction, especially the real estate development. The fundamental reason for this target shift, in turn, was the power transfer to the newly elected government team, who believed that 'industry is the blood but hard environment is the vein' (Rui 2001). Secondly, the short-term political desire does not always go hand-in-hand with the market fluctuation. When an industry experiences a short-term shrinkage or depression, the most common reaction of the local governments in China is to find a replacement in a rush. In the case of OVC, for example, the depression of the optoelectronic industry experienced by the Chinese companies around 2008 had pushed the local government to come up with a brand new development strategy, which focused on such 'hot' industries like biotechnology, energy saving & environment protection, and information service (Dajun 2008). All these industries, however, are absent in the foundations of OVC and do not complement well with its optoelectronic sector. The conflict between the short-term political interests of the local authorities and the long-time commitment required by constructing a functioning innovation system is thus the most urgent problem facing many local governments.

10.2.2.2 Pay attention to both the hard and the soft environment of the science parks

This implication is also obvious given the finding that, achieving economic success by a science park is relatively easy, but not so true when it comes to the 'soft' achievements. The desirability of a functioning IS, as discussed in chapter two, lies not so much in obtaining short-term economic gains, but in its long-term competitiveness. This long-term achievement, in turn, is secured by the reciprocal relations between various actors involved (Castells & Hall 1994b) and the co-evolution of the whole system (Freeman 1995; Lundvall 2007a). However, compared with such economic indexes as employment and revenue, these soft targets are not easy to qualify and assess, which makes them less noticed when evaluating a science park. The current achievement of OVC, as evaluated in chapters eight and nine, has proved to be impressive in economic terms, but it has not reached a parallel standard in terms of the entrepreneurship of its endogenous companies, their innovation desires and capabilities, as well as the interactions between the various system components. Therefore, equal, if not more attention of the local authorities should be paid to the soft environment while concentrating on the hard achievement of their LISs.

10.2.2.3 Cooperate with other innovation systems

Along with the concurrent globalization process and decentralization process, the LISs in many countries and regions are facing growing competitions from other ISs domestically and internationally. In the context of China, many local and regional governments tend to read this trend as a threat. In order to counter this threat and protect their benefits, local authorities rely on various kinds of measures, such as offering cheap land, tax holidays, and rebates in order to attract investments; setting up high tariffs to prevent inter-regional trading; and establishing similar industrial structures to realize ‘self-sufficiency’. This fierce competition not only results in wasting a large amount of resources through redundant construction (Brun et al. 2002; Batisse & Poncet 2004), but also delays the formation of a coherent NIS in China (OECD 2008). As a result, learning to co-operate with each other and complement each other are urgent requirements for the local governments if they want to build on the core competitive advantages of their LISs with limited resources.

10.2.2.4 Coordinate the relations between various actors

The importance of the local government in coordinating the various actors within a local innovation system is still undeniable in many developing countries and regions, at least in the current situation. In the case of OVC, the local authorities have been functioning as the leader and the growth engine for the bulk of the time along its growth trajectory, whereas the private sectors and other supporting actors used to be mobilized, motivated, and glued by this political force. The case of OVC is a vivid representative for the majority of LISs in China, and even for those in many developing/transitional countries and regions, where the intervention of governments is strong and the power of the private sector is limited. Under this situation, the local governments should take some responsibilities in promoting the interactions between the various components within their LISs, cultivating their mutual trust, providing a communication platform for industries and the knowledge institutes, and cultivating a functioned market system. It is only in this way that a thick local embeddedness and a reciprocal IS would gradually take shape. By that time, the local governments should learn to ‘let-go’ (Taylor & Raines 2001) and retreat to the supporting role, giving the private sector the centre of the innovation stage.

10.3 Significance

This PhD research bears the potential of adding to the existing studies as well as to the daily practices of science parks both theoretically and empirically. Theoretically, this study has developed the innovation system theory and the innovation studies in general, making the theoretical foundation of science parks more reliable and realistic. Empirically, the case study examined here is unique and interesting in its own right. Furthermore, the multiple research methodologies utilised in this research helps to revive the life trajectory of a system building process that rarely studied before. In what follows, the potential contributions of this research will be summarised.

10.3.1 Theoretical development

The first theoretical contribution of this research lies in its explicit argument for updating the theoretical foundation of science parks from the linear view of innovation to a systematic viewpoint. Although some scholars have implicitly depicted the science parks against a much wider institutional and technological backdrop, and paid more attention to the relationships between different innovation actors involved (see for example Castells & Hall 1994b; Segal Quince Wicksteed 2000), this study, in contrast, argues the necessity and urgency of upgrading the fundamental assumption of science parks towards the emerging IS theory, one of the most comprehensive viewpoints on the innovation activities and processes. Furthermore, this study has moved beyond the conceptual model and tested the feasibility of the IS framework in its empirical analysis.

Secondly, the author has adopted an eclectic approach in the theory construction. Four shortcomings of the IS theory have been identified after reviewing its main concepts in chapter two, and it is argued that development and extension of the IS theory is very much needed in order to broaden the applicability of this literature, particularly when it is going to be applied in developing regions and the system building processes. In this study, the resource-based view of the firm is selected because it focuses on the micro-level analysis and pays special attention to companies' learning activities and absorptive capabilities. The institutional environment emphasized by IS theory is thus neatly linked up with companies' internal resources and learning process, which compensates for the former's limited explanatory power on the micro-level activities.

The third noteworthy theoretical contribution of this study is the attention paid to companies' entrepreneurship. Although individual entrepreneurs occupy the center position of a whole branch of innovation research, companies' intra-preneurship has not yet attracted sufficient attentions from scholars (Reich 1999; Sharma & Chrisman 2007). In this study, companies' entrepreneurship levels are assumed to be related with their internal resources, and the external market, technological, and institutional opportunities. What is more, introducing companies' entrepreneurship into the IS theory helps to bridge the institutional dynamic with companies' learning activities. Moreover, the continuously changing nature of companies' entrepreneurship also makes an IS on the move. This improvement not only strengthens the IS theory on its account of the system building process, but only extends its applicability to the vast developing/transitional regions, where 'windows of opportunities' (Perez & Soete 1988) from the market, technological, and institutional domains keep arising, and how the potential entrepreneurs and companies could grasp them are crucial issues.

Incorporating the resource-based view of the company and the entrepreneurship analysis into the IS framework leads to the fourth innovative feature of this research: the proposal of the four-quadrant conceptual framework, which provides a simplified yet effective analytical toolkit. In this framework, quadrant I amplifies the resource-based view of the company. It distinguishes between a company's tangible and intangible resources on one hand and its entrepreneurship level on the other. A two-way feedback loop links up these assets of a company, which also partly decides its internal efficiency. On the other side of the coin, the private companies are also seeking for external partners to complement their internal resource deficiencies, a phenomenon that is prominent in the high-tech industries. As a result, an active process of scanning, exploring, and resource-seeking activities becomes obvious between the private sectors and their supporting environment, a bilateral interaction that is presented by quadrant II. Quadrant IV is inspired by the entrepreneurship theory. It assumes that a company's entrepreneurship level would either be triggered on or dispelled off by its institutional environment and opportunities. This is an interactive process in nature, because the private sectors are also proactively influencing their institutional environment: by actively creating and/or lobbying for favorable opportunities, the private sectors might alert and change the inert institutional environment and the institutional actors, such as the public institutes, which could eventually lead to the coevolution of the institutional environment with the private sectors. This process is illustrated by quadrant III, and it builds on the IS theory by pointing out the power adjustments and redistributions involved in this co-evolution process. Through this institutional learning and power reallocation process, the supporting environment of an IS are better equipped with resources and knowledge to supply the innovation activates of the private sectors. All in all, this four-quadrant conceptual framework improves the theoretical shortcomings of the IS theory in four dimensions, making it more micro-concerned, more dynamic-operable, more power-related, and more entrepreneurship-focused. The empirical analysis based on this conceptual model is also easier to conduct compared with the loosely defined IS theory.

The last but not least theoretical virtue of this study is arguably the summary of the typologies of the science park practices worldwide in chapter three. After reviewing the genesis and growth of six science parks under different institutional and economic contexts, three prototypes of science parks have been identified based on their leading forces and their growth engines, the combination of which has been presented in the three-by-three analytical matrix. A science park's relative position on this matrix reflects its efficiency in promoting innovation activities and cultivating systematic synergy. These typologies of science parks not only extended the application of the four-quadrant model, but also provided a preliminary analytical framework for the case study that followed.

10.3.2 Empirical significance

The potential theoretical contributions of this study are arguably further amplified by those in the empirical work. First of all, this research has moved beyond the 'hard' assessment criteria on science parks, such as the job creation, revenue incensement, and new firm formation. What has been taken instead was a history-friendly and relational-focused perspective towards the growth of science parks. The fundamental belief is that the current profiles of any ISs are shaped to a great degree by their diversified growth backgrounds and wider institutional settings. What is more, the intangible social capital and networks established among the innovation actors have been paid close attention to when tracing the science park's life trajectory. It is argued that the temporary figures of revenues, incomes, and employment would quickly become history, but the gradually established trust, networks, norms, and business atmosphere persist.

Secondly, the chosen case in this research – the Optics Valley of China (OVC) – is unique and timely. It is unique because OVC has experienced the most dramatic roller-coaster throughout its history, which could be seen as an epitome of China's reform process and reflects the multiple power relations involved. Moreover, OVC has achieved an indisputable leading position in Central China, whose economic success and political significance contrast clearly with its host region's less-favored status. This case study is timely because there are only a few science park studies based on the Chinese context, and even fewer when it comes to the vast hinterland. In reality, however, science parks are popular everywhere in China, and they are supposed to revitalize the lagging regions and to boost the Chinese economy sustainably. This contradiction between the paucity in research and popularity in reality thus requires a detailed case study to provide timely lessons.

The third noticeable merit of the empirical work would be found in its rich data collected for qualitative analysis. In order to retrace the history of OVC, identify the crucial cornerstones and wider regional context, getting hold of a rich factual records is a must. However, the available secondary information is very much limited: the lack of English publications has already been mentioned. Furthermore, the government documents are too often labeled as 'secret' or 'internal circulation only', making it difficult if not impossible to access. Moreover, the technology of the e-publications has just been popularized in this country. As a result, the relevant news and archives are mainly confined within the latest five years. In order to skirt the data constraint, the author's personal relationships have been explored to their limit. The worth celebrating outcome was a collection of anecdotes that were never recorded or less-documented before, which has helped to trace the growth of OVC in great detail and depth.

The fourth notable contribution of this empirical work lies in its widely-covered survey data for quantitative analysis and the sophisticated statistical methods. Collecting original data from surveys and interviews is most applicable under China's context because of the foregoing discussed data constraint. On the other hand, it could be equally, if not more difficult, to conduct good surveys and interviews in this country: First of all, firms in China are not so cooperative in academic studies compared with those in western countries. This difficulty was felt by the author as well during the field work. Secondly, the Chinese companies are well known for being less straightforward or even giving a dishonest answer out of business or political considerations. In order to overcome these barriers, pilot interviews and surveys were conducted in advance to make sure the questions were right in the point and were stated in an informal manner and easy to understand. What else could be done in reality, as far as this research is concerned, are just persistence and sincerity.

10.4 Future Research

Despite the author's best efforts, there are still some limitations in this study that deserve follow-on work. First of all, this study has chosen a single case study to explore the growth and characteristics of science parks. The danger of this method comes when trying to generalize the findings to other contexts (Yin 1994). The uniqueness of OVC, as discussed before, could be found in its regional context (hinterland), its specialized industry structure (optoelectronics), and its economic position within the specific location (leader in Central China). However, it is recognized that there are possibilities of conducing comparative studies between OVC and other promising optoelectronic clusters in the coastal regions, such as Z-Park in Beijing, Zhangjiang Science Park in Shanghai, and Shenzhen Science Park in Guangdong, to name just a few. What is more, there are some internationally prominent optoelectronic clusters, such as Wales and East Anglia in the UK, Arizona and Massachusetts in the US, and Munich and East Thuringia in Germany, whose profiles have been outlined by Hendry and his colleagues (1999; 2000; 2001; 2003; 2006). In Asia, Taiwan (Huang 1994) and Japan (Miyazaki 1995) emerge quickly as regional leaders in this high-tech field. If less emphasis is paid on their divergent institutional settings and development histories, and if more time and finance could be secured, comparative studies among these optoelectronic clusters in China, and between China and other countries are very much desired, as they could provide a more comprehensive picture of this high-tech industry, and to offer more general lessons to countries and regions that are struggling with cultivating their ISs.

The second shortcoming of this research lies in its dominant focus on the "soft" achievement of OVC, i.e., the social fabric and relationships between the innovation components of this LIS. This has partly resulted from the lack of comparable data between the on-park and off-park companies like what Westhead and his colleagues (1997; 1998; 1999; 2000) had obtained. A related limitation of this study could be found on its reliance on cross-sectional data for statistical analysis instead of longitudinal data. Although some indexes covered by the questionnaire had taken into consideration the dynamics of companies' performance, such as their employment and revenue changes and their different R & D activities over time; the face-to-face interviews have also encouraged the interviewees to recall the crucial events in their careers and their institutions' development, much more effort is needed to go beyond the relatively static picture of OVC provided in the quantitative analysis. These deficiencies once again are largely results of the time constraint. The difficulties of obtaining historical data in China and the limited publications on OVC have further complicated this situation. Follow-on studies on: 1) comparing the on- and off-OVC companies and 2) conducting longitudinal analysis based on a coherent group are highly desirable in this regard.

Finally, the impact of internalization on OVC's growth and achievement has been only marginally considered in this study. This in turn was mainly a result of the reality. As discussed in chapters five to nine, the quality and quantity of foreign investment is negligible in OVC, and this science park is still replaceable on the international market compared with other advanced LISs in China. This gloomy picture of OVC is arguably derived from the combined effect of its history, location, policy, and the market mechanism: Historically, Central China is the last region to enjoy the preferential policies on foreign trading from Beijing; Spatially, the agglomeration of FDI along the coastline will not be shifted within a short period of time; Politically, the stability of Central China is arguably more important than its value in reform, as this region occupies the central position in securing the safety of agriculture, rare materials, and heavy industries. As a result, less freedom has been allocated to Central China, which discourages foreign investment to a great extent. The market mechanism, on the other hand, is functioning in China now and increasingly becomes the main mechanism in resource allocation. A by-product of this growing market economy, however, is the severe brain drain from the less-favoured regions to the coastal areas and overseas. All in all, these factors have worked together towards the limited visibility of FDI in OVC, which further led the author to allocate little space for the effect of internalization in this study. Nevertheless, what should be made clear is that, these depressing scenes in Central China and in OVC in particular are arguably a temporary phenomenon. Benefitting from China's miraculous speed of growth, industry relocation, and the deepened 'open-up', OVC holds the promise of becoming an active international player in the optoelectronic sector in the future. By that time, this third shortcoming of this study, i.e. the limited attention paid to OVC's internalization process, will become more severe and will thus need updating.

10.5 Final remarks

When drawing this final chapter together, the author is aware that generalizations from a single case study based on a unique country's background, unavoidably, bear many exceptions. That said, some ending lines are emerging, which might be applicable for many other science park practices, and could shed light on the intentions to construct an IS from scratch in many less-favoured regions.

There seems to be little doubt that constructing a science park could be a concrete route towards building an IS, especially in developing/transitional countries and regions, where the cultivated development mode dominates. Moreover, it also proves plausible that, given enough time and comprehensive attention, a science park would make promising and significant economic contributions to regional growth. Nevertheless, this approval needs to be read with caution, because there are so many 'soft' factors that are hard to assess and difficult to deal with. Perhaps the most widely applicable findings from this research, given the foregoing discussions, are the value of using a systematic framework to evaluate the genesis and dynamics of the science parks, the multiple dimensions of entrepreneurship, and the power struggles accompanying the system construction process.

It is hoped that the local governments in the less-favored regions take these ‘soft’ factors into consideration when embarking on their own science park projects. The research institutes in developing counties or regions would be more engaged and proactive in facilitating the knowledge flow within the system. The Central Government takes its responsibility in providing an integrated and coherent policy framework, while supporting the regions to coordinate with each other when constructing their own ISs.

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Appendix A List of interviewees

(Removed as interviewees' names and institutions were treated as confidential)

Appendix B Questionnaire

(Chinese version)

No. _________

伦敦学院大学
巴特利规划环境学院
规划系

伦敦学院大学巴特利学院关于
湖北省企业产业链和创新能力调查

严格保密

说明:

本问卷调查由英国海外研究学者奖学金，中国国家留学基金委，香港王宽诚奖学金计划以及伦敦学院大学研究生院资助，其研究目的是探讨区域创新体系和科技园对高新技术企业创新发展的作用。完成此问卷不需花费 10 分钟时间。在没有明确许可的情况下，受访者姓名以及所在机构名称将被严格保密。

请勾选合适的选项框或在提供的空白处填写。

受访者姓名: ____
职位: ____
邮箱: ____
电话: ____
所在机构名称: ____
所在机构在此地开始生产经营的时间（年）: ____________________

第一节：基本信息

*1、贵机构登记注册类型为：（**请打勾“✓”**）*

a) 国有及国有控股 ☐　b) 集体 ☐　c) 私营 ☐　d) 股份合作 ☐　e) 联营 ☐
f) 有限责任 ☐　g) 股份有限 ☐　h) 港、澳、台商投资 ☐　i) 外商投资 ☐

*2、贵机构是：（**请将所有适用的打勾“✓”**）*

a)单址机构 ☐　b)拥有附属/分支的母机构 ☐　c)附属或分支*公司 ☐　d)从其他公司脱离*而组建的新公司 ☐　e)从研究机构/大学*脱离而组建的新公司 ☐　f) 其他(注明) _______

* 如果是 c)，请注明所属母机构所在城市：____

* 如果是 d) 或 e)，请注明所脱离公司或研究机构所在城市：________________________

*3、贵机构在现址承担或即将承担以下哪些活动？（**请将所有适用的打勾“✓”**）*

	1)基础性研究	2)应用性研究	3)产品改进	4)生产过程改进	5)生产组装	6)营销	7)分销	8)采购	9)其他(请注明)
a)目前	☐	☐	☐	☐	☐	☐	☐	☐	________
b)机构成立时	☐	☐	☐	☐	☐	☐	☐	☐	________
c)预计未来 3-5 年	☐	☐	☐	☐	☐	☐	☐	☐	________

第二节：人力资源

4、贵机构有多少雇员：(请提供数据)

a) 目前　1) 总数 _______________　2) 其中研发人员 ________________
b) 机构成立时　1) 总数 _______________　2) 其中研发人员 ________________

*5.1 贵机构**总经理**获得的最高学历或证书是：*

a) 本科以下 ☐　b) 本科 ☐　c) 硕士 ☐　d) 博士及以上 ☐　e) 其他 (请注明)__________

5.2 贵机构总经理在成立或加入本机构前是否有类似工作经验　a) 是 ☐　b) 否 ☐

第三节：创新能力

*6、自 2008 年（若 08 年以后成立，则自机构成立以来），贵机构推出了多少**产品或服务**属于：(请提供数据)*

a) 对贵机构而非对国内行业市场是首次 ____________ b) 对贵机构和国内行业市场都是首次 _____________

*7、自 2008 年（若 08 年以后成立，则自机构成立以来），贵机构引入了多少**生产流程、服务方式**属于:：(请提供数据)*

a) 对贵机构而非对国内行业市场是首次 ____________ b) 对贵机构和国内行业市场都是首次 _____________

*8.1、贵机构最近一个财政结算年的**利润总额相比较前一年**的变化为：(请填入数字 0~100，或勾选)*

a) 提高了 __________%　b) 降低了 __________%　c) 基本不变 ☐

8.2 贵机构最近一个财政结算年用于研发的资金占总营业额的比例为：__________% (请填入数字 0~100)

第四节：创新链与互动

*9、对于下列时间段请估计贵机构**每年用于购买原材料,机器设备等生产性投入**来自于以下地理位置的比例：*

	1) 武汉光谷	2) 武汉其他辖区	3) 湖北其他市县	4) 中国其他省市	5) 海外	**总计**
a) 目前	______%	______%	______%	______%	______%	**100%**
b) 机构成立时	______%	______%	______%	______%	______%	**100%**
c) 预计未来 3-5 年	①提高 ☐ ②基本不变 ☐ ③降低 ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	

*10、对于下列时间段，请估计贵机构的**年营业总额**来自以下市场的比例：*

	1) 武汉光谷	2) 武汉其他辖区	3) 湖北其他市县	4) 中国其他省市	5) 海外	**总计**
a) 目前	______%	______%	______%	______%	______%	**100%**
b) 机构成立时	______%	______%	______%	______%	______%	**100%**
c) 预计未来 3-5 年	①提高 ☐ ②基本不变 ☐ ③降低 ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	

(下页继续)

*11、以下主体对贵机构***产品、服务或生产流程创新***的动力,信息来源,技术支持及成果反馈等方面的重要性有多大？*

NA		不重要……				……非常重要
☐	a) 供 应 商	☐	☐	☐	☐	☐
☐	b) 客　户	☐	☐	☐	☐	☐
☐	c) 竞争对手	☐	☐	☐	☐	☐
☐	d) 商业服务机构如咨询公司、银行等	☐	☐	☐	☐	☐
☐	e) 大学/科研机构	☐	☐	☐	☐	☐
☐	f) 公共服务机构如产业协会、政府等	☐	☐	☐	☐	☐

*12、下列与大学或研究机构交流合作的方式对贵机构的重要性为：***（请选择一个打勾"√"；不适用请勾选 NA）**

NA		不重要……				……非常重要
☐	a) 利用大学或研究机构的专业文献或设备	☐	☐	☐	☐	☐
☐	b) 参加大学或研究机构组织的研讨会或培训	☐	☐	☐	☐	☐
☐	c) 与大学或研究机构人员的个人联系	☐	☐	☐	☐	☐
☐	d) 毕业生实习或录用	☐	☐	☐	☐	☐
☐	e) 聘请大学或研究机构的专业人士到机构任职	☐	☐	☐	☐	☐
☐	f) 建立联合研发项目	☐	☐	☐	☐	☐
☐	g) 外包研发项目给大学或研究机构	☐	☐	☐	☐	☐

第五节：企业家精神

*13、您认为下列因素对所属 3 个主题的重要性有多大？***(请选择一个打勾"√"，如果不适应请勾选 NA)**

	NA		不重要……				……非常重要
13.1 贵机构成立的原因为	☐	a) 潜在市场需求巨大	☐	☐	☐	☐	☐
	☐	b) 生产成本降低	☐	☐	☐	☐	☐
	☐	c) 技术成熟	☐	☐	☐	☐	☐
	☐	d) 有利的政策环境	☐	☐	☐	☐	☐
	☐	e) 制度改革	☐	☐	☐	☐	☐
	☐	f) 个人倾向	☐	☐	☐	☐	☐
13.2 贵机构的竞争优势为	☐	a) 对市场动向把握准确	☐	☐	☐	☐	☐
	☐	b) 对政策制度环境变化应对自如	☐	☐	☐	☐	☐
	☐	c) 拥有领先的核心技术	☐	☐	☐	☐	☐
	☐	d) 提高产品或服务质量，减低价格	☐	☐	☐	☐	☐
	☐	e) 不断推出新的产品或服务	☐	☐	☐	☐	☐
	☐	f) 生产、研发资金雄厚	☐	☐	☐	☐	☐
	☐	g) 优质人力资源充足	☐	☐	☐	☐	☐
13.3 以下活动对贵机构的重要性	☐	a) 提供员工在岗培训	☐	☐	☐	☐	☐
	☐	b) 提供员工离岗培训	☐	☐	☐	☐	☐
	☐	c) 鼓励员工/部门间的信息交流	☐	☐	☐	☐	☐
	☐	d) 经常岗位轮换	☐	☐	☐	☐	☐
	☐	e) 同其他机构短期的人员调换	☐	☐	☐	☐	☐
	☐	f) 培养内部创新文化	☐	☐	☐	☐	☐

第六节：制度环境

*14、您在多大程度上认同以下说法？***(请选择一个打勾"√"，如果不适用请勾选 NA)**

NA		非常不认同……				……非常认同
☐	a) 光谷管理队伍的办事效率和执政灵活度很高	☐	☐	☐	☐	☐
☐	b) 与其他光谷机构、大学及研究院所合作交流很多	☐	☐	☐	☐	☐
☐	c) 光谷的整体竞争力在全国处于领先水平	☐	☐	☐	☐	☐
☐	d) 光谷已融入全球贸易链条并逐渐凸现实力	☐	☐	☐	☐	☐
☐	e) 湖北省对企业创新的支持力度很大	☐	☐	☐	☐	☐
☐	f) 湖北省整体投资环境在全国领先	☐	☐	☐	☐	☐
☐	g) 国家对企业创新的支持力度很大	☐	☐	☐	☐	☐
☐	h) 国家对湖北的政策优惠倾向在加大	☐	☐	☐	☐	☐

*15、请回顾贵机构选址的时候，当时哪些因素促使您最终决定落户此地？***（请列举一至两项重要因素）**

____

____

非常感谢您的支持与合作。请用邮资已付的信封送还问卷，或发送至邮箱 miaotian0917@yahoo.com.cn。

Questionnaire (English version)

No. ___________

University College London
The Bartlett
Faculty of the Built Environment
PLANNING

SURVEY OF LINKAGES AND INNOVATION PERFORMANCE OF OPTOELECTRONIC FIRMS IN HUBEI

STRICTLY CONFIDENTIAL

GENERAL INSTRUCTIONS:

This survey is funded by UCL Overseas Research Scholarships, China Scholarship Council, and the KC-Wang Scholarship Programme, aiming to explore the roles of innovation system and science parks on high-tech companies' performance.

It should take you **no longer than ten minutes** to complete this questionnaire. **No reference will be made to your name or the name of this establishment unless authorized.**

Please tick the appropriate boxes or write in the spaces provided.

Respondent(s) Name: ______________________________
Position: ______________________________
Email address: ______________________________
Phone number: ______________________________
Institution's name: ______________________________
Year started operation on this site: ______________________________

SECTION ONE: GENERAL INFORMATION

1. *What is the registration type of this establishment? (please tick relevant box)*

a) State-owned/State-holding ☐ b) Collective-owned ☐ c) Cooperative ☐ d) Joint Ownership ☐ e) Limited Liability ☐ f) Share-holding ☐ g) Private ☐ h) Funds from Hong Kong, Macao, Taiwan ☐ i) Foreign Funded ☐

2. *This establishment is: (please tick all relevant boxes)*

a) Single-site company ☐ b) Head office of multi-site establishment ☐ c) Subsidiary or branch* ☐ d) Spin-off of other establishment * ☐ e) Spin-out of university* ☐ f) Other (specify)______ * If c), please state the city in which the head office is located: ______ *If d) or e), please state the city where the firm or university is located: ____

3. *Which of the following functions do (or will) you possess on site? (please tick all relevant boxes)*

	a) **At present**	**b) When established**	**c) Expect for the next 3-5 years**
a) Basic research	☐	☐	☐
b) Applied research	☐	☐	☐
c) Product development	☐	☐	☐
d) Process development	☐	☐	☐
e) Manufacturing/Assembling	☐	☐	☐
f) Sales/Marketing	☐	☐	☐
g) Distribution	☐	☐	☐
h) Purchasing	☐	☐	☐
i) Others (Please specify)	_____________	____________	_____________

SECTION TWO: HUMAN RESOURCES

4. *How many employees does this establishment have: (please provide figures)*

	a) **At present**	**b) When established**
a) Total	___________	___________
b) R & D personnel	___________	___________

5.1 *What is the highest degree or certification obtained by the managing director?*

a) Under Bachelor ☐ b) Bachelor ☐ c) Master ☐ d) PhD and above ☐ e) Others (specify) ____

5.2 *Did the managing director have similar work experience before?* a) Yes ☐ b) No ☐

SECTION THREE: INNOVATION PERFORMANCE

6. *Since 2008 (or when established), how many products/ services has this establishment introduced that are: (provide figures)*

a) New to the establishment but not new to the market_______ b) New to the market _______

7. Since 2008 (or when established), how many processes/services has this establishment introduced that are: (provide figures)

a) New to the establishment but not new to the market______ b) New to the market __________

8.1 By what percentage did this establishment's most recent annual profit change compared to last year? a) Increase by ________% b) Decrease by ________% c) Stayed the same ☐

8.2 What is the ratio of R & D spending within the most recent avenue: _______% (figure please)

SECTION FOUR: INNOVATION LINKAGES AND INTERACTIONS

9. *For each time span, please estimate what percentage of this establishment's inputs (by value) were/are purchased within:*

	1) OVC	2) Rest of Wuhan	3) Rest of Hubei	4) Rest of China	5) Overseas	Total
a) At present	_____%	_______%	_______%	_______%	_______%	100%
b) when established	_____%	_______%	_______%	_______%	_______%	100%
c) next 3-5 years ① Increase	☐	☐	☐	☐	☐	
②Stay the same	☐	☐	☐	☐	☐	
③Decrease	☐	☐	☐	☐	☐	

10. *For each time span, please estimate what percentage of this establishment's sales (by value) were/are made within:*

	1) OVC	2) Rest of Wuhan	3) Rest of Hubei	4) Rest of China	5) Overseas	Total
a) At present	_____%	_______%	_______%	_______%	_______%	100%
b) when established	_____%	_______%	_______%	_______%	_______%	100%
c) next 3-5 years ① Increase	☐	☐	☐	☐	☐	
②Stay the same	☐	☐	☐	☐	☐	
③Decrease	☐	☐	☐	☐	☐	

11. *Please rank the importance of the following actors in improving your establishment's innovation capabilities (tick only one box for each factor. Tick NA if not applicable).*

NA		**Not important at all**				**Very important**
☐	a) Suppliers	☐	☐	☐	☐	☐
☐	b) Clients	☐	☐	☐	☐	☐
☐	c) Competitors	☐	☐	☐	☐	☐
☐	d) Private service providers	☐	☐	☐	☐	☐
☐	e) HEIs/RIs	☐	☐	☐	☐	☐
☐	f) Public service institutes	☐	☐	☐	☐	☐

12. *Please rank the importance of the following cooperation with HEIs/RIs (tick only one box for each factor. Tick NA if not applicable)*

NA		**Not important at all**				**Very important**
☐	a) Use their professional publications/facilities	☐	☐	☐	☐	☐
☐	b) Attending seminars or forums	☐	☐	☐	☐	☐
☐	c) Personal contacts	☐	☐	☐	☐	☐
☐	d) Graduate internship or employment	☐	☐	☐	☐	☐
☐	e) Employ research staff	☐	☐	☐	☐	☐
☐	f) Establishing R & D cooperation projects	☐	☐	☐	☐	☐
☐	g) Out-sourcing R & D projects	☐	☐	☐	☐	☐

SECTION FIVE: ENTREPRENEURSHIP

13. *Please estimate the importance of the following factors (tick one box. Tick NA if not applicable).*

	NA		Not important at all				Very important
13.1 The reasons for starting this establishment	☐	a) Potential market demand	☐	☐	☐	☐	☐
	☐	b) Reduced cost of production factors	☐	☐	☐	☐	☐
	☐	c) Technology breakthrough	☐	☐	☐	☐	☐
	☐	d) Favorable policy environment	☐	☐	☐	☐	☐
	☐	e) Institutional adjustment	☐	☐	☐	☐	☐
	☐	f) Personal preference	☐	☐	☐	☐	☐
13.2 Competitive advantages of this establishment	☐	a) Accurate market estimate	☐	☐	☐	☐	☐
	☐	b) Flexible to the institutional environment	☐	☐	☐	☐	☐
	☐	c) Cutting-edge technologies	☐	☐	☐	☐	☐
	☐	d) Improve quality & low price	☐	☐	☐	☐	☐
	☐	e) New products or services	☐	☐	☐	☐	☐
	☐	f) Sufficient production, R & D finance	☐	☐	☐	☐	☐
	☐	g) Sufficient human capital	☐	☐	☐	☐	☐
13.3 Importance attached to the following internal activities	☐	a) Providing on-site training	☐	☐	☐	☐	☐
	☐	b) Providing off-site training	☐	☐	☐	☐	☐
	☐	c) Knowledge sharing among employees	☐	☐	☐	☐	☐
	☐	d) Regular job rotating	☐	☐	☐	☐	☐
	☐	e) Staff secondment with other companies	☐	☐	☐	☐	☐
	☐	f) Innovation culture cultivating	☐	☐	☐	☐	☐

SECTION SIX: INSTITUTIONAL ENVIRONMENT

14. *To what degree do you agree with the following statement? (tick one box)*

NA		Not agree at all				Totally agree
☐	a) Efficiency & flexibility of the management committee is high	☐	☐	☐	☐	☐
☐	b) Sufficient cooperation with HEIs/RIs/others	☐	☐	☐	☐	☐
☐	c) Overall competitiveness of OVC is leading in China	☐	☐	☐	☐	☐
☐	d) OVC has integrated in the global value chian	☐	☐	☐	☐	☐
☐	e) Hubei is increasing its support on innovation	☐	☐	☐	☐	☐
☐	f) Overall investment environment of Hubei is leading in China	☐	☐	☐	☐	☐
☐	g) China supports firms' innovation strongly	☐	☐	☐	☐	☐
☐	h) Central Government is preferring Hubei	☐	☐	☐	☐	☐

15. *What reasons made you to locate on OVC? (Please list one to two most important reasons)*

____

Thank you for your cooperation. Please return in the self-addressed envelope or email to miaotian0917@yahoo.com.cn

Appendix C Interview transcript example

(Removed as the names of the interviewee and his institution were mentioned in the transcript)