Towards a Dynamic Regional Innovation System

Investigation into the Electronics Industry
in the Pearl River Delta, China

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Master of Science Wenying Fu
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Referent: Prof. Dr. Javier Revilla Diez
Korreferent: Prof. Dr. Ingo Liefner
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Summary

China’s high-speed growth relying on low-cost advantages has been greatly constrained by the rise of factor prices and the shrink of international markets. Technological upgrading and innovation capabilities turn out to be the key to the successful restructuring process. Embedding the theoretical discussion on the framework of evolutionary regional innovation system that stresses the role of interactive learning and systemic innovation, this thesis aims to explore the formation and the specific elements of the regional innovation system in China, which is of great relevance to the release of innovation potential in the face of upgrading pressure.

One of the most developed regions in China the Pearl River Delta has been selected as the research region. The electronics industry forms the particular focus of the study due to its close integration into global production system and the huge technological opportunities that confer the knowledge exploitation through interactive learning.

The meso-level evidence with the application of secondary data firstly demonstrates that sufficient stock of FDI triggers the formation of local interactive learning process within the same industry. Micro-level evidences are further provided by a standardized electronics firm survey. The results from the survey support the positive impact of interactive learning with a wide scope of business partners, such as foreign customers, domestic customers, parent companies, sales agents, universities and research institutes, on promoting innovation outcomes. It is also revealed that interactive learning among the electronics firms in the Pearl River Delta is more organized within the social proximity, such as through informal relationships with business partners, relatives and friends, than within the organizational proximity with global lead firms. However, informal social assets have a limited influence on innovation outcomes due to the lean support of governance infrastructure in the regional innovation system. The empirical comparison between Shenzhen and Dongguan enlightens the direction of governance construct that supports systemic innovation, showing that dirigiste governance in the initial industrialization phase leads to a more mature and developed regional innovation system than the grassroots governance modality. In brief, policy action should be given with regard to enhancing the absorptive capacity of firms and related organizations as well as monitoring the external changes for new developmental dynamics.

Overall, the work shows the potential of interactive learning in fostering innovation activities and its supported governance infrastructure in China context, calling upon further research on the evolution of the regional innovation system in China in the face of fast-changing macro-economy conditions.

Key Words: Regional Innovation Systems, Knowledge Spillovers, Interactive Learning

Kurzzusammenfassung

Das hohe Wirtschaftswachstum Chinas war lange Zeit vor allem von Kostenvorteilen abhängig und wurde dadurch in jüngster Zeit durch steigende Faktorpreise und schrumpfende Märkte beschränkt. Technologische Aufwertungsprozesse und der Aufbau von Innovationskapazitäten sind in dieser Situation der Schlüssel für einen erfolgreichen Restrukturierungsprozess der chinesischen Wirtschaft. Eingebettet in die theoretische Diskussion evolutionärer Regionalentwicklung, die die Bedeutung interaktiven Lernens und systemischer Innovationsprozesse betont, ist es das Ziel dieser Doktorarbeit, die Entstehung und Entwicklung regionaler Innovationssysteme und derjenigen Einzelelemente zu untersuchen, die für die Realisierung von Innovationspotenzialen und das Meistern des Aufwertungsdrucks von Bedeutung sind.

Mit dem südchinesischen Perlflussdelta wurde eine der am weitesten entwickelten Regionen des Landes als Untersuchungsregion ausgewählt. Dabei wird auf die Elektronikindustrie fokussiert, die durch intensive Integration in globale Produktionssysteme und große technologische Entwicklungspotenziale besonders für die Untersuchung der Wissensgenerierung durch interaktives Lernen geeignet ist.

Unter Nutzung sekundärstatistischer Daten wird zunächst auf der Mesoebene gezeigt, dass das Vorhandensein ausländischer Direktinvestitionen in einer Region lokalisiertes interaktives Lernen innerhalb verbundener Industrien auslöst. Mit Hilfe von Daten aus einer standardisierten Unternehmensbefragung werden danach tiefergehende Erkenntnisse auf der Mikroebene generiert. Die Befragungsergebnisse unterstützen die These, dass interaktives Lernen mit einem weiten Spektrum von Partnern (z.B. ausländische und inländische Kunden, Mutterunternehmen, Handelsunternehmen, Universitäten und Forschungseinrichtungen) die Entstehung von Innovationen im Unternehmen fördert. Es wird außerdem belegt, dass interaktives Lernen innerhalb der Elektronikindustrie des Perlflussdeltas häufiger durch soziale Nähe, z.B. informelle persönliche Kontakte zwischen Geschäftspartnern, Freunden und Familienmitgliedern, moderiert wird als durch organisationale Nähe innerhalb globaler Unternehmensgruppen. Die Wirkung informeller sozialer Kontakte auf Innovationen wird jedoch durch die Art und Entwicklung der übergeordneten Governance-Struktur des jeweiligen regionalen Innovationssystems beeinflusst. Ein Vergleich zwischen den Städten Shenzhen und Dongguan zeigt, dass staatliche Lenkung in der Frühphase von Aufwertungsprozessen reifere regionale Innovationssysteme entstehen lässt als von der Basis aus gesteuerte Systeme. Politikmaßnahmen sollten sich auf die Entwicklung von unternehmerischen Absorptionsfähigkeiten und anderen Innovationsakteuren vor dem Hintergrund von Veränderungen in den globalen Rahmenbedingungen konzentrieren.

Zusammenfassend zeigt die vorliegende Arbeit das Potential interaktiven Lernens für Innovationsprozesse und die Bedeutung von Governance in regionalen Innovationssystemen Chinas.

Schlagwörter: Regionale Innovationssysteme, Wissensspillovers, Intensives Lernen

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Abbreviation

OECD	Organisation for Economic Co-operation and Development
CPI	Consumer Price Index
PPI	Production Price Index
STDP	Science and Technology Development Plan
DFG	German Research Foundation
PC	Personal Computer
FDI	Foreign Direct Investment
R&D	Research and Development
GDP	Gross Domestic Production
MAR	Marshall-Arrow-Romer
OEM	Original Equipment Manufacturer
ODM	Original Design Manufacturer
OBM	Original Brand Manufacturer
HHI	Hirschman-Herfindahl Index
RMB	Renminbi (Chinese Currency)
PRD	Pearl River Delta
CEO	Chief Executive Officer
SME	Small and Medium-sized Enterprise
TFP	Total Factor Productivity
NPI	New Product Ideas
NPCK	New Product supported Codified Knowledge
NPTK	New Product supported Tacit Knowledge
IW	Interaction Way
OLS	Ordinary Least Squares
RIS	Regional Innovation System
SECC	Shenzhen Electronic Chamber of Commerce
GECC	Guangdong Electronic Chamber of Commerce
LCD	Liquid Crystal Display
BIC	Bayesian Information Criteria
AIC	Akaike Information Criteria

Preface

The completion of this dissertation witnessed my precious experience during my overseas study in Hannover, Germany. I feel very lucky that I was able to do my doctoral work at the Institute of Economic and Cultural Geography at the Leibniz University of Hannover within the last three years, which is among the best in the field of Economic Geography in Germany.

First of all, I want to say thank you in all sincerity to my supervisor Prof. Javier Revilla Diez. He constantly challenged me to refine the theoretical discussions and to explore deeper for the implications of the empirical results. Owing to his professional instruction, this work has been greatly improved. Moreover, he supported me a lot in attending many international conferences and summer schools, which benefited me in making fruitful academic conversations with international scholars.

Another important support came from Prof. Li Xun at the School of Geography and Planning, Sun Yat-sen University in China. As the supervisor during my master study, we have already established a sustainable ‘Guanxi’. During my field work in Guangzhou, he took the initiative to arrange several interviews, from which I have gained a preliminary insight into the innovation pattern in the Pearl River Delta. Most importantly, he gave me the impulses frequently, pushing me to work harder and harder.

During the tedious days of thesis writing in Germany, I sometimes got the feeling of loneliness and homesick. I am very much indebted to Susanne and Daniel, who have now become my best friends, for their efforts in making my life in Hannover colorful. Susanne has taken great care of me since the first day that I came to Hannover. Daniel has also given a lot of efforts in reading through my far-from-perfect drafts and giving me constructive advices to improve the work.

For making indispensible contribution to this work, I would like to thank: Huang Shuxian, Liang Qingxia, Lu Meiru and Jiang Ling. It was lucky to have you guys as assistants, and the collection of our precious first-hand survey data would not have been possible without your efforts. I would also like to mention Prof. Kerndrup, Prof. Lundvall and Buru Im, who have given useful suggestions for my work in the DRUID Winter Conference 2011.

Next, I would like to express my special thanks for Li Ting, who has supported me all way along not only emotionally, but also with his brilliant talents. He helped solving most of the technical problems in this work and inspired me in interpreting the data more realistic to the state of the art in the Pearl River Delta.

Last but not least, I would like to dedicate this work to my parents, who have raised me and always care for me and love me just as sure as the stars shine above.

1 Introduction

1.1 Research Context

> *"China's re-emergence as a major power in the world economy is one of the most significant developments in modern history. Economic reforms and the "open door" policy have prepared the ground for the Chinese economy's nearly three decades of impressive performance and have yielded outstanding results in a number of areas… A major challenge for China is to make its future development economically, socially and ecologically sustainable. Developing the country's innovation capacity is a prerequisite for escaping from a pattern of specialization characterized by intensive use of low-skilled labor and natural resources and a low level of technological capabilities."* *(OECD, 2007:59)*

China's high-speed growth has been greatly constrained by both internal and external factors in recent years. On one hand, the high inflation rate that leads to continual pressure of rising costs gradually erodes the competitive edge on low cost production. In the first quarter of 2011, the Consumer Price Index (CPI) hit the record of 5.4% year-on-year, and the Production Price Index (PPI) also rose to 7.3% from the 7.2% in February (China Statistical Bureau, April 2011). On the other hand, Chinese export firms are encountered with more trade obstacles in the developed market due to the protection of local employment market after the financial crisis. Firms either have to meet the high standards on safety and quality in order to maintain the market share in developed countries, or they have to exploit the new market opportunities in the domestic economy.

In this circumstance, technological upgrading and innovation capabilities is the key to the successful restructuring process. The innovation investment cools down the fervent economic growth owing to its long period of returning rate, and at the same time ensure the sustainable growth engine in the long run. Responding to the call of the innovation issue in the context of inflationary growth and competition pressure, China's innovation policy has been greatly focused on science & technology policy

(STDP, 2006), aiming to foster indigenous innovation capabilities through R&D-incentivized tax reduction, improving intellectual property rights and setting its own technological standards. In other words, the Chinese innovation policy follows a linear legacy, in which innovation is taken as a sequential process of discovery and direct translation into commercial value.

Nevertheless, this linear approach underestimates the interactive and systemic nature of innovation in value creation (Lundvall, 1992; Cooke *et al.*, 1997; Howells, 1999; Revilla Diez, 2000; Smith, 2000; Asheim and Coenen, 2005). The system approach towards innovation has been proposed in the innovation milieu by Aydalot (1986), in cluster theory by Porter (1990), in national innovation systems by Lundvall (1992) and in regional innovation systems by Cooke *et al.* (1997), all of whom have recognized the interactive learning process and the resulting distribution power of a production system as the fundamental element of economic performance. In this way, the knowledge exploitation process in the economy yields increasing returns on the generated knowledge, propelling the endogenous process of economic growth.

As a latecomer country, China has the advantage of backwardness, in which the technological knowledge is available "off the shelf" (Nolan and Lenski, 1985). Consequently, knowledge exploitation is more important than knowledge generation. For latecomers, access to technology in industrialized countries as well as successful absorption and translation into market opportunities, combined with the low-cost and flexible manufacturing advantage, constitute the core elements of their competitiveness. Therefore, innovation potential in China can be at best released by implementing effective technology transfer and strengthening the distributive power of the economic system as a whole.

The distributive power of the system depends on the willingness and capability of local firms to undertake interactive learning. The regional innovation system approach proposes the institutional and organizational dimension as the supporting infrastructure that stabilizes the interactive learning process. Heidenreich (2004) defines the stabilizing factor as the regional orders, encompassing formalized rules and laws as well as informal habits and methods. The regional orders promote the interactive learning process and systemic innovation activities by reducing uncertainty, coordinating the use of knowledge and mediating conflicts.

Overall, this thesis aims to explore the formation process and specific elements of the regional innovation system in China, which is of great relevance to the release of

innovation potential in the face of upgrading pressure. As demonstrated by Heidenreich (2004), the strength of a regional innovation system does not lie in the static set of institutions, firms and technologies, but in its dynamic ability to overcome dilemmas and meet the challenge of market change and organizational restructuring. Therefore, the dynamic and evolutionary perspective on the regional innovation system is adopted in this thesis so that signs of a maturing regional innovation system can be captured, investigated and compared with regard to both the business superstructure and the governance infrastructure.

This thesis is supported within the framework of the Priority Programme 1233 "Megacity-Megachallenge: Informal Dynamics of Global Change" funded by the German Research Foundation (DFG). In this research program, one of the biggest megacity regions in China, the Pearl River Delta, has been selected as the research region. The electronics industry forms the particular focus of the study.

The electronics industry has been developing in the Pearl River Delta for over 30 years. For strategic reasons, nearly 90% of the global lead firms in the electronics industry have located themselves in the east coastal cities of the Pearl River Delta in particular, such as Shenzhen and Dongguan[1]. The electronics industry in this region is very export-oriented. The region manufactures over 50% of the world's desktop computers and 40% of PC components, such as PC heads, PC cases and other semi-manufactured products[1]. Moreover, many domestic brands in the Pearl River Delta have rapidly developed and taken a considerable share of the global market. However, with the increasing land and labor costs in the Pearl River Delta and the favorable policies offered by many inland governments, the trend of industrial shift to inland China is irreversible. Therefore, the FDI-driven growth mode is no longer sustainable, and there is an urgent call for the development of regional innovation system to generate sustainable and dynamic growth paths.

Moreover, the electronics industry has a large pool of technological opportunities, which confers the great possibility of opening up numerous niche markets with new product development. Firms can profit in niche markets by minor innovation when prerequisite absorptive capability, such as the ability to read and adjust the circuit board design, is ready. For minor innovators in electronics industry, interactive learning with users and other knowledge-intensive organizations assists in collecting

[1] Sources: http://www.gdiid.gd.gov.cn/gdiid/billion/lay2-3.htm

market information and supported technology.

One of the Shenzhen exhibitors in "China Sourcing Fair: Electronics & Components" displayed their new product – Solar Charger Backpack. The manager told the journalist that the orders have reached over 10 million Yuan. "What we do is just to make the collection and the use of solar energy more convenient, but this minor innovation led to higher added value for our products."

——Shenzhen News, 04.2011

1.2 Defining Innovation and Regional Innovation System in China Context

1.2.1 What does Innovation imply in China?

As China is a technological latecomer, innovation is more incremental than abrupt. Knowledge production activities are not dominant in these countries, since the modern natural sciences, such as physics, chemistry, biology and so on, are mostly developed in industrialized countries. R&D activity, which is a main proxy of knowledge production activities, displays an unbalanced pattern between industrialized countries and latecomer countries. Although R&D expenditure has greatly increased, for example to 1.7% of GDP in 2009, the intensity is still fairly weak compared to that of developed countries (OECD 2.3% in 2009, USA 2.9% in 2009, Japan 3.4% in 2009, Korea 3.3% in 2009[2]). Therefore, access to advanced knowledge and dissemination mechanisms remains the key factor for successful incremental innovation in the Chinese context (OECD, 2005).

Overall, innovation in China is characterized as:

1) Resource restriction of firm-level innovation. Because of the low entry barriers to simple assembly processing tasks, small and medium-sized firms are dominant in latecomer countries. The lack of economies of scale leads to resistance to conducting high-risk innovation activities at the firm level. Furthermore, the immature local financial system provides weak financial support for firms to invest in innovation.

2) Unbalanced knowledge base and the weaker regional innovation system. The industrialization process only began in China 30 years ago. The industrial knowledge

[2] Sources: OECD, Main Science and Technology Indicators database, January 2011.

base is weak and unevenly distributed among firms in the region. As a result, the mismatch of absorptive capability among firms in the region can hardly generate knowledge spillover to stimulate the cross-fertilization among the firms. Furthermore, the linkages between universities, research institutes and business firms are fairly weak.

3) Reliance on external sources for innovation. The globalization process is transforming from vertical disintegration within a lead company to organizational fragmentation, which spreads more widely into low-cost regions, and thus exerts network control on the upgrading and innovation of firms in China. Codified Technology transfer embedded in import goods as well as codified and tacit technology transfer from multinational corporations is, therefore, a fundamental source of innovation.

4) Unstable institutional system. In China, the market mechanism is not fully developed and the institutional environment is undergoing a continual transition process. In this context, firms face unexpected costs and risks which inhibit them from engaging in long-term innovation activities. Moreover, local protectionism shrinks the market size and expected innovation return, which reduces to a certain degree the incentive of firms to innovate.

5) Informality. In the uncertain environment in China, firms tend to apply an informal network-based strategy. The informal relations among firms, which are mostly sustained through Guanxi networks with relatives, friends and business partners, have contributed to the flexible and responsive production which has further strengthened China's low-cost manufacturing strategy. Providing a maturing and balanced development of the absorptive capacity of Chinese firms, informal networking is likely to play a more important role than the formal institutional framework in constructing regional orders that facilitate the distribution and exploitation of external advanced knowledge.

1.2.1 What does Regional Innovation System imply in China?

The term 'regional innovation system' is widely understood as "interacting knowledge generation and exploitation sub-systems linked to global, national and other regional systems for commercializing new knowledge" (Cooke, 2004: 3). Braczyk *et al.* (1998) proposed a two-dimensional structure for understanding the function of this territorial sub-system, consisting of the governance infrastructure and

the business superstructure. The governance infrastructure supports the competitiveness of firms' business performance and linkages towards each other and the outside world with orders that stabilize the interacting process of knowledge generation and exploitation, encompassing physical organizations such as research competence, education, funding and technological transfer agencies as well as socio-institutional rules and norms.

As indicated in the above discussion on the characteristics of innovation in China, the regional innovation system is still weak due to the scarcity of innovation-related resources, capabilities and institutions. As the production activities are highly dependent on the foreign direct investment in the developed coastal regions of China, the prospect of a well-functioning regional innovation system lies in its capacity to capitalize on the external linkages for commercializing new knowledge. Figure 1.1 graphically demonstrates the implication of a well-functioning regional innovation system within this context in China. It consists primarily of two general aspects: the exploitation by firms of both the external knowledge (mainly from foreign investment) and the local interdependency for enhancing the competitiveness (Asheim and Isaksen, 2002).

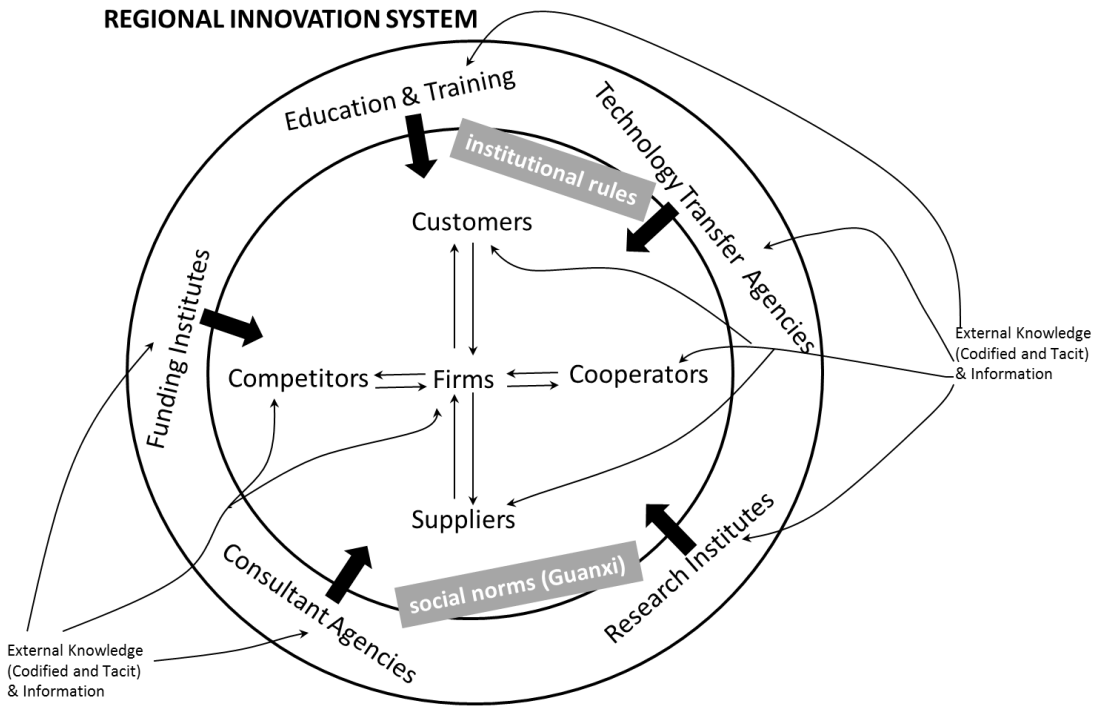


Figure 1.1 Conceptual Regional Innovation System

Source: own draft based on Cooke *et al.* (1997), Cooke *et al.* (2004)

Firstly, the regional specialized clusters in China should consistently source codified and tacit technological knowledge from the distant parent companies and foreign customers, feeding the regional innovation system with new knowledge and information. Therefore, the strategies of foreign affiliates of upgrading the value chain and introducing advanced technology, as well as the local firms' capacity to capitalize on organizational proximity with global lead firms in order to foster innovation, come into the center of the investigation.

Secondly, supported governance infrastructure (which Storper, 1995, also refers to as untraded interdependency) should be established to shape the localized cross-fertilization process, tapping into the increasing return on the knowledge spillover sourced externally. Because most of the import technology is concerned with complex products and processes, such as in the electronics and machinery industries, interactive and systemic actions should be in place to ensure fruitful knowledge exploitation. Fromhold-Eisebith (2002) calls it the "regional cycles of learning" that promotes the dissemination of know-how from foreign multinational branch plants. The interactive learning takes place either through vertical linkages (between customers and suppliers) or through horizontal linkages (with cooperators or even competitors). In general, the physical organizations in the governance infrastructure interact with the business sector and support them with necessary information and knowledge. Therefore, the formation of interactive learning activities in the sub-system is crucial for the distribution and joint-exploitation of external knowledge. Moreover, the informal Guanxi networks in the previous former discussion may be play a role as part of the social rules promoting the interactive learning activities.

In summary, three key terms can be derived from the discussion of the implication of RIS in the Chines context: linkage to external knowledge, interactive learning process and supported governance infrastructure. In the next section, the research questions will be formulated to tap into these issues.

1.3 Aim and Research Questions

OECD (2005) points out that the innovation process, rather than of innovation results, should become the analytical focus of the innovation studies in developing countries. Based on the previous discussion, innovation studies in China should have a systemic perspective instead of a linear one, which focuses on the distributing and

exploiting process of the regional innovation system. Following the previous line of argument, this thesis aims to contribute to the existing literature on regional innovation systems in three respects:

Firstly, the study aims to explore analytically and empirically the channels of external knowledge spillovers that are able to trigger the local-scale knowledge spillover. As defined by Cooke (2004: 3), a regional innovation system "consists of interacting knowledge generation and exploitation sub-systems linked to global, national and other regional systems for commercializing new knowledge". As stated previously, it is assumed in this study that the formation of a regional innovation system in latecomer regions depends on the regional capacity to disseminate and exploit the external knowledge. Therefore, a starting point in the territorial innovation studies in latecomer regions is an analysis and investigation of the possibility of the triggering effect from the inflowing external knowledge that creates dynamic externalities in the region, on which increasing returns are achieved through interactive learning and systemic innovation.

Secondly, the study aims to expand the understanding of the role of informality in reducing transaction costs further, through to its role in reducing uncertainties and risk faced with innovation activities. Especially in the context of China, the Guanxi network, which is widely applied in Chinese business modes, has been proved by many studies to have a positive role in reducing transaction costs (Luo, 2002; Zhou *et al.*, 2003; Wu and Choi, 2004; Meyer *et al.*, 2009). However, a dichotomous pattern in the application of informal Guanxi networks in China might exist. On the one hand, Guanxi networks are applied by the local suppliers to sustain reliable supplier-customer relationships as well as to achieve flexible and responsive production. On the other hand, innovation activities are kept within the formal hierarchical framework in the global production network, i.e. the innovation ideas and resources rely heavily on the parent companies or foreign customers. In this study, it is only when the informal Guanxi network serves as an important aspect of "regional orders" to incentivize and promote the interactive learning and systemic innovation, that it is considered to contribute to the emergence and performance of a regional innovation system in China.

Finally, this study aims to explore the spatial differences in the pattern of innovation activities. The degree and characteristics of a regional innovation system depend on a specific set of institutions and organizations. Therefore, spatial

heterogeneity in the provision of governance infrastructure results in different patterns of innovation activities, which refer to the scope and effect of interactive learning. Moreover, an evolutionary perspective will be applied in this investigation, as the regional innovation system is an evolving process in which dynamics and inertia consistently emerge with the changing market and technological environment.

In order to achieve the research aim, the following key research questions will be addressed:

Theory-guided questions:

- T1: How and under what circumstances do knowledge spillovers sourced externally trigger knowledge spillovers on the local scale, enabling the formation of regional innovation systems in latecomer export-oriented regions?
- T2: Why do firms undertake interactive learning with external partners in the decision-making and implementing process of innovation activities?
- T3: What is the role of social proximity and organizational proximity in interactive learning activities in latecomer export-oriented regions?
- T4: What leads to the dynamics and inertia of regional innovation systems under different governance infrastructures?

Empirical-guided questions:

- E1: Have local-scale knowledge spillovers have come into being to sustain long-term development in the face of a changing and fragile post-crisis global market in the export-oriented Guangdong Province, China?
- E2: Which aspects of absorptive capacity enable the electronics firms to undertake interactive learning with external partners through strategies of using organizational proximity and social proximity in the product innovation process?
- E3: How is interactive learning organized in the burgeoning regional innovation system? To be more specific, does interactive learning embed more in socially proximate networks or in organizationally proximate networks?
- E4: What is the effect of interactive learning in general on innovation outcomes? And what is the effect of interactive learning embedded within socially proximate networks and organizationally proximate networks on

innovation outcomes respectively?

- E5: How do regional innovation systems in Shenzhen and Dongguan, China, differ from each other in the scope and effect of interactive learning, considering that the two cities are evolving towards regional innovation systems under different governance infrastructures in the initial industrialization phase?

Policy-guided questions:

P1: What policy implications can be drawn from the previous answers from the theoretical and empirical perspectives to further enhance the innovation capability of firms and regions in China?

1.4 Outline

The thesis is organized according to three dimensions: the meso-level investigation, the firm-level investigation and the firm-regional level investigation. Chapter 2 firstly provides a theoretical framework for analyzing the overall impact of knowledge spillovers - within the same industry locally, across different industries locally, and through global linkages - on the performance of innovation and technological upgrading within the context of a latecomer export-oriented region. Based on the stylized facts on technological upgrading in one of the most export-oriented areas, the Guangdong Province of China, this chapter further collects empirical evidence of the triggering effect of external knowledge spillover on the local-scale knowledge spillover by applying a meso-scale secondary data set in the Guangdong Province.

In order to reveal the pattern of local-scale knowledge spillover, Chapter 3 further explores the micro-firm-level evidence of the upgrading and innovation activities among the electronics firms in the Pearl River Delta, China. It elucidates the logic behind the interactive process of innovation activities and discusses the role of informal Guanxi networks on interactive learning in China. In this chapter, the empirical investigation focuses on whether a wider scope and higher intensity of interactive learning activities would promote the innovation outcomes. Moreover, initial insight will be provided on the application of informal Guanxi networks as

electronics firms undertake interactive learning activities in the Pearl River Delta, China.

Chapter 4 is the second study at the firm-level, strengthening the argument in Chapter 3 on the role of interactive learning for electronics firms in the Pearl River Delta, China. It extends the understanding of interactive learning within the proximity concept and further investigates the capacity of electronics firms in the Pearl River Delta to capitalize on social proximity and organizational proximity respectively in the process of product innovation. As technology transfer and learning has relied heavily on organizational proximity to leading global firms ever since the initial industrialization in the Pearl River Delta, insights into the burgeoning regional innovation system are expected, as firms are gradually taking the initiative to capitalize on social proximity with many other business partners in the process of interactive learning and systemic innovation.

The investigation of the spatial difference with which the electronics firms under take interactive learning is introduced in Chapter 5. In this chapter, the general regional orders, i.e. the governance infrastructure that incentivizes and supports the systemic innovation at the territorial level, is the study focus. Moreover, an evolutionary perspective towards governance infrastructure will be taken. Adapted to the Chinese circumstance where the regional innovation system is just burgeoning, the evolutionary lens expands to the transition from governance that supports initial industrialization to the governance that supports the innovation activities. As comparative study is the most important means of fully understanding the function of regional innovation systems and capturing hidden variables that are of interest to its construction (Staber, 2001; Doloreux, 2002; Dolereux, 2004, Asheim and Coenen, 2005), an inter-city comparison of the governance evolutionary paths and the resulting innovation pattern between Shenzhen and Dongguan, China, will be made in order to gain these insights.

On the basis of the previous three theoretical discussions as well as empirical insights, the concluding Chapter 6 will provide answers to the key research questions. Furthermore, the limitations of this study and future research directions will be reflected upon and formulated. Finally, policy implications for further strengthening the innovation capability in China will be discussed.

Table 1.1 Schematic Overview of Chapters

CHAPTER 1 Introduction: Research Context, Key Concepts and Aim	
EMPIRICAL INVESTIGATION	
Meso-level Evidence	CHAPTER 2 Knowledge Spillovers and Technology Upgrading: The Case of the Guangdong Province, China
Firm-level Evidence	CHAPTER 3 Interactive Learning and Systemic Innovation in the Pearl River Delta, China: Firm-level Evidence from the Electronics Industry
	CHAPTER 4 Absorptive Capacity, Proximity and Innovation: Insights from an Electronics Firm Survey in the Pearl River Delta, China
Firm-regional Insights	CHAPTER 5 From Globalized Production System to Regional Innovation System: Governance and Innovation in Shenzhen and Dongguan, China
CHAPTER 6 Conclusions: Answers, Limitations and Policy Implications	

1.5 Survey Data and Evaluation

Except for Chapter 2, which applies the secondary data in the Guangdong Province, China, the empirical data for the rest of the investigation (Chapters 3-5) is a set of standardized questionnaire data on electronics firms in the Pearl River Delta, China. The electronics industry was chosen because it is not only dominant in the industrial structure in the Pearl River Delta (Figure 1.2), but is also facing the greatest upgrading pressure due to rapid technical change and market expansion.

The survey targeted electronics firms at three different types of locations for a deeper understanding of different phases of regional development: 1) the first ring city Shenzhen, where the share of the output value is over 47% of the electronics industry in the Guangdong province, and where many indigenous firms are thriving; 2) the second ring city Dongguan, where the share of the output value is over 12% and was developing quite rapidly in the late 1990s; 3) the third ring cities represented by Huizhou and Heyuan together, where the share of electronics is smaller, but is now developing due to the expanding, relocating and outsourcing activities in Shenzhen and Dongguan.

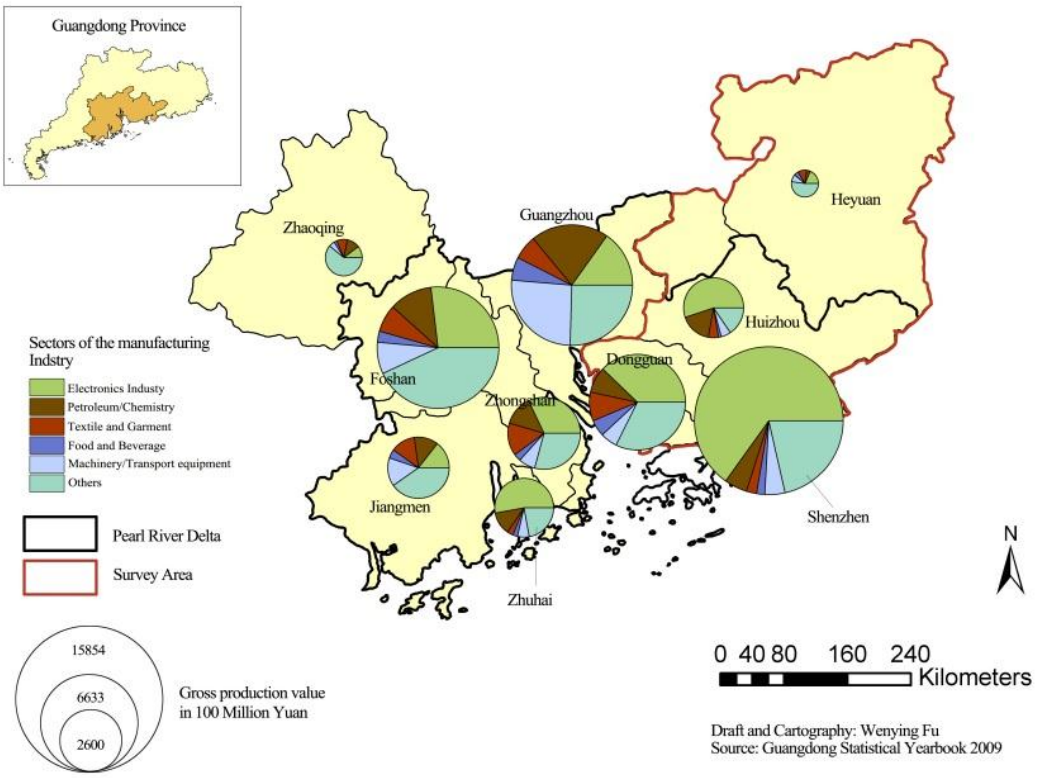


Figure 1.2 The Electronics Industry in the Pearl River Delta, China

Source: Own draft based on Guangdong Statistical Yearbook 2009

After the discussion with local experts at Sun Yat-sen University and based on the experience in a similar previous survey, the research team decided to conduct the company questionnaires via telephone and mail in order to ensure the feasibility of the survey and validity of the data. It is difficult to get all the questions answered correctly in a limited amount of time in a face-to-face interview, since our questionnaire covers a wide range of company operations from strategic management, marketing, sales, research and development, employment and training (for the final version of the questionnaire please refer to Appendix A), and the respondents needed time to search and consult others while filling out the questionnaires. The telephone and posting method was strengthened by a follow-up process, which aimed to remind and persuade the firms to fill out and send back the questionnaires as well as filling out unanswered questions after the questionnaires had been returned.

Our survey was conducted from September to November 2009. In this period, many electronics firms were recovering from the crisis and were quite busy with

employing new workers and devoting attention to production. This caused difficulties for our telephone and posting survey because the firms were too busy to pay much attention to us. In order to establish contact with firms, we applied the second method: trade fair visiting. We randomly selected the trade fairs and the firms there, and distributed the questionnaires at the fairs. Because of face-to-face communication, the managers (or people in a high position) felt more embarrassed refusing us than over the telephone. If they were able to answer the questionnaires on site, then we received them back immediately. If they needed some time to consult the boss or related departments about precise information, we asked them to send the answers back to us and carried out the follow-up process.

We cooperated with Sun Yat-sen University to conduct the company survey. Senior graded Bachelor and Master students were trained and employed to assist two of our doctoral candidates on site.

As for the survey in Shenzhen, the sampling frame was mainly the Guangdong Electronics Firm Directory 2010. There are about 2000 Shenzhen electronics firms in this directory, and we applied a random sampling method to select the firms to contact. Within a month, we contacted over 1000 firms, sent 202 questionnaires and received 68 questionnaires back. The students were then asked to recheck the completeness and correctness of the returned questionnaires, and we sent a gift to the responding firms to thank them and also to ensure the success of the follow-up process. Questionnaires were then further improved using the follow-up calls. In order to expand the sample size, we also attempted to contact firms at the fairs. In the spirit of random sampling, we visited three fairs and selected the exhibitors randomly. We firstly visited the 12th International Computer Communication and Consumer Products Expo (Dongguan, China) and received the agreement of 28 firms to fill out the questionnaires（44 Shenzhen firms in total in the fair）. We eventually received 23 completed questionnaires. The second one we visited was the 1st China (Shenzhen) International Industrial Fair. There were 145 exhibitors in the electronics field at this fair. We have received the agreement of 32 firms to fill out the questionnaires, and eventually received 29 completed questionnaires. The third fair we visited was the 12th China (Shenzhen) Hi-tech Fair. There were 129 exhibitors in the electronics field at this fair. We received the agreement of 50 firms to fill out the questionnaires, and finished with 47 completed questionnaires. The response rate at the fairs seems to

have been better than that of the post due to face-to-face communication. In total, we received 167 completed questionnaires in Shenzhen.

As for the survey in Dongguan, we firstly contacted the firms which answered our questionnaires in the first phase and established a long-term relationship with us. We contacted 31 firms and had 18 questionnaires completed. We then visited the 12th International Computer Communication and Consumer Products Expo (Dongguan, China). There were about 500 Dongguan electronics firms attending the fair, which is 56% of all electronics firms in Dongguan. In a sense, attending this fair was a political task of the town governments assigned from the Dongguan city government because 3C fair is a city card for Dongguan. Dongguan firms received considerable incentives from the town governments to attend this fair. Therefore, the representation of the Dongguan exhibitors was quite good and ensured the unbiased nature of the fair visiting result. We distributed 250 questionnaires there and received 159 completed questionnaires.

As for the survey in the third ring cities Huizhou and Heyuan, the sampling frame was the Huizhou Electronics Firm Directory 2010 and the Heyuan Electronics Firm Directory 2010. There are 590 and 90 electronics firms in these directories respectively. However, the quality of both directories is fairly low. The repetitiveness is quite high and the accuracy of the information is low. Many telephone numbers do not exist or were constantly engaged. We went through all the available firms. We eventually received permission from 178 Huizhou firms and 22 Heyuan firms to send the questionnaires. 67 questionnaires were returned back from Huizhou and 11 from Heyuan.

Table 1.2 Response rate in different cities and occasions

		Shenzhen	Dongguan	Huizhou	Heyuan
Telephone and posting	Survey firms	68	18	67	11
	Contacted firms*	202	31	178	22
	Response rate	34%	58%	38%	50%
Fair visiting and posting (or reclaiming on site)	Survey firms	99	159	–	–
	Contacted firms*	110	250	–	–
	Response rate	90%	64%	–	–

PS: contacted firms refer to firms which permitted us to send the questionnaires or agreed to fill out the questionnaires at the fairs.

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

The sample distributes quite equally between the first and second rings, while in the third ring, we received a smaller sample. There are two main reasons. Firstly, the total number of electronics firms in Huizhou and Heyuan is much smaller than that of Shenzhen and Dongguan (Table 1.3). The sample size has significantly limited the possible results. Secondly, the firms in Huizhou and Heyuan are much more informal and small-scale, and it is very difficult to establish contact with the bosses or managers. In some cases, the managers could not even understand the questionnaires after our explanation. Besides a lower education level, the cooperating attitude also tends to be lower in the third ring cities.

Table 1.3 Sample distribution (2009)

	Shenzhen	Dongguan	Huizhou	Heyuan
Survey firms	167	177	67	11
Number of Electronics firms in 2009[1]	1922	860	303	32

1. It refers to Manufacture of Communication Equipment, Computers and Other Electronic Equipment above designated size include all state-owned firms and firm with over five million sales

Source: Own survey conducted in DFG SPP 1233 [2009] and Guangdong Statistical Yearbook 2010

Due to the financial crisis, the telephone and posting methods we applied in the first phase encountered difficulties. Firms were eager to earn money after a long period of operation pause. The strategic development plan we offered to them afterwards seemed less attractive in this period. The fair visiting and posting (or reclaiming on site) method had a higher response rate under these circumstances. However, the more biased nature of the fair visiting method should be carefully managed. The large share of the exhibitors in the industry in the specific city (such as the Dongguan 3C Expo) can ensure the representativeness of the sample. If this cannot be assured, then the number of fairs visited should be enough to ensure the total quantity of exhibitors to balance the bias.

Table 1.4 presents the comparison between the survey sample and the whole population in Guangdong Province according to firm size and firm ownership. In terms of firm size, the sample and the population do not differ in a significant value of 0.01, but in a significant value of 0.05. However, the difference is quite small (5%) in spite of having a significant value of 0.05. Moreover, it is only possible to stratify the firm size in the sample according to sale and employment, leaving another important criteria, the asset value, unconsidered compared to the official statics in the whole

population. If asset value is considered, which is more difficult to achieve, the share of large and medium-sized firms would have been smaller in the sample. In the official statistics, one cannot differentiate between large firms and medium-sized firms, while large firms only take 7% of the whole sample according to the criteria of sale and employment, leaving most of the firms as small and medium-sized. The same goes to the distribution of firm ownership in the sample and the whole population, in which the sample has a slightly larger share (6%) of domestic firms than the whole population in a significant level of 0.05.

Table 1.4 Comparison between Sample and Population based on Size and Ownership

		Sample (n=422)	Population[1] (N=4645)
Firm size[2]	Small firms	286 (68%)	3386 (73%)[4]
	Large and medium-sized firms	135 (32%)[3]	1259 (27%)
	[a] χ^2=4.765 , p=0.029		
Firm ownership	Domestic firms	217 (52%)	2153 (46%)
	Foreign firms[5]	204 (48%)	2492 (54%)
	[a] χ^2=4.181 , p=0.041		

1. It refers to Manufacture of Communication Equipment, Computers and Other Electronic Equipment above designated size include all state-owned firms and firm with over five million sales in Guangdong Province.
2. Large and medium sized firms refers to firms with no less than 30 million Yuan sales, no less than 300 employees and no less than 40 million Yuan assets
3. In the sample, large and medium sized firms refers to firms with no less than 30 million Yuan sales and no less than 300 employees
4. Numbers in the parentheses indicate the share of the firms.
5. Foreign firms refer to wholly foreign-owned, Chinese-foreign equity and Chinese-foreign cooperative firms.

Source: Own survey conducted in DFG SPP 1233 [2009] and Guangdong Statistical Yearbook 2010

Overall, the survey sample in this study is slightly biased towards domestic and medium-sized firms. The biased problem can be partly attributed to the small share of sample in the whole population, which is less than 10%. This statistical problem is explained as the "Jeffrey's paradox" (Jeffreys, 1939), in which the population in this case is too large to lead to a significant level even if the difference is uncritical (about 5%). In fact, the χ^2 test is somewhat sensitive in the survey. If it has been managed to reach 18 more small firms in the sample (304 in total), for example, then the χ^2 test is not able to sustain in the significant level of 0.1. Similarly, theχ^2 test does not sustain

in the significant level of 0.1 if it has been managed to reach 9 more foreign firms in the sample (213 in total).

Therefore, conclusions can be generalized to the whole population in the Pearl River Delta by focusing the study on the effect and ways of undertaking interactive learning in the innovation process, given the fact that the difference in size and ownership distribution is very small even although in a statistically significant level. Nevertheless, it should be still dealt with cautiousness to compare the size group and ownership group in the sample and to draw conclusions merely by descriptive statistics.

2 Knowledge Spillovers and Technological Upgrading:

The Case of the Guangdong Province, China

Abstract: This chapter aims at analyzing the impact of knowledge spillovers through international channels, namely foreign direct investment (FDI) and trade on the technological upgrading in Guangdong province, China by using the panel data of 21 municipalities for the period of 2000-2008. The results show strong evidence of external knowledge spillover as effective trigger of local-scale knowledge spillover in the latecomer regions, which mainly takes place within the industries other than the one between industries. The chapter also demonstrates that the impact of external knowledge spillover is closely related to the investment stock, the degree of embeddedness and the absorptive abilities of local firms, and thus differs in different development phase. At the end, this chapter points out the future study should go further to explore microeconomic aspects of technological upgrading in the firm-level.

Keywords: Knowledge Spillover; Technological Upgrading; Latecomer; Foreign Direct Investment; Trade

2.1 Introduction

In recent decades, the role of knowledge spillovers in generating endogenous growth and determining world development patterns has gained considerable attention in the literature of economic growth. Knowledge spillovers are particularly effective in cities; more than explaining the mere existence of cities, as static externalities do, knowledge spillovers explain the growth of cities (Glaeser, 1999). Moreover, aside from explaining regional economic growth from the perspective of cost savings, such as savings on transportation and intermediate inputs (Hoover, 1937; Carlton, 1983; Krugman, 1991), as static externalities do, knowledge spillovers refit externalities in a dynamics way and suggest that innovation investment bears increasing returns because it contributes to a general stock of knowledge upon which neighboring firms or latecomer firms can build (Jacobs, 1969; Romer, 1986; Lucas, 1988; Glaeser, 1999).

Glaeser *et al.* (1992) provide evidence on two kinds of externalities on the local scale in the growth of cities, spurring much research attention. However, so far, research

findings on knowledge spillovers are unclear (Feldman, 2000). On one hand, it has been proven that specialization stimulates growth. Henderson and Cockburn (1996) report significant knowledge spillovers among pharmaceutical firms originating in America and Europe, and Henderson (2003) finds significant knowledge spillovers in high-tech industries. On the other hand, specialization is suggested to hinder growth in some way, and the positive impact of diversity has already been proven. Glaeser *et al.* (1992) discover that knowledge spillovers across industries—rather than within the same industries—help boost employment in a period of deindustrialization, particularly in traditional industrial US cities. Miraky (1994) suggests that industrial concentration somehow displays a negative effect on growth. Feldman and Audretsch (1999), and Rosenthal and Strange (2003) also confirm the benefits of diversity.

Research results vary due to different samples in different time and space (Combes, 2000; Smit *et al.*, 2007). However, generally, knowledge spillovers within the same industry primarily induce incremental innovation, whereas knowledge spillovers across industries are conducive to disruptive innovation. Neffke *et al.*'s (2008) discourse on the impact of different kinds of knowledge spillovers in the industrial life cycle proves this statement. The discourse suggests that knowledge spillovers take place across industries when industries are young and renewing, whereas knowledge spillovers within the same industry is more prevalent when industries grow and mature. However, the above literature lacks an open perspective in the era of globalization. Branstetter (2006) finds that Japanese foreign direct investments (FDIs) in the United States result in two-way knowledge spillovers between the two countries. Boschma and Iammarino (2009) conduct a systematic measurement of knowledge spillovers on the local and global scales in Italy, and find that a high variety of knowledge flowing into the region contributes to regional economic growth. Aside from knowledge spillovers in the developed world, knowledge spillovers between developed and developing countries are also examined and considered as a key mechanism for conditional convergence, as suggested by the theory of endogenous growth. Coe *et al.* (1997) examine the relationship between trade and growth in 77 developing countries, and find substantial knowledge spillovers from the industrial North to the developing South. Javorcik (2004) proves productivity spillovers induced by FDIs across industries in Lithuania, which are realized through forward and backward linkages.

Based on the literature review, this chapter argues that with easier access to external advanced knowledge and requisite absorptive ability on the local scale, it is very

possible for latecomer regions to seize the inflow of external knowledge, thereby triggering knowledge spillovers on the local scale, which are likely to create stronger regional innovation systems to sustain long-term economic growth.

This chapter contributes to the literature in two aspects. First, I put knowledge spillovers on both local and global scales in the latecomer context within a theoretical framework, and discuss how knowledge spillovers on the global scale trigger knowledge spillovers on the local scale. Second, evidence on knowledge spillovers, which underlies innovation and economic growth in the modern economy, is further collected within the latecomer context. Moreover, after the global financial crisis and the gradual recovery of some developing countries, such as those in East Asia (Thorbecke, 2009), it is important to examine whether the local dynamics of economic development, such as active knowledge spillovers, has come into shape to sustain long-term development in the face of a changing and fragile post-crisis global market.

The study area is Guangdong province in South China. I select the province based on two arguments. First, Guangdong has developed quickly after the opening of the Chinese economy by having successfully attracted labor-intensive production. Latest statistics in 2008 show that FDI in Guangdong accounts for 23% of the national figure, and Guangdong's total import and export volume accounts for about 27% of the national volume (Guangdong Provincial Bureau of Statistics, 2009). Second, since China's transition from a planned economy to a market economy in 1978, technological activities, such as investments in upgrading machines, processing innovation, and upgrading products, have become increasingly prevalent among enterprises in Guangdong (Wang, 2008). These factors justify the choice of Guangdong for testing the existence and impact of knowledge spillovers after decades of development.

The chapter has the following structure. Section 2 provides a theoretical framework for analyzing the overall impact of knowledge spillovers—within the same industry locally, across different industries locally, and through global linkages—on the performance of technological upgrading within the context of a latecomer region, such as Guangdong. The section also derives hypotheses for empirical testing. Section 3 collects stylized facts on technological upgrading in one of the most developed areas in China. Section 4 builds an econometric model, and explains the variable selection and data collection processes. Section 5 reports the results. Finally, Section 6 provides the conclusion and discusses ways to further extend our understanding of knowledge spillovers.

2.2 Technological Upgrading: Impact of knowledge spillover on the Local and Global Scales

In the management literature, technological upgrading is mainly determined at the firm level. For example, firms that set long-term technological development strategies and devote much of their resources to R&D activities are assumed to achieve better technological capabilities. The success of the Korean industry proves this assumption. The Korean government has created favorable policies in "preferred industries"; it has ensured efficient scale economies through mergers, project-specific financial support, and domestic market protection (Chang, 1993). Combined with their own R&D efforts, Korean companies have finally upgraded to a higher industrial value chain and established modern industries, such as the automobile and electronics industries.

However, firm-level internal efforts cannot explain two phenomena. First, regions with many small firms, such as Third Italy, which lack the financial ability to support internal R&D, perform quite well in technological upgrading (Storper, 1995). Moreover, mutual trust among firms constitutes the fundamental basis of long-term cooperation, facilitating knowledge exchange and stimulating growth. Second, firms with the same endowment and efforts in technological upgrading usually perform differently in different locations. All of these suggest that the external environment plays an important role in determining the technological capabilities of firms.

To explain these phenomena, I focus on three perspectives on knowledge spillovers. These perspectives are concerned with technological externalities achieved through knowledge spillovers that enable firms to benefit from each other's internal efforts. The first two knowledge spillovers, which take place within and between industries on the local scale, have been properly modeled and surveyed by many scholars (Loury, 1979; Glaeser *et al.*, 1992; Asheim, 2000; Neffke *et al.*, 2008). The third knowledge spillover deals with externalities on the global scale (Grossman and Helpman, 1990; Branstetter, 2001; Javorcik, 2004; Branstetter, 2006), which are highly important for firms in latecomer countries, where spillovers from neighboring firms are quite limited.

The flow of ideas is intrinsic to the new knowledge production system that underpins economic growth (Lucas, 1988). Glaeser *et al.* (1992) suggest that people agglomerate in high-rent cities because they benefit from learning opportunities. In this respect, it is assumed that physical proximity facilitates information transmission. Marshall–Arrow–Romer's (MAR) externalities and Jacobs' externalities focus on spillovers on the local

scale.

The MAR externalities were developed by Arrow (1962) and Romer (1986) based on Marshall's (1920) agglomeration theory. Marshall's agglomeration theory states that firms in the same industry agglomerate to benefit from knowledge spillovers. Moreover, their agglomeration is a cost-saving strategy in their search for intermediate goods and skilled workers. Arrow further expands the theory by stressing the role of knowledge spillovers between workers within the same working area, and notes that experience and learning by doing are vital to endogenous technical changes. Romer's work asserts that knowledge stock generates increasing returns; thus, specialization is conducive to long-run growth. According to Glaeser's (1999) argument on learning in cities, cities filled with young people who can learn only from skilled members in their own industries tend to be specialized. The concept of proximity further explains the function of specialization. Moreover, geographical and cognitive proximity works in the knowledge spillover process. Cognitive proximity in the same industry assures the basic absorptive ability of firms to assimilate and improve transmitted knowledge; the transmission of knowledge is facilitated by geographical proximity. Generally, knowledge spillovers within industries accelerate the generation of know-how and lead to incremental innovation; this is prevalent in traditional industrial districts (Amin, 2000). The success of the computer chip industry in Silicon Valley proves the positive relationship between specialization and technological development. Skilled workers "meet, chat, and eavesdrop" and labor flows across firms, thereby spreading ideas quickly among co-locating firms.

Meanwhile, Jacobs (1969) holds a different opinion on the way knowledge spillovers take place. Jacobs' externalities stress the diversity of industries as an important factor causing human capital spillovers and the formation of new ideas. Unlike Arrow's statement that human capital is enhanced by interaction in the same line of work, Jacobs suggests that cross-fertilization across different lines of work enhances human capital in cities. The vivid examples given by Jacobs are new forms of adhesive tapes developed by a sand mining company, brassiere invented by a dress maker in New York, and Japanese bicycle repair shops gradually moving into bicycle manufacturing. Boschma (2004) further develops this argument by evolutionary thinking, stressing that knowledge diversity is a key factor determining the effective interaction of actors in territories and preventing the negative "lock-in" effect of specialization. In other words, diversity brings two benefits: knowledge spillovers across different industries, and the

portfolio effect that makes regions resilient to external shocks. However, a diversified economy may lead to the lack of focus on general services, such as administrative services, advertising, and legal consultation (Neffke *et al.*, 2008). On the other hand, a specialized economy enables local governments and professional service providers, such as marketing and accountancy firms, to create tailor-made services.

Neffke *et al.* (2008) discuss the relationship between the industrial cycle and externalities. They conclude that MAR externalities are vital to growing and maturing industries when technological activities focus on improvement, whereas Jacobs' externalities are vital to emerging new industries when technological activities focus on innovation and change. Under MAR externalities, experience and learning by doing seem to play a considerable role only when specific technological standards and paradigms are established in the industry. Glaeser (1999) also argues that diversification tends to be lower in cities when imitation is more feasible. In contrast, at the onset of new industries, various new products emerge in the market to compete fiercely because standardization does not yet occur (Gort and Klepper, 1982). Therefore, for an infant industry experiencing rapid technological changes, the need to absorb different fields of knowledge to spur ideas and innovations is imperative, and Jacobs' externalities are more important in this case.

Based on the foregoing discussion on knowledge spillovers on the local scale, the first hypothesis is drawn:

Hypothesis 1: In many latecomer regions where technological improvements are prioritized, knowledge spillovers within industries, which stimulate the process of learning by doing, contribute more to technological upgrading than knowledge spillovers across industries.

At the early phase of industrialization, it is difficult to realize knowledge spillovers on the local scale due to a weak local industrial base and an unbalanced knowledge distribution among firms, which altogether hinder the functioning of knowledge spillover mechanisms. Knowledge spillovers are realized mainly through four mechanisms: inter-firm collaboration, inter-firm cooperation, spin-off, and talent mobility. In the first two mechanisms, firms should have developed their own core technological capabilities, enabling collaboration with customer firms or supplier firms, as well as cooperation with firms producing similar products. This ensures the reciprocal exchange of respective knowledge stocks. If firm-level technological capabilities are not fully and consciously developed, and those between firms are not equivalent and

supplementary, firms would be less inclined to exchange knowledge due to the lack of mutual benefits. Similarly, spin-off activities happen only when parent firms have mature technological paradigms and particular sets of technological capabilities, enabling key employees to exploit the existing knowledge by establishing new organizations. For the last mechanism, transfer by skilled workers and talents, its effective functioning is also determined by a high level of educational and professional skills and human capital, which is difficult to achieve at the early phase of industrialization due to the higher percentage of employment in the agricultural sector.

External knowledge spillovers can trigger knowledge spillovers on the local scale through the abovementioned mechanisms. The importance of external linkages in technological upgrading has attracted much attention within the latecomer context (Coe *et al.*, 1997; Humphrey and Schmitz, 2000; Falvey *et al.*, 2004; Javorcik, 2004; Revilla Diez and Kiese, 2006). Revilla Diez and Kiese (2006) conduct a comparative study between Southese Asia and European countries, and suggest that the strong orientation in R&D centers of multinational corporations in the industrialized city-state of Singapore, as well as in the cities of Penang and Bangkok, results in industrial development leapfrogging. Humphrey and Schmitz (2000) also demonstrate that quasi-hierarchical relationships with globally leading firms increase the chances of embarking on rapid product upgrading. Meanwhile, Oro and Prichard (2010) argue that Japanese-led firms, under captive governance, facilitate the flow of advanced technology and tacit know-how from Australia to Japan, satisfying the high domestic demand for premium beef.

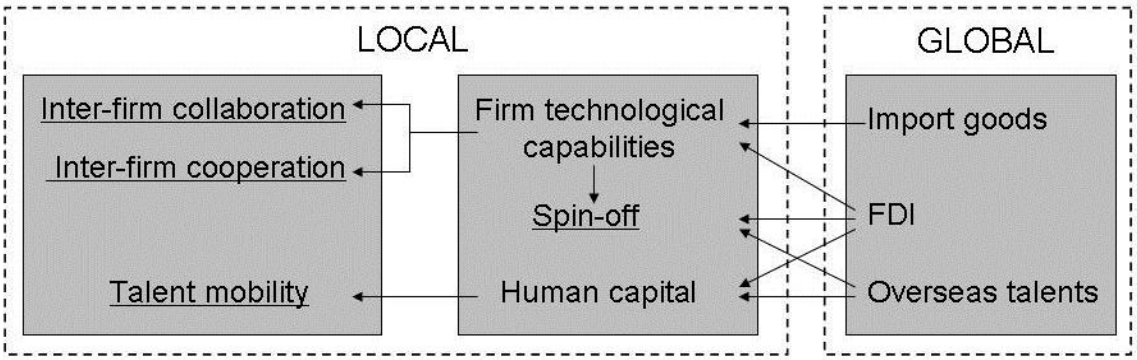
External knowledge spillovers in latecomer countries take place in three ways: trade, FDIs, and overseas talents. Figure 2.1 illustrates the logic of how external knowledge spillovers trigger local-scale knowledge spillovers. These ways can trigger the mechanism of local knowledge spillovers either directly or indirectly (the underlined words in the figure indicate the four mechanisms of local knowledge spillovers).

First, trade transmits knowledge embedded in imported goods. Imported goods from industrialized countries serve as advanced product samples for reverse engineering, and boost intra-firm learning as a process of shaping the technological capabilities of particular firms. The enhancement of technological capabilities further enables inter-firm collaboration and cooperation, inducing knowledge spillovers between firms, as well as triggers spin-off activities that further exploit the value of enhanced capabilities. However, one point must be stressed: the impact of the importation of

intermediate goods and capital outweighs that of the import of final goods. This requires careful indicator selection and explanation in establishing our research model.

Second, FDI generates a large production network in latecomer countries and helps related firms, such as subsidiaries, original equipment manufacturer (OEM) suppliers, and non-OEM suppliers, not only by linking them to fiercely competitive places in low-cost regions, but also by introducing, interpreting, and instructing production know-how and product-specific technologies to these firms. As such, technological capabilities are strengthened, enabling the functioning of the three mechanisms of local knowledge spillovers as shown in Figure 2.1. Ivarsson and Alvstam (2005) study Volvo plants in many developing countries, and assert that geographical proximity to Volvo enables local suppliers to absorb external technology successfully. In addition, FDI demonstrates the effect of training. Through training, the technical, market, and managerial knowledge of people who once worked in foreign or foreign-related firms is increased. Employees with improved technical knowledge and who are lured by higher salaries in other local firms carry knowledge to these firms, triggering the functioning of the talent mobility mechanism. Meanwhile, employees with improved market and managerial knowledge might seize one of the technological opportunities in their parent companies and establish new firms to exploit the market potential of a particular technology, triggering the functioning of the spin-off mechanism.

Last but not the least, the inflow of overseas talents not only increases the quality of human capital on the local scale but also induces spin-off activities under an effective incentive framework offered by the local government. Incentives are provided to attract overseas entrepreneurs, leading to the introduction of latest technologies in the local market. Overseas talents may even establish dynamism between developing home countries and the developed world thorough their personal networks in both places. This is made possible by the existence of “technological communities,” a concept introduced by Saxenian and Hsu (2001). The overwhelming development of Hsinchu high-tech cluster in Taiwan is greatly supported by the “technological communities” of US-educated Taiwanese engineers who transfer capital, skills, and know-how to Taiwan, and who facilitate collaborations between Silicon Valley and Hsinchu using their personal networks in both regions.



* the underlined words indicate the four KS mechanisms

Figure 2.1 How External Knowledge Spillovers Trigger Local Knowledge Spillovers

Source: Own draft

Following the above argument and hypothesis 1, the second hypothesis is drawn:

Hypothesis 2: Knowledge spillover within industries in latecomer regions can be effectively triggered by external knowledge spillover through import goods, FDI and oversea talents.

However, the external perspective on the global value chain should not overlook the coordination of local-level resource and strategies, which is a determinant of technological upgrading, especially in latecomer countries (Humphrey and Schmitz, 2000). The interaction of global- and local-level knowledge spillovers underpins the success of upgrading. In fact, the trigger effect of external knowledge spillovers does not take place automatically. The impact of FDIs and imported good on technological upgrading depends on the investment stock, degree of embeddedness, and absorptive ability of local firms.

At the early phase of FDIs, leading global firms seek optimal locations where they can conduct parts of their complex production processes—to take advantage of cheaper production factors and utilize location-specific resources. Their previous investment is aimed at cost reduction, which is achieved through low labor cost and favorable policies. At this stage, global firms take a “stand-alone” attitude and exert minimal influence on local capabilities.

Globalization is entering a new phase in the 21st century. The strategy of organizational fragmentation is gradually replacing vertical integration under an ownership. Production networks led by globally leading firms are taking form in many

latecomer regions. With the maturation of industries and technological development, activities are increasingly being outsourced, and local firms grow in the process. Empirical evidence proves that FDIs can generate a positive knowledge spillover effect only when local firms have sufficient absorptive ability (Kokko, 1994; Kinoshita, 2001; Du *et al.*, 2008). Moreover, the growth of absorptive capacity on the local scale enables local firms to initiate the strategic management and mediation of the benefits derived from knowledge spillover, both on the global and local scales (Hassink, 2005; Lowe, 2009).

Foreign investment at later phase aims to utilize resources and capabilities in exploring and maximizing location-specific know-how; thus, investments expand from simple production to basic R&D activities (Maskell and Malmberg, 2007). Today, many R&D activities are becoming standardized and codified, facilitating the geographical dispersion of R&D units. These R&D units, given their geographical proximity, support large-scale production activities in latecomer regions. At this phase, the impact of foreign investment on the technological upgrading of local industries is becoming increasingly larger as the scale of production expands.

A traditional argument holds that the benefits of trade liberalization are reaped at once. In fact, the requirement of which imports trigger knowledge spillovers to latecomer countries is more demanding than what FDIs require because the learning process through imports is active, whereas learning by FDI spillovers is passive. The learning process by imports requires firms to identify strategically and assimilate imported goods, and to use these goods in transforming their technological capabilities. Cohen and Levinthal (1990) argue that firms rely on previous knowledge to understand and absorb new external knowledge. Moreover, absorptive ability determines the assimilation of imported goods and the effective transformation of knowledge learned from imported goods into the technological capabilities of firms. Furthermore, trade has different impacts at different phases of technological development. Investment on technological upgrading is stimulated by anticipated profits; hence, trade reduces technological efforts in import-competing industries (Lawrence and Weinstein, 1999). In this sense, local firms can only benefit from imported goods when their own absorptive abilities are developed to a certain level; otherwise, the incentives of local firms to invest in technological efforts are suppressed because imported goods with better quality overtake the market. This constitutes the logic of “import substitution” policies in many developing countries.

Hypothesis 3: The impact of external knowledge spillovers on technological upgrading is closely related to the investment stock, degree of embeddedness, and absorptive ability of local firms. Therefore, the impact of FDIs on technological upgrading increases with growing production, and imported goods may harm the incentive of local firms to invest in technological upgrading when their absorptive ability is still low.

Before testing the three hypotheses by establishing econometric models using panel data on Guangdong, I first collect evidence to demonstrate the province's technological upgrading in 2000–2008. This justifies the selection of the study area and provides an overall impression of the characteristics of technological upgrading in the province.

2.3 Technological Upgrading in Guangdong Province, China:

Trade in Guangdong is characterized as processing trade. However, "processing" does not necessarily mean low-level or stagnating technological development. From 2000 to 2008, the share of high-tech products in total exports in Guangdong increased from 19% to 37%, whereas the share of garments and shoes in total exports decreased from 33% to 18%. The content upgrading of trade from low-tech products, such as garment and shoes, to high-tech products, such as electronics, clearly indicates the greater ability of firms to understand, absorb, and process more complex products. However, if the export of high-tech products is just based on simple assembly, then it does not require more skills than processing garments and shoes.

Therefore, I investigate deeper into structural changes in primary high-tech trade products, and draw a clearer picture of technological upgrading in Guangdong (Table 2.1). Data processing equipment and handheld telephones did not appear in the main high-tech export product catalog in 2000. Meanwhile, in 2008, these products accounted for 21% and 7% of the major exports, respectively. Clearly, the surge in data processing equipment and handheld telephone exports relies heavily on the importation of more complex, semi-finished integrated circuit products (from 12% to 35%), which Guangdong firms are still incapable of producing. However, the increasing import share of core parts, such as semiconductor and circuit protection devices, shows that firms are gradually abandoning their reliance on the importation of high-tech parts to produce

goods. Instead of only applying imported technology, they are strengthening their capability to adapt and improve imported technology. Usually such complex electronic components are used in integrated circuits. The processing of these components clearly indicates a deeper understanding of the principle of circuit running and requires an increasing ability in the field of circuit design adjustments for different purposes. Additionally, whereas the export of color TV has increased, the import of kinescopes—the core technological component of TV sets—has decreased. Thus, it can be concluded that firms in Guangdong are now more capable of producing TV sets on their own; this signifies a degree of technological upgrading.

Table 2.1 Structural change of several main high-tech trade products

	Unit: 10 thousand	**in all main export products**		**in all main import products**	
		2001	2008	2000	2008
Finished product	Data Processing Equipment	39328 (15)[1]	87226(21)	4577(4)	23524(7)
	Hand-held or Vehicle-mounted Cordless Telephones	988(2)	20860(7)	—	—
	Color TV Sets	529(0.7)	2129(1)	—	—
	Cameras	6568(1)	7293(2)	—	—
Semi-finished product	Integrated Circuit and Parts of Electronic components	160831(0.6)	794000(1)	1710950 (12)	5735800 (35)
Core parts	Parts of Semi-conductor Devices	—	—	6562167(3)	16183800(5)
	Circuit Protection Devices	—	—	— (2)	— (4)
	Kinescopes	—	—	448(1)	296(0.06)

1. Number in brackets indicates the share (%) of this product in all main export or import products

Source: Guangdong Statistical Yearbook 2001,2002 and 2009.

New product development is an important aspect of technological upgrading. Under China's statistical standards, new products refer to brand new products that utilize new technological principles or new design ideas, or greatly improved products in terms of structure, material, or processing methods, all of which would significantly enhance the performance of the products or expand their functions. It is assumed that firms in latecomer countries have a large room for learning and for adapting technology developed by industrialized countries to improve performance. Hence, within the latecomer context, new product development is a more market-oriented indicator than patents in the technological frontier. The output value of new products in Guangdong increased more than eight times in 2000–2008, whereas the export value of new

products increased 11 times during the same period (Figure 2.2).

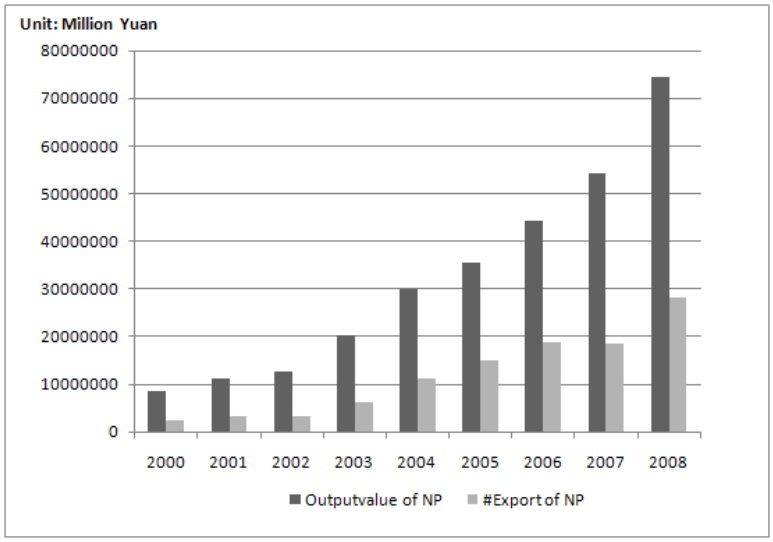


Figure 2.2 New product development in Guangdong

Source: Guangdong Statistical Yearbook (2001-2009)

The significant achievements in new product development cannot be realized without the internal learning efforts of firms. R&D expenditure and new product development activities are not normally distributed in Guangdong; hence, I use Spearman's rho to calculate the correlation between new product value and export, and R&D expenditures from 2001 to 2008 (except 2004 because of missing data) across 21 municipalities in Guangdong. The result shows that the new product output value is significantly and positively correlated (0.837) with R&D expenditure. The same significant and positive correlation (0.754) is found between new product export and R&D expenditure (Table 2.2).

Table 2.2 Spearman's Correlation of new product performance with firm R&D expenditure

Spearman's rho Correlation		firm R&D expenditure
New product value	Correlation Coefficient	.837**
	Sig. (2-tailed)	.000
New product export	Correlation Coefficient	.754**
	Sig. (2-tailed)	.000

*Correlation is significant at the 0.01 level (2-tailed). List wise N = 147

Source: Calculation based on Guangdong Statistical Yearbook 2009

R&D activities imply efforts in improving existing knowledge (develop) and pushing technological frontiers (research). International comparative studies indicate that an R&D share of over 1% signifies that a firm has passed the phase of basic technological introduction and application, and has developed an increasing ability to absorb and assimilate technology. In 2000, Guangdong's R&D share in GDP (1.1%) sharply increased (0.2% in 1995). In 2008, R&D share reached 1.4%. However, compared to R&D shares in the GDP of industrialized countries (e.g., United States, 2.7%; and Japan, 2.7%), members of the Organization for Economic Co-operation and Development (2.3%), and newly industrialized countries or regions (e.g., South Korea, 3.5%; Taiwan, 2.6%; and Singapore, 2.3)[3], Guangdong still lags behind. Moreover, R&D activities in Guangdong mainly involve learning efforts in assimilating and improving technologies from industrialized countries.

The character of R&D activities in Guangdong is better revealed in comparison with other developed provinces in China and the national average (Table 2.3). First, R&D intensity is comparatively low as compared with the national level. This may be attributed to the insufficiency of technological investment in universities and research institutions, as well as the absence of globally leading firms devoted to R&D activities, compared to Beijing and Shanghai (Kroll and Tagscherer, 2009). Second, aside from the influence of government and research institutes, technological upgrading in Guangdong is largely market-driven; it is mainly led by firms themselves. The percentage of firms' investment in R&D in Guangdong is 82%, which is higher than the national average (73%) and that of other developed regions, except Zhejiang province, where the private economy is also developing very well. Third, aside from basic and application research, technological changes in Guangdong are mainly pushed by test and development activities, showing that Guangdong's technological activities are incremental rather than radical.

Table 2.3 National Comparison of Technological Indicators (2008)

	National average	Guangdong	Shanghai	Beijing	Jiangsu	Zhejiang
R&D expense (percentage in GDP)	1.5%	1.4%	2.6%	5.9%	1.9%	1.6%
# Firm investment in R&D (%)	73%	82%	68%	47%	70%	86%
# Investment in Basic Research (%)	5%	1.4%	7%	8%	2%	—
# Investment in Application Research (%)	12.5%	1.6%	14%	22%	—	—
# Investment in Test & Development (%)	82.5%	97%	79%	60%	—	—

Sources: Calculation based on China Statistical Yearbook 2009 and The Statistical Yearbooks 2009 of Guangdong, Shanghai, Beijing,Jiangsu and Zhejiang .

[3] Sources: OECD, Main Science and Technology Indicators 2008.

To summarize, in the first decade of the 21st century, in which global competition for low-cost regions had been more intense than in the 1990s, Guangdong showed its learning ability to renew and upgrade products gradually, leading to the sustainable competitiveness of its export products. Technological upgrading activities in Guangdong are characterized by firm-led assimilation and improvement undertakings. Comparatively, the mechanism favoring rapid technological changes is missing due to the absence of excellent universities and research institutions, as well as basic research activities. Aside from the internal efforts of firms, knowledge spillovers that transfer know-how and induce learning by doing in firms are supposed to be important to the dynamic self-sustaining technological progress of Guangdong, according to the discussion in the previous section. The next section further explores the nature of knowledge spillovers.

2.4 Econometrical Model and Data

The empirical testing of knowledge spillovers is mainly conducted using three methods. The first method includes the effects of knowledge spillovers as part of the technology term into a regional production function by using city-industry data (Glaeser *et al.*, 1992; Feldman and Audretsch, 1999; Neffke *et al.*, 2008). The second method constructs a knowledge function (patents or new products) to catch the "technological leakage" of private (firms within or across industries), public, and academic research institutions (Jaffe, 1989; Feldman, 1994b). The third method traces the time and spatial scale of patent citations (Trajtenberg, 1990; Jaffe *et al.*, 1993).

Applied in the latecomer context, in which knowledge assimilation and adaptation is more prevalent than knowledge production, the use of patent data is inappropriate. Griliches (1990) and Feldman *et al.* (1999) suggest that new product introductions are more direct and market-oriented indicators than patented inventions. Although Cheung and Lin (2004) find a positive spillover effect by FDIs on domestic patent application in major coastal provinces of China, this spillover effect is strongest in the field of minor innovations, such as external design innovations. According to an innovation survey involving 8,962 firms in Guangdong in 2008 (See Wang, 2008), product innovation is as important as process innovation. Therefore, I use new product value as the dependent variable, serving as proxy for technological upgrading. With regard to the specific function form, the first method of testing knowledge spillovers mentioned above cannot

be utilized because city-industry data on external linkages, such as those on FDIs, imports, and exports, are missing, although Glaeser *et al.* (1992) suggest the method as the most direct way of testing spillovers. Nevertheless, the second method of testing knowledge spillovers can still catch the general effect, although it cannot examine differences across industries. Therefore, to test knowledge spillovers in the China context using available data, I adjust the second method of testing knowledge spillovers, which examines specifically the impact of knowledge spillovers within industries, across industries, and from external sources on the development of new products in Guangdong.

2.4.1 Construction of Data Set and the Model

In building the model, I use panel data encompassing 21 municipalities in Guangdong during the period 2000–2008. The scale of this geographical unit is more appropriate for knowledge spillovers to take place than that of the provincial unit. The starting year, 2000, is selected because it was during this year that data on new product development first became available.

As mentioned previously, the dependent variable in the model is new product value. The introduction of new products results from many aspects. If discussed in the Guangdong context, where technological upgrading is characterized as improvements rather than radical innovations, new products emerge from improvements in technologies that are central to firms, the reverse engineering of new technological principles, and the recombination or redesign of existing components through the deep assimilation of existing technological principles (Kogut and Zander, 1992). It should be noted that I do not use new product rate in our model as the dependable variable, so as not to deviate from the current practice in regional innovation system research. In the context of an immature regional innovation system, it makes more sense to investigate the factors driving the emergence of innovation rather than innovation intensity.

Jacobs' externalities are measured in various ways. Measuring a city's industrial diversity is a common way of testing the impact of knowledge spillovers across industries on the technological upgrading of firms. Indexes, such as Hirschman–Herfindahl Index (HHI) and entropy index, are mostly used in the literature. The difference between these two indexes is that HHI calculation is based on the square of the shares of respective industries, whereas entropy index calculation is based on the logarithm of the shares of respective industries. Thus, HHI stresses the influence of

stronger industries. The entropy index is chosen for the model because it is aimed to measure diversity instead of concentration.

$$\text{Diversification index} = \sum_{i=1}^{N} p_i \log(1/p_i)$$

where p_i is the percentage of industry i in the whole manufacturing output value.

The index of MAR externalities aims to measure the city's degree of specialization. If city-industry data are not used (which means that the location quotient cannot be calculated), the measure of specialization can somehow be replaced by the measure of diversity. To conduct a robust examination of knowledge spillovers on the local scale, the model introduces a more accurate measure of specialization, which is the share of the city's biggest industry according to its output value. The specialization index in the model is defined as

$$\text{Specialization index} = p_{\max}$$

where $p_{\max}$ is the percentage share of the largest industry in the city according to output value.

Aside from measuring knowledge spillovers on the local scale, I also intend to assess the impact of external linkages on technological upgrading in Guangdong. Here, import value and FDI are included in the model. The import value seeks to measure knowledge spillovers embedded in foreign commodities, whereas FDI aims to measure know-how spillovers from global production organizations. The impact of overseas talents cannot be measured because of missing data. Two issues should be mentioned in the measurement of external knowledge spillovers. First, FDIs need time to become embedded in the local environment and to exert a knowledge spillover effect on local firms; therefore, FDI stock quantity since 1985 is used instead of the annual FDI flow. Second, data on import value are generally at the municipal level of Guangdong; thus, I cannot categorize trade information into original trade, processing and assembly trade, and compensation trade, among others. In fact, only a proportion of imports, such as imports for processing trade and imported equipment, can boost intra-firm learning processes, and thus increase the technological capabilities of firms. Therefore, the general import value would generate a biased estimation of the impact of import goods on technological upgrading; the result of import value should be carefully explained in the model.

To avoid the omitted variable bias in the model, two control variables are introduced.

1) Firm-level human capital: The management literature holds that technological

upgrading is mainly a firm-level decision, and internal efforts are of major importance. Moreover, internal features, such as the level of human capital, determine to a large extent how firms search, absorb, and internalize knowledge spillovers and translate them into better technological performance. In this model, I use the number of personnel engaged in scientific and technological activities to control for firm-level internal efforts.

2) Urban externalities: Compared to dynamic externalities (knowledge spillovers) brought by MAR externalities and Jacobs' externalities, urban externalities bring two major advantages to firms located in larger cities in favor of technological upgrading. First, larger cities offer better infrastructure, especially transport infrastructure, such as highways and airports, which enhances the market access of firms. Second, larger cities offer larger bases and larger odds of interaction (Glaeser, 1999), indirectly influencing the impact of MAR externalities and Jacobs' externalities on technological upgrading. However, larger cities can also harm the local industry due to negative externalities, such as congestion, very high factor costs, and pollution. Therefore, I construct a quadratic term for urban population to seize the threshold value of urban size. It is assumed that under this threshold value, the urban population exerts a positive effect on technological upgrading; on the other hand, beyond this threshold value, the urban population exerts a negative effect on technological upgrading.

2.4.2 Panel Data Approach

Panel data are a set of data in which certain individuals are continuously observed over a period of time. Three aspects reflect the benefits of using panel data (Baltagi, 2005): (1) panel data can control for individual heterogeneity, (2) they can catch the dynamics of adjustment compared to cross-sectional data; and (3) they have less collinearity among variables and they add more variability compared to time-series data.

The general form of the panel data model is as follows:

$$y_{it} = \alpha + \beta x_{it} + v_i + \varepsilon_{it}$$

where i=1,2… N refers to the cross-sectional unit, t=1,2… N refers to the time series, yit is the dependent variable, xit is the matrix of independent variables, and v_i is the unit-specific residual. The unit-specific residual differs between units and is constant for any particular unit. In our model, it may refer to regional properties. Moreover, ε_{it} is

the error term that is assumed to be homoskedastic.

Unlike a simple regression model that pools all the data together, the panel data model applies three techniques to utilize the different scales of variation in panel data: fixed-effects model, between-effects model, and random-effects model. The fixed-effects model uses within-individual variations in the panel data, the between-effects model utilizes between-individual variations in the panel data, and the random-effects model makes use of both variations. In the between-effects and random-effects models, the absence of any correlation between v_i and x is a required assumption. The fixed-effects model loses this limitation and assumes that v_i is correlated with the regressors. In other words, the random-effects model is most efficient because it utilizes comprehensive information on the panel data, thereby catching cross-section and within-individual data variations. However, it has a stricter assumption than the fixed-effects model. Generally, the fixed-effects and random-effects models are more often used than the between-effects model.

In this study, F statistics is applied to test the appropriateness of the fixed-effects model compared to the pooled regression model. The null hypothesis is that fixed effects are not significant:

H_0: $v_1 = v_2 = \ldots v_n$

If the null hypothesis is rejected at a certain level of significance (normally under 5%), then fixed effects exist. Moreover, it suggests that the fixed-effects model outperforms the pooled regression model.

The Breusch–Pagan Lagrange multiplier test is designed to test random effects, and its null hypothesis is that the variance of groups is zero:

H_0: $\sigma_v^2 = 0$ v.s. H_1: $\sigma_v^2 \neq 0$

If the null hypothesis is rejected at a certain level of significance (normally under 5%), then the random-effects model is more appropriate than the pooled regression model.

The preceding two tests can only prove the appropriate form of the fixed-effects and random-effects models compared to the pooled regression model. A decision should be made on the estimation of the effectiveness of the fixed-effects and random-effects models. The Hausman test solves this problem. Based on the idea of Hausman test, when v_i is uncorrelated with the regressors, the estimation of the fixed-effects model is

in accordance with the estimation of the random-effects model, although the former is no longer effective.

$$\text{Cov}\left[b-\hat{\beta}),\beta\right] = \text{Cov}\,[b,\ \hat{\beta}\,] - \text{Var}\,[\,\hat{\beta}\,] = 0$$

If the null hypothesis is rejected at a certain level of significance (normally under 5%), then v_i is correlated with the regressors. In this case, I choose the fixed-effects model or use an instrumental variable to deal with the endogenous problem.

2.4.3 Description of the Data

In the previous section, it has been explained in detail the construction of variables for estimation purposes. In this section, I highlight some features of the data (Table 2.4). Simultaneously, the new product value increases steadily and the standard deviation increases greatly, indicating a uniform upward trend across municipalities in Guangdong (Figure 2.3). As Figure 1 shows, Shenzhen experiences the largest increase in new product development; the most dramatic increase occurred in 2008. Other cities in the core area of Guangdong, such as Guangzhou and Foshan, experience larger increases. Meanwhile, product development in Huizhou has a moderate increase, that in Zhuhai increases as time fluctuates, and those in other cities have comparatively low increases.

Table 2.4 Descriptive statistics of several variables over time

	2000	2002	2004	2006	2008
New product value （Unit: 10 thousand Yuan）	413669 (826184)*	606765 (1054310)	1423287 (2607879)	2104553 (3957404)	3541318 (7656674)
Industrial diversity	3.8 (0.53)	3.7 (0.57)	3.6 (0.67)	3.7 (0.62)	3.7 (0.56)
Industrial Specialization	0.26 (0.14)	0.27 (0.15)	0.29 (0.17)	0.28 (0.15)	0.27 (0.14)
FDI stock (Unit: billion Yuan)	54.12 (64.85)	69.45 (85.94)	81.64 (101.76)	94.43 (118.98)	111.71 (140.73)
Import value (Unit: billion Yuan)	37.2 (70.9)	48.9 (97.6)	78.8 (162.1)	107.3 (231.9)	133.0 (279.5)
Firm personnel engaged in technological activities (Unit: Thousand)	—	4957.3 (6807.3)	—	9926.5 (17076.1)	16258.8 (35431.4)
Population at the end of the year (Unit: Million)	405.96 (210.03)	421.05 (211.64)	433.84 (212.98)	443.05 (218.62)	454.48 (227.95)

* Numbers outside the brackets indicate average value; numbers in brackets indicate the standard deviation.

Source: Calculation based on Guangdong Statistical Yearbook 2001, 2003, 2005, 2007 and 2009

The average and standard deviation of the diversity and specialization index do not change over time, indicating a path-dependent pattern of industrial development. Cities tend to do the things they were good at in the past.

FDI stock increases twice on average in Guangdong in 2000–2008; however, the standard deviation also increases more than twice, showing the uneven flow and distribution of FDI in Guangdong. FDI tracks a path-dependent route because of the sinking cost of capital investment and increasing returns from the technical know-how of local firms developed in the process of transacting business with foreign firms.

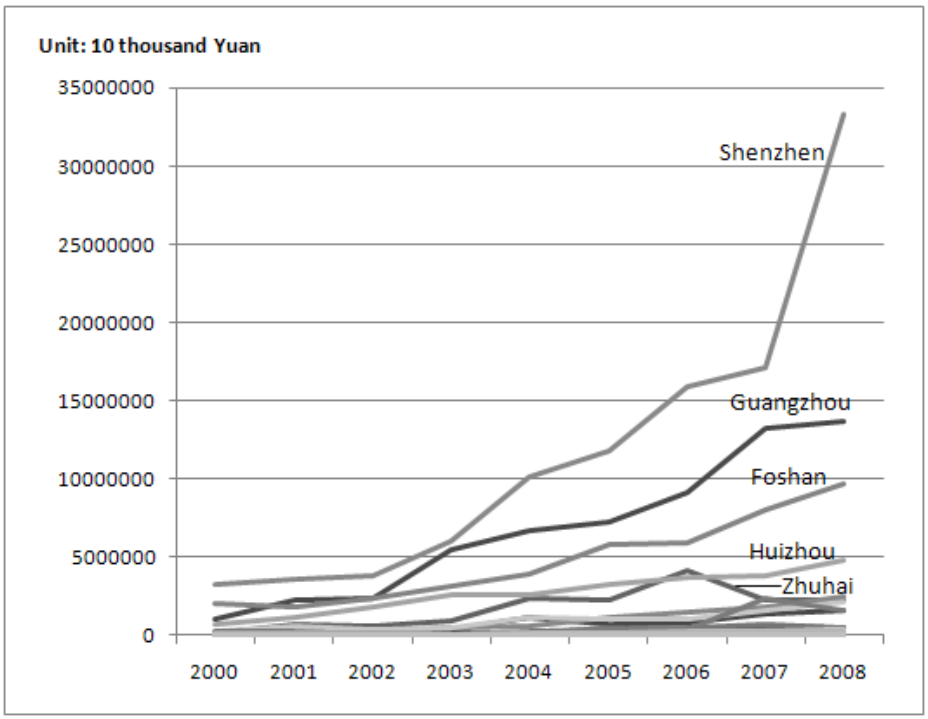


Figure 2.3 New Product Output Value over Time among the Municipalities

Source: Guangdong Statistical Yearbook 2001-2009

Import value follows a similar pattern as that of FDI stock across municipalities in Guangdong. In 2008, the import value in the core area of Guangdong (which includes the nine municipalities in the Pearl River Delta) accounted for 96% of the whole import value of the province. This may be attributed to higher consumption levels in these areas, leading to the importation of final goods, as well as the higher absorptive ability of firms in these areas to import intermediate goods and capital goods that can be used for learning.

Finally, firm-level human capital also increases unevenly across municipalities in

Guangdong over time, and the population shows a comparatively stable pattern of distribution in 2000 and 2008. Large variations in most of the indicators justify the application of panel data to include more informative data in the model. As seen in the econometric results in the next section, the dynamic differences among FDI stock, import value, and human capital, as well as their interaction effects with specialization, adequately explain the differences in new product development achievements across the 21 municipalities of Guangdong.

2.5 Report of Empirical Test

Table 2.5 presents the regression results for new product output value, in which the three hypotheses are to be systematically examined.

Table 2.5 Regression results of the Fixed-effect Models

INDEPENDENT VARIABLE	New Product Output Value （Unit: billion Yuan）				
	(1)	(2)	(3)	(4)	(5)
Constant	-28.37	50.01*	-108.43***	-86**	-90.92***
	(-1.3)	(1.9)	(-3.19)	(-2.59)	(-2.69)
Specialization index	0.58***	—	0.32**	-0.02	0.22
Unit: %	(3.26)		(1.98)	(-0.11)	(1.33)
Diversified index	—	-17.75***	—	—	—
		(-3.82)			
FDI stock	4.02***	4.17***	-0.3	-0.46	1.28
Unit: billion Yuan	(8.11)	(8.53)	(-0.37)	(-0.59)	(1.32)
FDI quadratic term	—	—	0.09***	0.07***	0.08***
(FDI stock*FDI stock)			(6.78)	(5.05)	(5.94)
Interaction term	—	—	—	0.06***	—
(FDI stock*specialization)				(3.58)	
Import value	-0.86***	-0.94***	-1.1***	-1.49***	-2.18***
Unit: billion Yuan	(-4.11)	(-4.48)	(-5.66)	(-6.9)	(-5.04)
Interaction term	—	—	—	—	0.02***
(import value*specialization)					(2.78)
Human capital	1.84***	1.86***	1.59***	1.62***	1.54***
Unit: thousand	(15.44)	(15.76)	(14.42)	(15.28)	(14.17)
Population	-3.16	-2.56	35.62**	29.89**	29.86**
Unit: Million	(-0.61)	(-0.5)	(2.59)	(2.25)	(2.2)
Population quadratic term	—	—	-2.45**	-2.29**	-2.36**
(population*population)			(-2.25)	(-2.19)	(-2.22)
Within Adjusted R^2	0.91	0.91	0.93	0.94	0.93
Number of Observations	168	168	168	168	168
F test	6.52***	6.09***	5.77***	6.76***	6.08***
Hausman test	55.31***	57.54***	114.6***	30.3***	38.94***

Notes: Standard errors in parentheses; *p<0.10, **p<0.05, ***p<0.01

Source: Calculation based on Guangdong Statistical Yearbook 2001-2009

As a baseline, I initially estimate the effects of different scales of knowledge spillovers without including the interaction term. Only one of the two regressors is included in the model at one time because the diversified index and specialization index are mutually substitutive. Columns (1) and (2) show the results. As for knowledge spillovers on the local scale, whether they are measured by diversity (entropy index of the city's industries) or specialization (share of the city's largest industry), the result of our model confirms the first hypothesis: specialization contributes to product upgrading in Guangdong. In accordance with MAR externalities, knowledge spillovers within industries tend to generate a higher value of new products than knowledge spillovers across industries as suggested by Jacobs' externalities. In addition, as expected, FDI stock has a significantly positive impact on new product value, and the impact of imports on new product value is significantly negative, supporting Hypothesis 3, which states that import goods can reduce the technological efforts of local firms when their absorptive ability is still low. This view differs from other empirical studies on the impact of trade on productivity. However, considering the data and study context in this model, it is helpful to think about differences in trade impacts across the different developmental phases. Considering the positive impact of FDI stock, it can be concluded that the absorptive ability of Guangdong firms is high enough to avail themselves of knowledge spillovers brought by FDIs, but still not high enough to transform actively the knowledge spillovers brought by imported goods into their own technological capabilities. As expected by the traditional management literature, internal efforts are greatly important in new product development; an increase of 1,000 technological personnel increases the new product output value by over 1 billion yuan. According to Models (1) and (2), the disadvantages of urban externalities seem to outweigh their advantages. However, this impact is not significant even at 10% level.

In Column (3), I include the quadratic term of FDI and population, based on the previous discussion on their nonlinear impact on technological upgrading. Specialization still exerts a positive impact on new product development at 5% significant level, whereas the impact coefficient decreases from 0.58 to 0.32, implying that a 1% increase in specialization of the largest industry in the city would increase the new product output value by 0.32 billion Yuan. The impact coefficient and the significance of imports and firm-level human capital are almost unchanged. This model clearly shows the nonlinear impact of FDIs and population. From the coefficient and significance of FDI stock and its quadratic term, it can be drawn that the impact of FDI stock on new product

development depends on the amount of FDI stock; the relationship between FDI stock and new product value follows a quadratic curve where a>0 (a=0.09). When the FDI stock is at a comparatively low level, its impact is of little importance. With an increase in FDI stock, the impact of FDI on new product development becomes larger, implying that the local production network led by global firms has become more mature. In addition, knowledge spillovers from foreign investment become larger when they are embedded in local industrial cluster and when the absorptive abilities of local firms have co-evolved. As for urban externalities, the limit value is calculated at 7.26 million people (-b/2a = -35.62/2*2.45=7.26). This means that when the city population is below 7.26 million, then the impact of urban externalities is positive due to better infrastructure and larger odds of interaction for knowledge spillovers. However, the positive impact decreases with the growing population; when the city population exceeds 7.26 million, the impact of urban externalities becomes negative, and this negative impact increases as the population continues to grow. Such growth is attributed to high factor costs, congestion, and pollution.

The thrust of this chapter is proving that external knowledge spillovers trigger knowledge spillovers on the local scale in latecomer regions. To catch these triggering effects, I include the interaction term separately in Models (4) and (5) to avoid correlation problems. In Column (4), the interaction term between FDI stock and specialization is included. Results show that the interaction term is positive at 1% significant level, although specialization alone does not exert any significant impact on new product development. The estimates imply that the impact of specialization on new product development relies on the value of FDI stock—the larger the FDI stock, the larger is the impact that specialization exerts. In Column (5), the interaction term between import and specialization is also significantly positive, although specialization itself does not have a significant impact. This estimation is consistent with the result in Column (4), which also implies that the amount of import determines the degree of impact of specialization on new product development. It may be surprising to find this positive relationship between imports and specialization when imports would actually harm new product development (significant at 1% level). As discussed earlier, the impact of imports is greatly determined by the absorptive ability of firms, and the literature on firm clustering asserts that leading firms act as gatekeepers that determine the effective diffusion of import knowledge to other cluster firms (Owen-Smith and Powell, 2004; Giuliani, 2005). In this sense, the absorptive ability of leading firms

determines the impact of imports on knowledge spillovers on the local scale. Due to economies of scale and low transaction and coordination costs in more specialized areas, the absorptive capacity of leading firms in more specialized locations is stronger, and they are better at utilizing imports to realize technological upgrading. Therefore, it is no wonder that more specialized areas benefit from imports, although imports generally harm the technological efforts of firms in the whole area.

Test of Model Appropriateness and Robustness

The fixed-effects model is proved to be appropriate due to the significance of the F value and the Hausman test parameter, as shown in the last two lines in Table 5. All five models achieve the 1% significance level in the F test, justifying the application of the fixed-effects model instead of the pooled regression model. The Hausman test shows the correlation between individually determined standard errors and other regressors, indicating the inappropriateness of the random-effects model.

The new product output value in Shenzhen is much higher than that of the rest of the municipalities in Guangdong (See Figure 2.3), especially in 2008. To avoid the influence of large fluctuations in the sample, the models are re-run without the Shenzhen data to check the robustness of our results. The overall picture presented in Table 5 shows that the results are robust and in line with our theoretical hypotheses.

2.6 Discussion and Conclusion

The results of this chapter shed light on the role of knowledge spillovers in the technological upgrading of latecomer countries as they approach the technological frontier. Consistent with Neffke *et al.*'s (2008) argument on the relationship between the industrial cycle and knowledge spillovers on the local scale, explaining the unclear empirical results in the literature, the results in this chapter show that knowledge spillovers within industries matter more when technological activities are incremental and are focused on improvements.

More importantly, the analysis considers external knowledge spillovers, which are suggested by Kuznets (1973) as "advantages of backwardness." The analysis also demonstrates that external knowledge spillovers, especially through the mechanism of FDIs, trigger knowledge spillovers within industries on the local scale in latecomer regions, such as Guangdong. However, external knowledge spillovers to latecomer

regions do not take place right away. In fact, the spillovers are closely related to the investment stock, degree of embeddedness, and absorptive ability of local firms. Imports actually harm technological efforts, such as the development of new products, when the absorptive ability of firms is low. This phenomenon further supports our analysis.

An important policy implication derived from the results is the importance of upgrading the technological capabilities of local firms, such as enhancing human capital and providing incentives for small and medium-sized firms to invest in technological upgrading, especially in the post-financial crisis era. Since the onset of the financial crisis, China has faced great pressures from RMB appreciation. In March 2009, Chinese Prime Minister Wen proposed that China would further expand its import volume, particularly the volume of high-tech products, to balance the trade structure and stabilize the exchange rate. Imports can be utilized in a positive way without harming the domestic consumption market—only by increasing the technological capabilities of local firms. This strategy is particularly important for Chinese firms while the Western market is shrinking.

Theoretically, the results indicate that external knowledge spillovers are keys to the catch-up efforts of latecomer countries and the conditional convergence between technological leaders and technological followers. However, as indicated by Helpman (1993), and Barro and Sala-i-Martin (1992), the low cost of imitation and the absence of intellectual property rights give technological followers the incentive to copy as a means of achieving growth. However, as the technological gap decreases and the cost of imitation increases, the growth rate of technological followers tends to decrease. This line of thought provides two future research directions.

First, convergence does not take place as long as a technological gap between firms exists. Convergence requires firms to avail themselves of external knowledge spillovers and convert these spillovers into their own technological capabilities. Therefore, the first research direction is analyzing the microeconomic aspects of the question. Although the aggregate analysis in this chapter can provide informative implications on the impact of external knowledge spillovers within the latecomer context, the channels through which technological development in latecomer regions work are still far from clear. As suggested by Martin and Sunley (2007), economic change and system adaptation is complex and differentiated across space. In other words, to start the catch-up process, the characteristics of firms and regions should be analyzed to explore the success of latecomer regions in availing themselves of external knowledge spillovers (Budd and

Hirmis, 2004). Moreover, in the absence of a framework for the protection of intellectual property rights in most of these regions, informality becomes an important aspect in the analysis.

Second, the results of this chapter are valid at certain developmental phases. As imitation cost increases, behavioral transition in technological activities should be changed to ensure sustainable development. Another dimension for further study pertains to the trailing of this transformation in latecomer countries, and analyzing the changing impacts of knowledge spillovers, as well as the responsive strategies of firms and governments.

Overall, this study calls upon econometric studies that take a dynamic perspective and considers the impact of knowledge spillovers across different development phases. Moreover, it suggests that a firm-level study must go beyond the general information provided by econometric studies to explore the microeconomic aspects of the technological upgrading activities of latecomer countries.

3 Interactive Learning and Systemic Innovation in the Pearl River Delta, China:

Firm-level Evidence from the Electronics Industry

Abstract: Learning by interacting defines the endogenous path of economic development in modern innovation studies. In this chapter, I aim to investigate the role of interactive learning in promoting innovation as well as the application of informal social networks in interactive learning. By investigating the willingness and capacity of firms to undertake interactive learning in product innovation, this chapter sheds light on the emergence of dynamic externalities of a regional innovation system. Based on a survey of 359 innovative electronics firms in the Pearl River Delta, China, this chapter demonstrates that firms undertaking the highest intensity of interactive learning with the widest scope of business partners, such as foreign customers, domestic customers, parent companies, universities and sales agents, tend to achieve better innovation outcomes. Moreover, the intensive interactive learning firms have a much higher tendency to apply informal Guanxi networks, for example with business partners, relatives and friends, in tinteractive learning than other firms. Overall, this chapter contributes to the understanding of the form and effect of interactive learning in the Chinese context. Finally, the chapter addresses the possible lock-in issue and points out further research questions on the changing pattern of interactive learning with a maturing institutional framework.
Keywords: Interactive Learning; Innovation; Informal Networks; Guanxi

3.1 Introduction

Modern innovation studies adopt a system approach, in which the inter-firm linkages involve sustained quasi-cooperative relationships that shape the learning process and determine the innovation outcomes. The interactive learning process undertaken by groups of users and producers creates the diverse complexes of technological capabilities and determines the dynamics of the regional innovation system as a whole (Smith, 2000; Lundvall, 1992). In addition, the research on regional innovation system extends the scope of interactive learning from within inter-firm linkages to the linkages between firms and other knowledge-producing institutes such as universities, research institutes and related service providers (Cooke

et al., 1997; Howells, 1999; Revilla Diez, 2000; Asheim and Coenen, 2005).

In an industrial cluster, the inter-firm linkages which are oriented towards the reduction of transaction costs create static externalities among the clustering firms (Marshall, 1920; Williamson, 1981). In contrast, the dynamic externalities generate increasing returns for the whole economy, where one input into innovation activities in a single firm is able to generate disproportionately more output in the whole cluster owing to spillover effects based on the interactive learning process. Therefore, the willingness and capacity of clustering firms to undertake interactive learning is vital for long-term economic growth dynamics (Cooke *et al.*, 1998; Arrow, 1962; Romer, 1986; Krugman, 1991).

Ever since the beginning of the opening policy in 1978, industrial clusters have been emerging in coastal areas of China, taking the opportunity of relocation and of subcontracting processing functions from global lead firms. Firms in these agglomerations draw significantly on the static externalities advantages, such as saving intermediate goods costs and sharing supported infrastructure. Moreover, flexible and responsive production is able to be sustained thanks to the use of networked enforcement mechanisms based on informality and cooperation (Meyer *et al.*, 2009). In this way, the specialization of industrial clustering in China facilitates the use of comparative advantages such as cheap labor and land.

Nevertheless, the source of regional economic grow does not lie in static externalities, but in the dynamic externalities that induced by interactive learning and innovation synergies between the economic players to jointly exploit the new combinations and market opportunities, creating increasing return to the large stock of knowledge in the clusters. For the regional innovation systems in China, the formation of this dynamic mechanism is of particular importance as the dependence on FDI for technology persisted for long and contrasted with the poor interaction among the local firms. It is expected that interactive learning should take place as the local firms have accumulated certain level of balanced knowledge stock, enabling them to reciprocally learn from each other. Even the high-end technology might still come from global lead firms, the local firms can be motivated by the imported technology with the joint-exploitation of new market opportunities and combinations through interactive learning. Hence, the aim of this chapter is to find out how interactive learning is strategically managed and how the scope and intensity of interactive learning contribute to innovation outcome.

This study focuses on one of the largest electronics industry clusters in the Pearl River Delta, China. The issue of interactive learning and systematic innovation is very relevant in the electronics industry in China. Firstly, Chinese electronics firms are mainly technology adopters, integrating "off the shelf" subcomponents into new product design. The modularity in the electronics industry necessitates the interaction between specialized firms to explore the new market opportunities of new combinations, as well as to solve the technical problems of integrating components. Secondly, the technological frontier is moving at an astounding rate in the electronics industry. As indicated by Gjerde *et al.* (2002), firms are forced to innovate when the technological frontier moves quickly due to the fear of missing innovation opportunities.

Therefore, by investigating the willingness and capacity of electronics firms in the Pearl River Delta, China to undertake interactive learning in product innovation activities, this chapter sheds light on whether dynamic knowledge spillover externalities emerge in China. In the face of the global recession and domestic inflation, the capacity to draw on innovation externalities is of great importance for regional structural adjustments and long-term development.

The remainder of this chapter is structured as follows: the second section elucidates the need and the scope of undertaking interactive activities in order to promote innovation. Hypotheses are derived based on the theoretical discussion. The third section presents the dataset, related parameters and the methodology applied. The fourth section discusses the empirical results. The fifth section concludes and discusses policy implications.

3.2 Innovation as an Interactive Process

Unlike exogenous inputs such as capital and labor, innovation and learning contribute to the improvement of productivity and are determinant to long-term economic growth (Arrow 1962; Romer 1986; Nelson and Siegel 1987). March (1991) emphasizes the importance of knowledge diversity in learning process and defines the dichotomy of exploration/exploitation. While exploitation makes exclusive use of the existing knowledge such in the process innovation, exploration enables the firms to make use of new opportunity and avoid competency traps.

Hence, the firms need to go beyond the organizational boundary and interact with

external agents in order to undertake knowledge exploration. In Lundvall (1992)'s seminal work on national systems of innovation, he proposed that the approach towards systemic innovation and interactive learning considers the stock and rate of the R&D investment as the new determining variable in economic growth. That is to say, interactive learning creates increasing returns for the stock of knowledge and thus underpins long-term economic growth.

In order to tap into the interactive learning activities, it is useful to discuss the nature of knowledge which is shaped and reshaped by learning processes. Salter and Reddaway (1969) distinguish between different types of production-relevant knowledge: firm-specific knowledge, sector product-field specific knowledge and generally applicable knowledge. Asheim and Coenen (2005) further elaborate the dimension of sector product-field specific knowledge into synthetic knowledge and analytical knowledge. The synthetic knowledge base is more based on know-how and experience, strengthening the pattern of industrial specialization. The analytical knowledge, on the other hand, is more general in a scientific sense, requiring frequent industry-university interaction and cooperation.

Firm-specific knowledge

The firm-specific knowledge is well elaborated on by Nelson and Winter (1982)'s proposition of organizational routine. Routine consists of particular resources, skills, experience and know-how that the firm accumulates over time (Levitt and March, 1988), and is therefore difficult to imitate for others.

Firm-specific knowledge are accumulated over time and selected by competitive market, determining the competitiveness of the firms (Teece *et al.* 1997). More importantly, organizational routines develop in a path-dependent manner, in which the firm tends to search for information and undertake activities related to its own knowledge sphere (Kline and Rosenberg, 1986). Therefore, the firm displays bounded rationality and competence in the innovation-related activities, which has two important implications for the role of interactive learning in innovation.

Firstly, bounded rationality implies that the decision making process is determined by limited information, limited knowledge and limited resources of the individuals or entities, and thus leading them to base decision making on existing knowledge and capacity, which results in a satisfactory solution rather than an optimal one based on total rationality (Simon 1957; Simon 1991). Firms tend to identify the knowledge that

is similar to their knowledge stock among the bulk of information, leading to larger chance of similar knowledge selected by firms for further learning. In another way, the ability to search relevant information for innovation is limited, which necessitates interactive learning to expand the scope of knowledge and competence. As a result, firms with bounded rationality are not able to calculate the result of decision-making on innovation investment when faced with uncertainty in the environment. In order to reduce risk-related uncertainty, firms have to collect more technical information and market information from outside organizations.

Secondly, the firms only master and excel in a limited range of products and processes due to the bounded competence. As a result, firms are constantly confronted with technological problems in the innovation process which lie outside their range of knowledge and competence (Smith, 2000). This kind of knowledge is not only limited to codified knowledge, such as the support of specialized equipment and operating software, but also refers to the more important tacit knowledge such as technical know-how and experience, which is a key to problem-solving in the process of prototype development and the technically specific design. Due to the tacitness of most knowledge, the firms need to engage in face-to-face interaction with other organizations in order to solve these problems and optimize the innovation outcomes.

In a broader sense, the market selection process reshuffles the relative efficiency of competing firms, and impels the firms to constantly monitor and adapt by developing new products and new markets, applying new set of inputs and new processes, and thus finally to adjust the organizational routine, which only based on the current knowledge and capacity (Nelson and Winter, 1982). This process is more like a swirling ladder than a liner growth process. The adjustment process might be stagnated or slowed down because of the limited knowledge and capacity. It might be also backward because the firms might make mistakes. Whatsoever, the adjustment process, which underlies its dynamic competitiveness in the market, necessitates knowledge transfer within and between firms and constant learning due to the newness of knowledge and information for the firms.

Based on the above discussion, I propose the following hypothesis, which is included in the investigating dimension of the empirical analysis:

Hypothesis1A: Due to bounded rationality and competence, firms need to complement internal efforts in innovation with interaction with other organizations in order to facilitate innovation-related decisions by searching for relevant

information, and must also support innovation implementation with external codified and tacit knowledge.

Sector product-field specific knowledge

Tacit knowledge is not only confined to individuals or groups of co-operating individuals, but also embeds within specific industries, which is often referred to in the literature as the "technological paradigm"(Dosi, 1988b). Technological paradigm refers to the common technological features such as technical parameters, performance characteristics, and use of materials shared by firms in an industry (Smith, 2000). Moreover, sector product-field specific knowledge also covers knowledge on markets, such as customer needs and the supply of industry-specific skills.

Therefore, firms within the same production field are close in cognitive proximity, which facilities the interactive learning process (Boschma, 2004). Cognitive proximity within the same industrial space and supplier link would affect the search and imitation costs when exploiting knowledge. North (1996) proposes that social capital would affect the vertical division of labor. Futhermore, Lundvall argues that learning by interacting between the users and producers is able to make most use out of the learning by doing and learning by using effect within the organizational boundary, creating knowledge embodied in new machinery, new components and new software-systems (Lundvall 2005).

Kline and Rosenberg's (1986) early work on the "chain-linked model of innovation" suggests that increased demand of the user firms would generate rapid rate of technical changes for the suppliers. Specifically, in the chain of innovation from the initial design to the production process, the later phase shifts more towards systematic interaction with user needs. In the Aalborg school of innovation systems, innovative activities within the vertically organized units have been the analytical focus. The search strategies and learning processes organized within the prevalent vertical linkages between the firms and their supplying firms of intermediate and capital goods distribute and transmit the qualitative knowledge related to product innovation (Lundvall *et al.*, 2002; Lundvall, 1988). In order to secure profitable innovation outcomes, the user-producer interaction must be in place to ensure constant feedback on needs, adjusted design, and on performance (Hage and Alter, 1997). Asheim and Gertler (2005) further elaborate that interactive learning between

users and producers often takes place in industries in which synthetic knowledge is dominant. Synthetic knowledge pertains to the importance of applied and problem-solving knowledge, where the innovation process is oriented towards new combinations, new solutions and new utility concerning the user demands.

Interactive processes of knowledge transfer within supplier linkages bring about dynamic synergies rather than static efficiency on transaction cost reduction (Capello, 1999). In the dynamic synergies between customers and suppliers, market information is constantly exchanged, while experience and know-how are shared through engineering knowledge instruction and quality monitoring (often undertaken by the customers). Consequently, the technology trajectory is co-evolving due to the coordination of the production process. In the context of latecomer countries, the firms also rely heavily on the parent companies and foreign customers to acquire advanced codified knowledge and better absorb the codified knowledge by having the engineers and managers from foreign partners train on site (Morrison *et al.*, 2008; Yang, 2009; Yeung, 2009).

In addition to vertical collaboration, innovative cooperation among horizontal firms also plays a role in the aspect of exchanging sector-specific know-how. Teece (1986a) argues that when new products can easily be reverse engineered and imitated by competitors, firms tend to establish partnerships or alliances with other firms who have the potential capacity to produce them.

The following hypothesis provides a summary of how interactive learning is undertaken within the scope of sector product-field specific knowledge, which the empirical investigation will take into account.

Hypothesis 1B: Interactive learning within the vertically organized units, i.e. between suppliers and customers, ensures the effective exchange of market information and constant feedback on technical problems and product adjustment, and thus promotes the product innovation outcomes.

Generally applicable knowledge

Generally applicable knowledge refers to widely applicable knowledge. This generic knowledge is more about the scientific "know-why" knowledge that is playing an increasingly important role in the problem-solving of innovative efforts (Lundvall and Johnson, 1994). It is of greater relevance for high-tech industries such as electronics, pharmaceuticals and chemistry, where the technological frontier is

expanding at a rapid rate.

In contrast to the synthetic knowledge, which is more connected to sector product-field specific knowledge, Asheim and Gertler (2005) conclude that analytical knowledge is dominated by scientific know-why knowledge and is generated from internal documentation activities as well as collaboration with research institutes. From the research on Danish clusters, Jensen *et al.* (2007) also found that the mode of learning by doing, using and interacting is no longer able to sustain the competitiveness of firms. Firms that combine the DUI (doing, using and interacting) mode with the STI (science, technology and innovation) mode, i.e. connecting systematically with sources of codified and scientific knowledge outperform other firms in terms of finding new solutions and developing new products. Systematic connection with generic scientific knowledge can be achieved in the following two ways.

Firstly, generic scientific knowledge can be absorbed through internal efforts such as R&D activities, reverse engineering and licensing into tacit knowledge. R&D function often exists in large firms due to the scale economy of research activities. Actually, the role of R&D activities in generating new knowledge in the context of latecomer firms is insignificant. More importantly, R&D activities display a social rate of return by influencing the absorptive capacity of the firms (Griffith *et al.* 2003), determining the capability of firms to transform externally codified scientific knowledge into their own routines of more tacit knowledge. For latecomer firms in particular, they can also gain access to advanced codified knowledge either through reverse engineering of the import products from global lead firms, or through formal licensing of the codified knowledge such as patents. However, the efficiency of these activities is determined by the absorptive capacity of firms to adapt them to their own specific needs.

Secondly, interaction with universities and research institutes assists firms in acquiring new knowledge through their intra- and interregional networks as well as in applying abstract scientific knowledge to production. Generally applicable knowledge cannot be immediately applied to commercial needs and the spillover risk for the knowledge investors is too high. The public sector such as universities and research institutes, there, which normally operates without profit-maximization goals, should be involved in the production of generally applicable knowledge due to the problem of appropriability (Smith 2000). Other than distribution of knowledge between

suppliers and customers, the distribution of knowledge among universities, research institutions and industry is also one of the most important aspects relevant for innovation activities (David and Foray 1995).

Overall, the following two hypotheses are proposed:

Hypothesis 1C: Use of external scientific knowledge depends on the firms' absorptive capacity, which is accumulated by activities such as R&D activities, reverse engineering and licensing.

Hypothesis 1D: Interactive learning with universities and research institutes assists firms in acquiring new knowledge through their intra- and interregional networks as well as in applying abstract scientific knowledge to their own production needs.

Based on the hypotheses 1A-1D, it can be concluded that interactive learning is needed both in the decision-making and undertaking processes of innovation due to the bounded rationality and bounded competence of firms, and it extends the scope of supplier linkages to knowledge-generating institutes. The scope of interactive learning actually brings superadditivity among its effects, which Storper and Venables (2004) refer to as a "buzz effect". The superadditivity refers specifically to the increasing return of knowledge stock, in which the more information and knowledge the firms acquire through a wide scope of interaction, the more easily they are able to understand complex ideas. Moreover, Lundvall (2005) also implicitly implies that the scope of interactive learning should be widened in order to escape the lock-in effect of learning with limited numbers of organizations, especially in a sector with turbulent technological change and rapid change in customer needs. Therefore, firms in a buzz environment are highly motivated to undertake more complex innovation activities that are more likely to produce more significant innovation outcomes.

Furthermore, firms need not only to extend the scope of interactive learning, but also to intensify interaction in order to better absorb each piece of information and knowledge from external organizations. The more the innovation is distinct from firms' existing knowledge and competence, the more efforts they should put into unlearning old routines and learning new ones. Due to the path-dependent accumulation of knowledge development, as previously discussed, firms have to undertake the interactive learning activities to an intensified degree, because they tend to return to their old ways of cognition and practice in the interaction process. Moreover, new codes have to be developed on a trial and error basis in innovation

activities, especially the ones with higher rate (Lundvall, 1992; Meeus *et al.*, 2001). Therefore, firms must intensify the interaction with customers and other knowledge-producing institutes in order to ensure their success in developing new products.

Finally, the second general hypothesis is proposed and its validity is to be tested in the empirical analysis:

Hypothesis 2: The scope and intensity of interactive learning with customers, universities and research institutes in the innovation process contribute to the innovation outcomes.

3.3 Survey Data and Indicators

The data applied in the following analysis is a set of standardized questionnaire data on electronics firms in the Pearl River Delta, China, which was collected during the period between September and November 2009. The company survey was aimed at electronics firms mainly in four cities on the east coast of the Pearl River Delta, where the electronics industry is dominant (as in Shenzhen and Dongguan) or developing very quickly (as in Huizhou and Heyuan). The questionnaire survey was conducted via telephone and mail, in which the questions were addressed to the CEOs or senior executives of electronics companies in the PRD. Follow-up was conducted via telephone, aiming to complete the unanswered questions and improve the quality of the questionnaires. In total, 793 firms were contacted and 422 firms filled out the questionnaires, providing a response rate of 53%. Among the firms surveyed, 167 are located in Shenzhen, 177 in Dongguan, 67 in Huizhou and 11 in Heyuan. In the analysis, I concentrate on firms that undertake product innovation activities, of which there are 359 in total.

It should be mentioned that unanswered questions among the firms surveyed along with firms which refused to answer, are likely to lead to the sample selection being biased. Firms that are willing and able to answer the questionnaires completely usually have a higher level of human capital or more formal organizational frameworks, which eases the understanding and communication between firms and the universities that conducted the survey. Moreover, these firms are more interested in the strategic development plan the research team promised to provide after the survey than the firms that refused or left too many questions unanswered, which

reflects their upgrading-oriented strategy. In fact, this selection bias controls for the technological level of the surveyed firms to a certain degree, because it ensures that the survey firms' innovation activities are not limited to very low-value innovation, such as complete imitation without adaptation, and thus require more coordination and learning in the innovation process.

In light of hypothesis 1A, three aspects are taken into account throughout the interactive learning process are taken into account: searching for information to facilitate innovation decision making (acquiring new innovation ideas), obtaining codified knowledge and obtaining tacit knowledge in the implementation process. Furthermore, the scope of interactive learning is derived from hypothesis 1B and hypotheses 1C (See Table 3.1).

Table 3.1 Indicators of Interactive Learning and Internal Efforts in Innovation

			Remarks
New Product Ideas	Internal Efforts		*Own development of ideas*; Self Absorption and Learning through *license purchasing and reverse engineering*
	Sector product-field specific knowledge		Interacting with *parent companies, foreign customers, domestic customers*
	Generally applicable knowledge		Interacting with *universities, research institutions and sales agents*
Obtaining Codified Knowledge	Internal Efforts		Self-purchasing of equipment and software
	Sector product-field specific knowledge		Interacting with *parent companies, foreign customers and domestic customers*
Obtaining Tacit Knowledge	Sector product-field specific knowledge	Active	Sending staff *to foreign customers or foreign lead firms, domestic customers or domestic lead firms*
		Passive	Receiving training and know-how from people sent *by parent company, foreign customers and domestic customers*
	Generally applicable knowledge		Sending staff *to universities* for training
Interaction Mode	Informal Guanxi Network		Interacting through Guanxi, for example gaining information on the reputation and capacity of innovation partners from other *business partners, relatives and friends* in the innovation process
	Active Searching		Searching for information on partners *via Internet, exhibition and sales agents* in the innovation process

Source: Own Survey Questionnaire (See Appendix A, Part C, Question 27-30)

The intensity of the interaction with these players in the innovation process is measured by the firms' evaluation of the importance (from 1-5 with increasing importance). The firms are also asked to rank the importance of active searching, Guanxi with business partners as well as Guanxi with relatives and friends when they interact with these agents in the innovation process. In this aspect, active searching refers to arm-length-market relation which based on pure contract relation, while Guanxi with business partners, relatives and friends refers to informal aspect of social relations. Although the interaction mode is not the main investigated aspect in this chapter, it will provide a first insight into the way that interactive learning is organized among the electronics firms in the Pearl River Delta, China, which would pave the empirical evidence for further exploration on the way to secure and sustain interactive learning in the following chapters.

3.4 Empirical Results

3.4.1 Descriptive Results

A general overview of firm characteristics concerned about the innovation investment and the innovation outcomes among the firms surveyed is provided. The average age of the innovating firms was 10.8 years (until 2010). Among the innovating firms, 8% were large firms with no less than 300 million Yuan sale and no less than 2000 employees. 39% of firms had foreign participation. The median value of the share of innovation input in sales was 20% in the first half of 2009, and one third of the firms invested over 20% of sales in product innovation. Note that the survey year was during the recovering period of the financial crisis, so it indicates the stronger incentive to undertake innovation among electronics firms, even under market uncertainty. As for the innovation outcomes, more than 40% of the firms surveyed had achieved significant or very significant improvement on product function expansion and product category upgrading.

Interactive learning that facilitates the decision making process and assists in the realization process of innovation activities is analyzed in the following section. From Table 3.2, it can be seen that electronics firms in the Pearl River Delta rely very much on their own competence and reverse engineering to trigger innovation activities, indicating to some extent that firms in the Pearl River Delta are increasing their internal absorptive capacity to transform externally codified knowledge, such as

advanced product samples, into new product ideas and market opportunities. On the other side, the demands from foreign customers and domestic customers play a significant role in pushing the incentives of firms to undertake innovation. Compared to internal competence and closely linked partners in business operation, the impact of external knowledge-producing institutes, such as sales agents, universities and research institutes, on triggering innovation ideas is insignificant.

Table 3.2 Firm Evaluation of Origins of Innovation Ideas

	Importance					Sum
	Strong (5)		——→		Weak (1)	
Demand from domestic customers	30%	28%	21%	8%	14%	359
Own idea collection	30%	26%	25%	9%	10%	356
Reverse engineering	20%	33%	24%	10%	14%	359
Demand from foreign customers	28%	24%	17%	8%	24%	360
Market report of sales agent	15%	22%	23%	10%	30%	357
Licensing	8%	18%	21%	14%	40%	359
Demand from parent company	11%	14%	10%	12%	53%	354
Market reports of universities or research institutes	7%	10%	24%	15%	44%	358

PS: numbers in the first five columns indicate the percentage of firms providing the answer

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

In the process of undertaking product innovation (See Table 3.3), electronics firms in the Pearl River Delta turn firstly to domestic customers for the support of equipment and software, secondly to foreign customers and finally to the parent companies, which corresponds to the aspect of triggering innovation ideas.

Table 3.3 Firm Evaluation of Channels of Equipment Support

	Importance					Sum
	Strong (5)		——→		Weak (1)	
Support from domestic customers	27%	24%	18%	9%	22%	347
Support from foreign customers	22%	18%	18%	12%	31%	343
Own purchase	11%	6%	8%	6%	70%	342
Support from parent company	8%	6%	6%	2%	77%	343

PS: numbers in the first five columns indicate the percentage of firms providing the answer

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

As for the tacit knowledge the electronics firms in the Pearl River Delta interact more with domestic customers to acquire technical experience and know-how, either in an active way (engineers sent to domestic lead firms or customers) or in a passive way (engineers sent by domestic customers). The interaction with foreign

customers is the second most important channel of acquiring necessary tacit knowledge in order to undertake successful innovations. The other channels, such as universities and the parent company, have the least weighting in the interactive learning activities aimed at acquiring tacit knowledge.

Table 3.4 Firm Evaluation of Channels of Technical Know-how Support

	Importance					Sum
	Strong (5)		——→		Weak (1)	
Engineers sent to domestic lead firms or customers	23%	27%	22%	7%	21%	350
Engineers sent by domestic customer	17%	24%	19%	11%	30%	348
Engineers sent to foreign lead firms or customers	16%	21%	18%	9%	36%	349
Engineers sent by foreign customer	16%	17%	17%	13%	37%	349
Engineers sent to universities	13%	12%	21%	14%	41%	349
Engineers sent by parent company	7%	6%	3%	4%	81%	350

PS: numbers in the first five columns indicate the percentage of firms providing the answer

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

In Table 3.5, it is shown that electronics firms in the Pearl River Delta interact with external agents in innovation activities mostly through exhibitions, the Internet and sales agents, confirming an arms-length market relationship. Business contacts through recommendation by business partners are also widely applied. In contrast, the most informal personal networks such as recommendation by relatives and friends are rarely applied. In the process of interactive learning, informal relations are more able to promote the level of information sharing and knowledge transfer due to trust between the partners. However, when the firm capabilities are not equally developed among the firms, interactive learning within informal frameworks tends to harm the incentives of firms with higher capabilities, and therefore reduces the frequency of interactive learning.

Table 3.5 Firm Evaluation of Interaction Modes

	Importance					Sum
	Strong (5)		——→		Weak (1)	
Active searching	49%	29%	14%	3%	5%	354
Business contacts	37%	35%	17%	3%	7%	354
Personal contacts	16%	21%	29%	13%	21%	353

PS: numbers in the first five columns indicate the percentage of firms providing the answer

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

3.4.2 Econometrical Analysis

As the observed data in the questionnaire take the form of ordered responses, latent class analysis is applied first to characterize clusters of similar cases in interactive learning behavior in product innovation processes. A latent class model groups the observations in terms of probability. This stands out from normal clustering methods, as it is able to provide measurements of parsimony and goodness of fit that are statistically sound. In this way, the subjectivity of decision about class number can be effectively controlled.

Table 3.6 Clustering of Electronics firms based on the Latent Class Model

	Probability of high evaluation[1]	Weak Interactive Learning Cluster	Moderate Interactive Learning Cluster	Intensive Interactive Learning Cluster
Origins of Innovation ideas	Own idea collection	0.49	0.50	0.81
	Reverse engineering	0.45	0.48	0.77
	Licensing	0.14	0.24	0.56
	Demand from parent company	0.15	0.26	0.48
	Demand from foreign customers	0.38	0.51	0.83
	Demand from domestic customers	0.49	0.53	0.86
	Market reports of Sales agent	0.22	0.40	0.69
	Market report of universities or research institutes	0.03	0.17	0.49
Support of Equipment and Software	Support from parent company	0.09	0.10	0.33
	Support from foreign customers	0.24	0.24	0.94
	Support from domestic customers	0.38	0.40	0.93
	Own purchase	0.19	0.06	0.27
Support of Related Technical know-how and experience	Engineers sent by parent company	0.08	0.09	0.26
	Engineers sent by foreign customers	0.16	0.29	0.76
	Engineers sent by domestic customers	0.24	0.41	0.80
	Engineers sent to foreign lead firms or customers	0.19	0.38	0.77
	Engineers sent to domestic lead firms or customers	0.35	0.53	0.78
	Engineers sent to universities	0.09	0.31	0.50
Interacting mode in the innovation process	Active searching	0.72	0.72	0.99
	Business contacts	0.65	0.68	0.97
	Personal contacts	0.25	0.38	0.59
Share of each cluster		50%	28%	22%

1. Probabilities that the firm in each cluster give a high evaluation, i.e. important (4) or very important (5) of the importance of each aspect in the product innovation process.

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

Table 3.6 shows the results of a latent class model when the 3-cluster solution is used. The fitness of this solution outperforms the 4-cluster solution owing to the more parsimonious and theoretically sound interpretability (Appendix B). The numbers in the table indicates the probabilities of firm's high evaluation of the importance of each aspect in the innovation process conditional to the respective cluster.

The three clusters identified differ in terms of the scope and intensity of interactive learning in the product innovation process. The first cluster is an underperformer in interactive learning activities. It groups together firms that are neither competent in internal learning activities, such as reverse engineering, licensing and triggering of innovation ideas by internal discussion, nor actively involved in interactive learning processes, such as getting innovation-related information and ideas and obtaining necessary codified and tacit knowledge for successful innovation outcomes.

The second cluster, which is referred to as the moderate interactive learning cluster, outperforms the weak interactive learning cluster in the aspect of applying interactive learning processes to trigger innovation ideas and obtain technical know-how and experience. Firms belonging to this group seem to interact more with domestic customers (or domestic lead firms in terms of obtaining tacit knowledge) in the innovation process. Like the weak interactive learning cluster, the firms in the moderate interactive learning cluster mostly implemented strategies of active searching and business networks when undertaking interactive learning. The probabilities of applying Guanxi networks for the second cluster are marginal (68% and 38% respectively with business partners and with relatives and friends).

The third cluster, which is referred to as the intensive interactive learning cluster, shows the greatest inclination to undertake interactive learning activities in the innovation process, especially in the aspect of interacting with foreign and domestic customers to obtain innovation ideas and related codified and tacit knowledge. In addition, they also tend to interact with sales agents, universities and research institutes to trigger innovation ideas. Unlike the other two clusters, intensive interactive learners are inclined to apply Guanxi networks with business partners, relatives and friends, combining these with the active search strategy.

The class distribution indicates that interactive learning processes are still underdeveloped in the Pearl River Delta, China. Half of the firms surveyed are still very weak in undertaking this kind of learning activity to take advantage of dynamic

externalities, i.e. the knowledge spillovers from other firms. 28% of the firms surveyed are nurturing the capability of interactive learning while 22% have shown the willingness and acquired the capability to undertake interactive learning in order to trigger product innovation and obtain support for necessary codified and tacit knowledge. The low frequency of the PRD's electronics firms in undertaking interactive learning reflects the immature internal absorptive capacity of most firms to understand and adapt knowledge from other agents effectively.

Table 3.7 shows the characteristics of each cluster in the aspects of average firm age, share of large firm, share of firms with foreign participation, sales growth, export market share, human capital and product innovation outcome.

Table 3.7 Descriptive Statistics of Each Cluster

	Cluster of latent analysis	Weak Interactive Learning Cluster	Moderate Interactive Learning Cluster	Intensive Interactive Learning Cluster
Firm Characteristic	Firm age(years until 2010)	9.84	12.22	11.37
	Firm ownership (% of foreign firms)	0.36	0.41	0.42
	Firm size (% of large firms)	0.08	0.05	0.12
	Technical staff above bachelor degree (%)	33.75	32.61	42.15
Firm Performance	Sales growth(2007-first half of 2009)	-12.6	-5.6	-2.5
	Export market(% of sales)	40.4	45.8	50.7
	Improvement on product function expansion(% of firms with evaluation as significant or very significant)	3.6	3.6	4.1
	Improvement on product category upgrading(% of firms with evaluation as significant or very significant)	3.4	3.8	3.9

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

In terms of firm characteristics, the intensive interactive learning cluster has slightly more participation from foreign capital. Furthermore, there are more large firms in the group of intensive interactive learning cluster. The characteristic that stands out is the human capital. The share of technical staff possessing at least a bachelor degree in intensive interactive learning firms exceeds others by almost 10 percentage points. As for the firm performance, it is not surprising to find out

intensive interactive learning firms underwent the least reduction in sales during the first half of 2009 compared to 2007 due to the financial crisis in late 2008, which again affirms the role of interactive learning in acquiring market information and reducing uncertainty. Moreover, they also lead other firms in terms of export performance and product innovation outcome.

The effect of interactive learning on the firm product innovation outcome could then be tested. The primary independent variables are the binary responses on whether the firm belongs to a specific class, and the benchmark is the weak interactive learning cluster. Other control variables in the regression are listed in Table 3.8.

Table 3.8 Control variables in Ordered Logit Regression

	Indicators	Description
Firm Characteristics	Firm Size	Defined according to Chinese firm size standard, 1 as large firms with no less 300 million Yuan sales and no less than 2000 employee, otherwise as small and medium-sized with the value of 0
	Firm Ownership	1 as firms with foreign participation (wholly owned or joint venture), 0 as firms with 100% domestic participation
	Firm Age	Years since establishment of the firm
Absorptive Capacity	CEO Education	1 as CEO below bachelor degree 2 as CEO with bachelor degree 3 as CEO with graduate degree (master or doctor) 4 as CEO with bachelor or above combined with overseas experience
	Level of technical staff	Percentage of technical staff that have bachelor degree or above *multiplied by* training frequency
	Initial product technology	Defined according to International Standard Industrial Classification of all Economic Activities, Rev 3[1], 0 as producing low-tech products when starting business, 1 as producing medium- and high tech products when starting business

1. Specific classification of products into the different levels could be referred to Appendix C.

Source: Own Survey Questionnaire (See Appendix A)

The dependent variable in the regression takes the firms' evaluation of the degree of improvement (ranging from 0 to 5 with increasing significance of change) in product function expansion and product category upgrading into account. It is considered that functional expansion and category upgrading are more complex and thus require more interactive learning than improvement on design and quality. The product function expansion refers to the addition or upgrading of product functions

within the same product category, while the product category upgrading refers to more disruptive innovation, such as producing mainboard instead of network adapters, or producing mp3 players instead of flash memory. Due to the discrete and ordered feature of this multinomial-choice variable, the ordered logit model was applied. In order to reduce the dimension of the dependent variable that might influence the stability of the ordered logit model with a medium-sized sample, the dependent variable round of the average of the evaluations on function expansion and category upgrading. In this way, the dependent variable measures the approximate evaluation of firms on the improvement of function expansion and category upgrading with increasing degree from 0 to 5.

Table 3.9 shows the result of the ordered logit regression.

Table 3.9 Ordered Logit Regression on product innovation outcome

Independent variables	*Product Innovation outcome* *（Average score of evaluation）*			
	Model 1 (Without Control)		Model 2 (With Control)	
	Odds ratio estimate	Coefficient estimate	Odds ratio estimate	Coefficient estimate
Moderate Interactive Learning Cluster	1.243	0.217 （0.230）	1.073	0.070 (0.259)
Intensive Interactive Learning Cluster	2.395	0.873*** (0.264)	2.710	0.997*** (0.298)
Firm Age	—	—	1.020	0.019 (0.016)
Firm Size	—	—	0.739	-0.303 (0.439)
Firm Ownership	—	—	0.572	-0.559** (0.222)
Level of technical staff	—	—	1.003	0.003** (0.002)
CEO Education	—	—	1.355	0.304** (0.123)
Initial product technology	—	—	1.456	0.376 (0.242)
Prob > chi2	0.0038	0.0038	0.0000	0.0000
Pseudo R square	0.0122	0.0122	0.0518	0.0518
Number of Observations	339	339	283	283
Proportional odds assumption test	χ^2=15.23, p=0.02		χ^2=36.17, p=0.05	

1. Standard errors in parentheses; *p<0.10, **p<0.05, ***p<0.01.

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

The p-values of the chi-square likelihood ratio are all under 0.01, which guarantees that the model as a whole fits significantly better than an empty model. The coefficients in the ordered logit model display the ordered log-odds scale of change to higher order by one unit increase in the predictor while other variables are held constant. For example, if a firm were to apply intensive interactive learning in the product innovation process, the ordered log-odds of making better improvement on innovation outcomes would increase by 0.989 while other variables in the model are held constant.

Model one presents the results without control variables, in which the probability of having better improvement on product function expansion and product category upgrading for firms belonging to the intensive interactive learning clusters is more than twice as high, while for the moderate interactive learning cluster the positive impact is not significant.

Model two presents further results with the control variables, such as firm characteristics and firm absorptive capacity. Again, the intensive interactive learning firms possess a significantly higher probability of achieving better product innovation outcome than weak interactive learning firms, while the impact of belonging to moderate interactive learning cluster does not significantly improve the product innovation outcome compared to belonging to the weak interactive learning cluster. This verifies the hypothesis that the wide scope and high intensity of interactive learning activities contribute to innovation outcome due to the complexity and uncertainty of innovation processes.

The higher probability of achieving better innovation outcome when belonging to the intensive interactive learning clusters in model 2 compared to model 1 can be accounted for by the over-representation of foreign firms in the intensive interactive learning cluster, which has a significantly negative impact on the probability of achieving better product improvements. It is proved by model two that foreign participation would significantly reduce the probability of achieving better innovation outcomes. It can be concluded at least that foreign firms do not participate actively in incremental product innovation activities, which I measure in the study according to function expansion and category upgrading. They might focus on fields of R&D activities, patenting and scientific publication. However, if they undertake product innovation activities, they also rely on interactive learning to an even more intensified degree than domestic firms (See Table 3.7), in order to foster product innovation

outcomes.

Robustness Test

For ordered logit regression, it is assumed that the relationship between each pair of outcome groups is the same. This is called the proportional odds assumption. In the last row of Table 3.9, the test of proportional odds assumption is demonstrated. For model 1, it has not sustained the test (p=0.02). Model 2 does not violate the assumption in a confidence level of 95%. However, it has violated the assumption if the confidence level is raised to 99%. The results indicate that the relationship between each pair of outcome groups does not hold for the same and one single model (model 1 and model 2) is not representable. Thereby, a generalized ordered logistic model is run to show the difference of the coefficients between each pair of outcome groups.

Table 3.10 shows the coefficients and significance level for each pair of outcome groups. Each model demonstrates the probability to move the evaluation to the next higher level (e.g. from 1 to 2, 2 to 3, and so on).

Table 3.10 Generalized Logit Regression on product innovation outcome

Independent variables	Probability estimates (1 to 2)	Probability estimates (2 to 3)	Probability estimates (3 to 4)	Probability estimates (4 to 5)
Moderate Interactive Learning Cluster	19.690	0.998*	0.053	-0.417
	(783.58)	(0.588)	(0.323)	(0.363)
Intensive Interactive Learning Cluster	0.946	1.543	0.871**	0.867**
	(2.024)	(0.957)	(0.401)	(0.340)
Firm Age	-0.083	0.009	0.059**	0.012
	(0.124)	(0.035)	(0.024)	(0.021)
Firm Size	—	13.782	-0.470	-0.212
		(1331.126)	(0.592)	(0.537)
Firm Ownership	-4.985***	0.074	-0.381	-0.688**
	(1.591)	(0.504)	(0.294)	(0.307)
Level of technical staff	-0.015	0.004	0.003	0.003*
	(0.010)	(0.004)	(0.002)	(0.002)
CEO Education	0.304	0.421**	0.376**	0.275*
	(0.673)	(0.266)	(0.158)	(0.156)
Initial product level	-4.004**	0.486	0.439	0.503
	(1.625)	(0.455)	(0.293)	(0.328)
Constant	8.626***	0.303	-1.199***	-2.269***
	(2.744)	(0.712)	(0.459)	(0.512)
Prob > chi2		0.000		
Pseudo R square		0.128		
Number of Observations		283		

1. Standard errors in parentheses; *p<0.10, **p<0.05, ***p<0.01.

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

For the low-scale improvement on function expansion and category upgrading (i.e. from not significant to a little significant and from a little significant to normally significant improvement), the intensive interactive learning firms does not perform a significantly higher probability of achieving better innovation outcomes than the weak interactive learning firms. While for the high-scale improvement on function expansion and category upgrading (i.e. from normally significant to significant and from significant to very significant improvement), the widest scope and highest intensity of interactive learning displays a significantly important role in promoting the innovation outcomes. Meanwhile, the moderate interactive learning contributes to the innovation outcome when a firm is to scale up from making a little improvement to making normal improvement on production function expansion and product category upgrading.

It might be interesting to note that the domestic firms display significantly higher probability in fostering product innovation than foreign firms in low-scale product improvement (β = -4.617***), but their superiority over foreign firms in promoting product innovation become insignificant (from 2 to 3 and from 3 to 4) or decreases a lot (from 4 to 5). This demonstrates the limited capacity of domestic firms in promoting product innovation.

3.5 Discussion and Conclusion

Learning by interacting generates increasing return for the internal learning by doing and learning by using, creating positive externalities for the whole economy (Lundvall, 2005). This chapter testifies to the complementary role of interactive learning to internal efforts both in assisting firms in acquiring information to make innovation-related decisions in an uncertain market, and supporting firms with necessary codified and tacit knowledge in problem-solving and knowledge exploration during the innovation process. Empirical investigation of electronics firms in one of the world's largest electronics clusters – the Pearl River Delta, China – highlights the importance of interactive learning with domestic customer in the production innovation process, while generally applicable knowledge is more attained through activities such as introduction of advanced samples and internal imitation process, leaving the channel of universities and research institutes rarely applied among the electronics firms.

In general, this chapter verifies that the scope and intensity of interactive learning contribute to better innovation outcomes. Based on the latent class model, it is possible to identify three clusters of firms that bear increasing degree of interactive learning activities. The third cluster, which includes one-fifth of the surveyed firms, undertakes the widest scope and highest intensity of interactive learning activities. Moreover, the intensive interactive learning firms have a much higher tendency to apply informal Guanxi networks, for example with business partners, relatives and friends, in the interactive learning process than the other two firm clusters.

The empirical results also demonstrate that both domestic firms and foreign firms embed informal social networks in interactive learning as a way to promote product innovation. However, the foreign electronics firms do not show great interest in undertaking product innovation in the Pearl River Delta, China. Therefore, the Chinese government should encourage the foreign firms to be involved more actively in product innovation with measures such as tax reduction, subsidies and permits for domestic market access, because the interactive learning organized by foreign firms in the product innovation process does not only foster innovation outcome for themselves, but is also able to generate knowledge spillover from the foreign sector to the domestic sector.

The role of informal social assets in supporting interactive learning and fostering innovation merits deeper investigation. Informal Guanxi networks, which are widely applied in Chinese business modes, have been proved by many studies to have a positive role in reducing transaction costs and sustaining reliable and responsive supplier-customer relationships (Meyer *et al.*, 2009; Wu and Choi, 2004; Luo, 2002; Zhou *et al.*, 2003). However, the role of informal Guanxi networks in fostering interactive learning processes and boosting innovation outcome still remains unclear. Therefore, the consideration of informal Guanxi networks into interactive learning processes contributes further to the understanding of social factors that facilitates innovation in the Chinese context.

This chapter contributes to the understanding of the role of interactive learning in promoting innovation activities in the context of China, where innovation is presently viewed as the essential dynamics of economic growth in the face of external market change and domestic inflation pressure. Also, the empirical substances call upon research on the role of informal social networks in supporting interactive learning activities and its implication in the Chinese context. However, Boschma (2005)

indicates that too much commitment to social networks might induce a lock-in effect and underestimation related to the risk of opportunism. In China, it can be expected that firms resort less to social networks when stability-induced institutions are in place. Therefore, it is important to trace the interactive learning pattern and relate its evolution to the maturing institutional framework conditions in future research.

4 Absorptive Capacity, Proximity and Innovation

Insights from an Electronics Firm Survey in the Pearl River Delta, China

Abstract: Proximity concept provides a measurement of accessibility other than the concept of externality as just being there. To determine the impact of proximity on learning and innovation has become a key issue in economic geography. In the context of transition economy, this chapter focuses on the role of organizational proximity and social proximity in fostering complex product innovation activities with the comprehensive consideration of sufficient absorptive capacity. Based on a set of questionnaires conducted in the Pearl River Delta, China, this chapter investigates the capacity and strategy of local electronics firms to capitalize on proximity. The result shows that electronics firm, especially small and medium sized firms are more interested and capable to interact with domestic customers and external institutions to get tacit knowledge and trigger innovative ideas. Moreover, production experience in high-tech fields is an important component of absorptive capacity that enables the use of proximity, while the educated level of managerial staff and entrepreneurs that are able to negotiate and strategically couple with global firms is crucial in using organizational proximity to foster innovation. Finally, this chapter shows that a group of social active firms has emerged, which is essential for the formation of a dynamic regional innovation system. However, the effect of social proximity in fostering innovation is marginal. Finally, the chapter pointed out that governance infrastructure should be established to stabilize and support the interactive learning, especially that within the social proximity.
Keywords: Social Proximity; Organizational Proximity; Learning; Product Innovation

4.1 Introduction

In recent studies on economic growth, innovation and learning are considered as the primary dynamics, and territories instead of firms are becoming the foci of learning, particularly collective learning process among local agents (Lundvall and Johnson, 1994). The literature of proximity provides a feasible analytical grid to understand the conditions for learning within and between different agents (Malmberg, 1997; Boschma, 2005; Menzel, 2008). Due to the uncertainty of innovation process, innovation outcome strongly depends on firms' ability to capitalize on various proximities to facilitate learning and coordinate complex problem solving process.

Boschma (2005) classifies proximity into cognitive proximity, organizational

proximity, social proximity, institutional proximity and geographical proximity. This chapter adopts this classification as the departure of analysis. In China, institutional framework such as formal rules and law is weak, and geographical proximity serves as a precondition for other proximities such as social proximity and institutional proximity to function. Therefore, this chapter would focus on the role of social proximity and organizational proximity in facilitating interactive learning and how cognitive proximity, which can be reflected and measured as the firms' absorptive capacity in this chapter, influences the use of these two proximities.

On one hand, the literature of global production network suggests that organizational proximity is more accessible to firms organized under global flagship network, and this entitles them to access to particular product and process technology and intra-organizational know-how under the hierarchical control of the flagship (Ernst and Kim, 2002; Gereffi *et al.*, 2005; Yeung, 2009; Whitford and Potter, 2007). On the other hand, the literature of regional innovation system stresses the role of social proximity, which is often correlated with geographical proximity, in accelerating learning and constituting dynamic innovation synergies (Malmberg, 1997; Porter, 2000b; Lazaarini *et al.*, 2001; Asheim and Isaksen, 2002; Iammarino and McCann, 2006; Malmberg and Maskell, 2006; Asheim *et al.*, 2007). Furthermore, social proximity is widely applied as the informal inter-personal relationships in the research region the Pearl River Delta, China (Zhou *et al.*, 2003; Meyer *et al.*, 2009) with regard to production activities. Consequently, the capacity to capitalize further on informal social relations in order to foster innovation is critical for the emergence of regional innovation system in the Pearl River Delta, China.

In a dynamic global economy, local firms are required to reinforce social and organizational proximity mutually. On one hand, the capacity of local firms to capitalize on social proximity and to transform it into innovative synergy and profit gives higher incentive of foreign firms to transfer more advanced technology and activities to their organizational proximate partners in developing countries. Moreover, this entitles the local firms and governments more bargaining power to negotiate with foreign partners, which results in easier and more stable manipulation of strategic coupling. On the other hand, new technologies and market opportunities that are pumped into the local system by strategic coupling with distant partners initiate a dynamic collective learning process in the region (Bathelt *et al.*, 2004).

In proximity approach, cognitive proximity is the basic one to gain other

proximities. This implies that firms should develop certain level of absorptive capacity in order to capitalize on organizational proximity and social proximity. Cohen and Levinthal (1990) suggest that absorptive capacity is the primary requirement for firms to identify, interpret and exploit the new knowledge. This chapter identifies the absorptive capacity in Chinese firms embodied as the human capital, R&D activities and product technology endowments and further explores the influence of cognitive proximity, which is promoted through the strengthening of absorptive capacity, on the firms' capacity to use social proximity and organizational proximity in the interactive learning process.

Most of the firms in developing countries are weak in capitalizing on the proximities to foster innovation outcome due to the constraint of internal absorptive capacity. Usually, they rely on organizational proximity and social proximity only to gain market information and sustain reliable supplier-customer relationship. Therefore, this chapter aims to investigate the use of organizational proximity and social proximity in the process of product innovation, and compare their respective effect of fostering innovation outcomes. In addition, it tries to reveal their relationships with absorptive capacity of the firms, such as human capital, R&D activities and product technology. Moreover, distinction between large firms and small and medium sized firms in their willingness and ability to use different proximities would be identified as to provide more insight into the development of regional innovation system.

In sum, this chapter aims at answering three questions:

1) Which components of absorptive capacity enable a firm to conduct extra-learning using either organizational proximity or social proximity in product innovation process?

2) What is the difference of SMEs in terms of using proximity compared to large firms?

3) Controlling for other firm-specific characteristics, does use of proximity contribute to the product innovation outcome? And does the effect of social proximity differ from the organizational proximity?

In general, the empirical analysis of this chapter provides insight into the way of interactive learning in the product innovation process in the Pearl River Delta from the proximity perspective. The comparative investigation between the role of organizational proximity and social proximity in promoting innovation outcomes is able to offer insights into the development of regional innovation system which starts

from a FDI-driven platform in late 1970s.

The chapter proceeds as follows: the second part analyzes the role of social proximity and organizational proximity in supporting trust-based interactive learning, putting the theoretical discussion on a global-local interaction scale. The third part analyzes the firm-specific factors influencing the absorptive capacity that is determinant in external interactive learning. In the theoretical discussion in the previous two parts, hypotheses are drawn. The fourth part presents the data and the applied methodology to operationalize the analysis and test the hypotheses. The fifth part discusses the results. The sixth part concludes and draws future research direction from the empirical evidence.

4.2 Use of Proximity in Interactive Learning

4.2.1 Proximity: concept and taxonomy

The concept of proximity developed in 1990s by French School contributes to the understanding of the mechanisms that is working through the interactive process of knowledge transfer (Kirat and Lung, 1999; Torre and Gilly, 2000; Torre and Rallett, 2005; Boschma, 2005, Menzel, 2008). Proximity is a concept that is usually discussed with innovation, since it plays an important role in promoting the trust and understanding when undertaking complex and highly risky innovation activities.

Proximity bears a plural sense. It goes beyond the geographical proximity, which has limited role without the support of other proximities. There are many classification of proximity in the literature. They are mainly associated with two perspectives: institutionalist approach and interactionist approach. The institutionalist approach concerns about three proximities: geographical proximity, organizational proximity and institutional proximity. In this approach, geographical proximity indicates the physical proximity without institutional context, while organizational proximity and institutional proximity bear institutional meaning in the way that the scope and scale of shared and common rules determines the function of proximity (Kirat and Lung, 1999; Torre and Rallet, 2005;). However, interactionist approach only differs proximity from physical one (geographical proximity) from non-physical one, which is either defined by common resemblance or belonging to the same affiliation.

In some ways, the two approaches are overlapping, and it is possible to bridge over these two classifications (Carrincazeaux *et al.*, 2008). In order to make the points clearer, this chapter adopts the classification developed by Boschma (2005), who tries to make a comprehensive understanding of various proximities. According to Boschma (2005), there are five different kinds of proximity considered:

- Cognitive Proximity: People have the same knowledge base and expertise can better learn from each other. For organizations which possess idiosyncratic nature of knowledge due to cumulative process of routine development, cognitive proximity rests on the similarities of technical and market competencies between the actors that affect the search and imitation cost when exploring new knowledge in other organizations.
- Geographical Proximity: It indicates the physical distance between the interacting actors measured by time or money, which depends on the infrastructure. Geographical proximity alone is not able to foster knowledge transfer and innovation. It might combine with cognitive proximity for firms to conduct in-time monitoring and comparing without direct interaction. It also strengthens the social proximity by offering more chances for face-to-face contact. As Howells (2002) puts it, the impact of geographical proximity is rather indirect and subtle.
- Organizational Proximity: It refers to the sharing of reference space and knowledge that is strengthened by hierarchy and control within the same organization (firm, group, cooperation network). With the development of information, communication and transportation technology, pure co-location is no longer determinant in knowledge transfer. Network, which even transcends the boundary of countries, begins to play a role as vehicles of knowledge diffusion.
- Social Proximity: It relates to trust and commitment based on kinship, friendship and cooperation experience. Social proximity does not only foster the communication of tacit knowledge which is difficult to trade in the market, but also reduces opportunist behavior through the establishment of durable relations. It is often geography bounded because the geographical proximity enhances the chances of meeting and communicating.
- Institutional Proximity: Unlike social proximity which is based on informal social relations between agents at the micro level, institutional proximity is based on norms and values at the macro-level. It is depersonalized and relies on general

trust, which is brought by common rules, norms and values that have been developed and established over a long term such as laws, regulations and cultural habits. Institutional proximity is also geography bounded at most of the time, but the scale might be larger than social proximity because institutions may exist in the level of town, city, province and country.

Proximity is not panacea. Too much proximity would lead to negative results such as too high factor price, lock-in effect, vicious competition and mistrust (Torre and Rallett, 2005; Vicente and Suire, 2007; Brossard and Vicente, 2007). Boschma (2005) has summarizes the appropriateness of proximity, as summarize in Table 4.1.

Table 4.1 Appropriate Distance of various Proximities

	Too little	Too much	Solutions
Cognitive proximity	Less absorption	1) less to learn from 2) risk of lock-in 3) undesirable spillovers to competitors	Diverse and complementary knowledge base of actors
Organizational proximity	Strong tie (hierarchical): 1) Control mechanism to ensure ownership rights and rewards when new knowledge creation is with uncertainty and opportunism 2) Makes complex knowledge transfer more effective	1) lock-in in specific exchange relations (esp. the relations are asymmetric) 2) lacks feedback mechanisms 3) lacks organization flexibility to implement innovation (interest group, vested interests)	loosely coupled network
Social proximity	Lack of trust and commitment	underestimation of opportunism	Mixture of market and embeddedness
Institutional proximity	Weak formal institutions s	Institutional lock-in and inertia	Institutional checks
Geographical proximity	No spatial externalities	Specialized region's case, but not geographical factor alone	Pipeline-

Source: Summarization based on Boschma (2005)

Cognitive proximity serves as perquisite for learning, and it is easier achieved via the interaction within the supplier link and organizational boundary due to the continuity of knowledge transfer. Social proximity and institutional proximity rest often on geographical proximity to function properly. Capello (1999) demonstrates that social proximity and institutional proximity set in motion an informal and tacit

transfer of information and know-how, which contributes to the transformation process for a specialized area to an innovative milieu. On the extra-local scale, organizational proximity gives a different meaning to supplier linkages, which facilitates the transfer of tacit knowledge by control and hierarchy.

In the context of China, which is undergoing a gradual transition towards a market economy, many formal institutions such as laws, regulations and organizations (work unions, research institutes, patent office, etc.) have already been established, although their enforcement is still problematic. Moreover, the institutional framework is unstable in the transition phase. As a result, the economic players in China do not tend to rely too much on institutions to do business (Zhou *et al.* 2003; Meyer *et al.* 2009). In the following discussion, I therefore do not focus on the role of institutional proximity at the macro level. Instead, the role of organizational and social proximity in fostering tacit knowledge transfer and dynamic innovative synergies is examined and compared.

4.2.2 The role of Organizational Proximity and Social Proximity in promoting Innovation in Latecomer context: Comparison and Dynamism

Figure 4.1 shows the how information and knowledge transfer across the firm boundary to support the complex innovation process. The knowledge transfer organized within the social proximity and organizational proximity facilitates communication and strengthens cooperation owing to understanding and trust within the proximity boundary. Firms can on one hand interact and cooperate with organizationally proximate partners such as parent companies and foreign customers to gain information, ideas and supported knowledge, which surpasses the limit of geographical proximity. On the other hand, firms can also establish trust-based social network with the organizationally distant partners such as the domestic customers, universities, research institutes and market agencies, seeking the information and knowledge within the social proximity. Social proximity is usually geography bounded due to the positive role of face-to-face interaction in solving incentive problems, facilitating learning and providing psychological motivation (Storper and Venable, 2004).

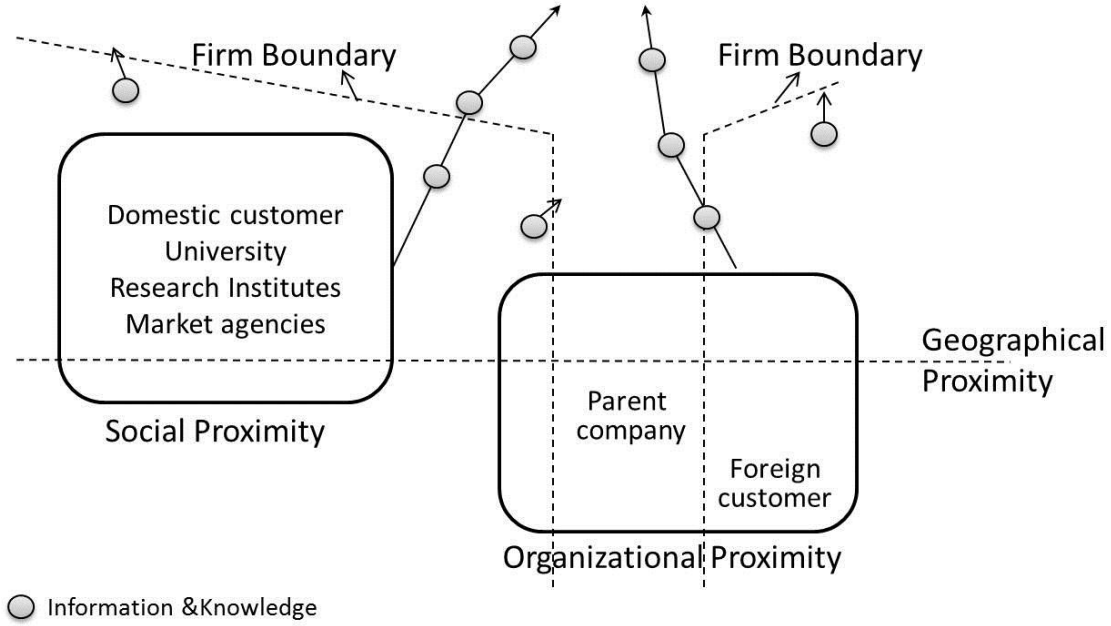


Figure 4.1 The Knowledge Transfer across the Firm Boundary

Source: Own draft

(1) The role of organizational proximity in innovation in latecomer context

The literature on global production network has provided insight into the role of organizational proximity in industrial organization for multinational companies and its function as a vehicle of cross-country knowledge transfer. The global production network perspective "covers both intra-firm and inter-firm transactions and forms of network coordination. It links together the flagship's own subsidiaries, affiliates and joint ventures with its subcontractors, suppliers, service providers, as well as with partners in strategic alliance" (Ernst, 2002: 91).

The main purpose of this network is to provide the flagship, which includes the brand firms, contract manufacturer, first-tier supplier and large trade companies, with quick and low-cost access to resources, capabilities and knowledge that are complementary to its core competencies. Outsourcing of volume manufacturing enables these firms to combine cost reduction, product differentiation and quick response to the market (Ernst and Kim, 2002).

Organization exists as a bundle of transactions or contracts (Coase, 1937) and as a bundle of knowledge (Barney, 1991, Barney, 2001). Following the logic of transaction cost minimizing, organizational boundary helps to curb the opportunist behavior of business partners, such as distorting business information, failing to fulfill

commitments or malicious imitation, when rules and trust are lacking. Kindleberger (1964: 146 & 147) argued that the industrial organization separating firms that deal with each other in arm-length market (British case) "may have impeded technological change because of the possibility that part of the benefits of that change would have been external to the separated firms". Hennart (1993) suggests further that the organizational boundary remains when the internal managerial cost does not exceed the market transaction cost related to opportunism. On the other hand, the path-dependent nature of firm-routine development enables firm-specific tacit knowledge transfer more easily, which reduces internal management cost to a large extent.

Thereby, the governance of global value chain depends on three factors: 1) the complexity of transactions; 2) the ability to codify knowledge; 3) the capabilities in the supply-base (Gereffi *et al.*, 2005). In another word, the principle of exerting organizational control on distant subsidiaries and suppliers is that the more complex the transactions, the harder it is to codify knowledge and the lower capabilities the supply-base has, the closer organizational proximity is needed. The three aspects are closely related to the opportunism risk and transferability of knowledge.

According to these three standards, Gereffi *et al.* (2005) define five types of global value chain governance: hierarchy, captive, relational, modular and market, which range from high to low levels of explicit coordination and power asymmetry. In Table 4.2, I summarize the characteristics of these five governance forms.

Table 4.2 Governance of Global Value Chain according to Organizational Proximity

	Organizational Proximity: Close ⟶ Far				
	Hierarchy	Captive	Relational	Modular	Market
Description	Managerial control from headquarters to subsidiaries and affiliates	Small suppliers monitored and controlled by large firms	Relations managed through reputation and trust	Suppliers provide customer-specified products and "turn-key" services	Relations on contract specifications

Source: Summarization based on Gereffi *et al.* (2005)

For the global flagship that organizes production in developing countries, organizational proximity is conductive to reducing opportunist risk related to physical

and human capital investment. Global flagship takes on the responsibility of investing in setting up and upgrading machines as well as training skill in the beginning of operation in developing countries due to the underdevelopment of technology and human skills in these regions. In addition, hierarchy and control within the same organization enables the efficient downward transfer of knowledge. Many studies on developing countries have shown that most of the firms conduct innovation "in-house" instead licensing and assigning contractual arrangements to unaffiliated firms (Schmitz, 1995; Schmitz and Nadvi, 1999). One of the explanations offered by Teece (1986b) are that proprietary considerations are assisted by organizational integration, since contracts, proprietary rights and technology transfer via the market are complex and, especially in developing countries, often too expensive.

In short, when the institutional environment, consisting of elements such as property rights and related business laws, is not fully developed, and the embeddedness of global firms is not mature enough to ensure social proximity that brings mutual trust, flagship companies tend to restrict knowledge to flowing only within the boundaries of the firm in order to reduce the chances of opportunism and ensure return on internal R&D efforts.

Accordingly, for firms in latecomer countries, organizational proximity provides two advantages:

Firstly, it provides them the access to knowledge, especially tacit knowledge in advanced technological field. The flagship typically provide subsidiaries or closely cooperating suppliers with encoded knowledge, such as machinery, blueprints, production and quality control manuals, product and service specification and training handouts. For latecomer firms, they have much more profit room than lead firms by just sourcing the existing technology to push the internal technological frontier. Yeung (2009) state the importance of external network building in acquiring capabilities in the Asian context, and introduces a concept called "strategic coupling" to better understand the evolution of local and regional firms in their dynamic articulation in global production network. Morrison *et al.* (2008) also show firms gain technological capabilities from participating in global value chains. Not only that, latecomer firms also join the international production network in order to acquire tacit knowledge to absorb better the encoded knowledge by having the engineers and managers from foreign partners train on site. However, Ivarsson and Alvstam (2005) demonstrate that geographical proximity to the foreign transnational corporations is crucial for local

suppliers to absorb external technology through regular and ongoing interaction with their primary foreign customers.

Secondly, reliance on organizational proximity prohibits involuntary knowledge spillover between organizationally distant firms when the cognitive proximity between clustering firms is too little. Because of the abundance of labor force in China, it undermines the incentive of firms to stick to long-term technological and managerial upgrading activities in the face of large-volume production demand from developed countries. Low-cost and flexible responding strategy becomes the general choice. Many firms in the specialized areas in China compete fiercely in low-tech product field with price and flexibility advantage. Because of the standardization of most of these low-tech products, the idiosyncratic nature of knowledge is rather insignificant and little complementary knowledge can be shared between them, which all lead to a too close cognitive proximity. In this case, firms are reluctant to share knowledge because the imitation cost is rather low. By contrast, firms stick to organizational proximity to source external knowledge to support complex innovation and upgrading activities.

In sum, global flagship companies tend to use organizational proximity to reduce opportunism when institutional proximity and social proximity cannot be assured, and local firms tend to rely on organizational proximity to access to knowledge and prevent involuntary knowledge spillover when firm-specific routines has not yet fully developed and diversified to ensure an appropriate cognitive distance between local firms.

It is possible that the suppliers upgrade and co-evolve with the buyer when the technological and organizational change enables a more sophisticated supply chain (Yeung 2009). In 2004, Lenovo bought the PC operation from IBM and upgraded from an OEM to an OBM producer. In 2004, TCL (Shenzhen) co-established a mobile phone joint venture with Alcatel. In 2007, China Electronic Cooperation subsidiary Sungfei (Shenzhen) acquired the mobile phone operation from Phillips. These are examples of upgrading by enhancing internal absorptive capacity and strategically recognizing the coupling chances with leading global firms.

However, organizational proximity alone has a limited role in upgrading and innovation. Firstly, many brand owners arrange the global strategic layout in such a way that strategic R&D, marketing and management are located in their home countries or in regions in developed countries where innovation partners and reliable

institutions are available (Feinberg and Gupta, 2004), while functions such as production, sales and logistics are located in developing countries (Pan and Chi, 1999). Although the internationalization of R&D activities has grown significantly since 1990s (OECD, 1998), technology and knowledge to which domestic firms have access is still limited and mostly low-end. Secondly, global buyers tend to promote incremental product and process upgrading and oppose upgrading if this creates opportunities for suppliers to acquire a broader range of customers (Humphrey, 2004). Consequently, the global buyers and traders might be by-passed by suppliers if the latter gain the ability to work directly with brand companies in developed countries.

In the electronics industry, there is a trend of applying less hierarchy relations in global chain governance mode. Maturing technology such as module production that enables the codifiability of knowledge is one of the reasons behind this trend. The rise of contract manufacturers in the Pearl River Delta, China displays a massive shift towards large-scale vertical re-integration that offers the one-stop buying services for many brand companies (Luthje, 2004). In a sense, the growing capability of local firms shortens the cognitive distance with global flagships and, at the same time, widens the cognitive distance between local firms. For local firms in a gradually maturing industrial cluster, they possess the benefit of use social proximity due to co-location and cultural similarity. Thereby, I would like to turn to the role of social proximity in fostering innovation as a means of overcoming the shortcomings of organizational proximity.

(2) The role of social proximity in innovation in latecomer context

Social ties and relations have an influence on economic outcomes (Granovetter, 1985). Social proximity is secured through informal daily face-to-face interaction such as meeting, chatting, eating together and joint entertainment. Trust and commitment are gradually established in the social interaction process, which contributes to interactive learning and cooperation. Social networks are not spatially bounded, but it can be sustained and produced by the ongoing collective interaction of player located close to each other (Boschma, 2005). It is worth mentioning that social proximity differs from institutional proximity: in the case of the former, people build trust in each other due to continual interaction and a deeper understanding in daily life, rather than in the latter, where common sets of values and recognition of rules are the

key factors (North, 1990; Boschma, 2005).

As discussed before, many firms in specialized clusters of developing countries compete fiercely in low-tech production. Because of the standardization of most low-tech products, firms are reluctant to share knowledge because the reciprocity of interaction is low and the risk of imitation is high. In this case, social proximity, such as that between customers and suppliers, is only used as a way of sustaining an agile and responsive production system. As a result, the role of social proximity in fostering innovation is limited, which leads to rather loose local innovation networks.

The socially and territorially embedded collectively interactive learning process is becoming prominent feature of competitive industrial clusters even in a globalized era (Maskell, 1998; Asheim and Isaksen, 2002). The approach of regional innovation system takes the regionalized assets and processes as the primary account for the innovation capabilities of the firms (Cooke *et al.*, 1997; Doloreux and Parto, 2005). In a well-functioning regional innovation system, the local firms are capable of capitalizing on social proximity not only to facilitate effective knowledge transfer, but also to generate innovation outcomes.

Guanxi, as an informal way of doing business in China, has received growing attention in the recent organizational literature (Park and Luo 2001; Ramasamy *et al.* 2006; Zhang and Zhang 2006). Similar to the concept of social proximity, Guanxi refers to the informal interpersonal relationships and exchanges of favors for the purpose of doing business in traditional Chinese society (Lovett *et al.* 1999). There are three major categories of Guanxi: obligation and loyalty to family members or relatives - defined as the obligatory type of Guanxi, mutual assurance to friends, mutual classmates and colleagues - defined as the reciprocal type of Guanxi, and understandings with acquaintances - defined as the utilitarian type of Guanxi (Zhang and Zhang, 2006). Peng (2003) points out further that the reciprocal and utilitarian types of Guanxi are becoming more important than the obligatory type in later phases of the institutional transition. In reciprocal Guanxi between friends and colleagues in particular, the implicit rule of “paying back favors” (Chinese term: Renqing), due to the fear of damaging one's social reputation and prestige, actually strengthens the constant social interaction through the idea of exchanging favors. Generally speaking, Guanxi in China is a common practice and is even more complicated than any kind of Western interpersonal relationship, since the Chinese have been more or less unintentionally or unconsciously involved in complex Guanxi networks ever since

they began their working lives.

From the organizational perspective, local firms tend to apply an informal network-based strategy in the uncertain environment in China (Peng, 2003). Due to the gradual approach in the transition, many institutional setups have been subverted and not yet substituted, which has resulted in institutional loopholes. As a result, the legal system, property rights protection, industrial regulations and standards are all underdeveloped. Furthermore, the transparency and corruption issues have created an unreliable institutional environment. Under these circumstances, people tend to resort to Guanxi whenever issues emerge.

In the Chinese business world today, Guanxi plays an important role in facilitating economic exchanges and overcoming administrative costs in the face of a deficient institutional framework (Park and Luo, 2001), such as when starting the business, concluding contracts, acquiring institutional protection, and responding flexibly to changing demands. However, its role in innovation has not yet been analyzed. In fact, there are several aspects in which Guanxi can function to promote communication and innovation synergies among firms with sufficient internal capabilities.

The precondition of interactive learning for the purpose of innovation is the sharing of information, knowledge and ideas, as well as commitment and loyalty in the investment phase. In this case, there are risks of opportunism, i.e. asset specificity, and behavioral and environmental uncertainty (Standifird and Marshall, 2000). In summary, Guanxi curbs the risk of opportunism related to innovation in the following ways:

First of all, Guanxi with managers of a business partners can reduce the risk of asset specificity, which refers to the circumstance in which partners, who do not own and invest specific assets, switch suddenly to other partners in the process of innovation. The essence of Guanxi lies in the Confucian thought of harmony and an orderly world. Reciprocal Guanxi with business partners is path-dependent to some extent, because people are less disposed to ruining the precious Guanxi networks for quick profit. Long-term Guanxi acts as a constraint for opportunism, and this brings mutual trust and assurance in the cooperation process.

Secondly, Guanxi networks with other partners can reduce the risk of behavioral uncertainty when sharing knowledge and ideas with cooperation partners. As an old Chinese saying goes, “you will never be defeated if you know everything about your opponent”. For example, if the cooperation partner has the potential to steal your

ideas in order to develop a new product ahead of you, and the contracts and legal systems are not able to help or cost too much, it is safer to know ex ante about the background, reputation and capacity of your cooperation partner through the Guanxi network with other managers (as intermediaries) in the industry.

Thirdly, Guanxi with government officials can reduce the risk of environmental uncertainty, as innovation policies are always unsteady and vague in China. Mangers and entrepreneurs cannot simply rely on government bulletins as their information channel. They actually rely more on Guanxi for information searches and authentication. They often obtain key information and detailed explanation of the policies through obligatory or reciprocal Guanxi. Information transferred within the Guanxi networks is more reliable and trustworthy, thus facilitating the managers' decision-making on investing in innovation projects. Moreover, Guanxi, i.e. being related to or befriended with government officials provides access to scarce resources such as innovation funds and high-end technology transfers, because government officials in China exercise personal preference in the selection process in lieu of strict regulations and market mechanisms

However, Guanxi networks carry the risk of a negative lock-in effect. As Guanxi networks depend on the constant exchange of favors, it is also fragile once the exchange stops. Firms are locked in with current business partners, fearing a destruction of the subtle Guanxi network with a single business partner and all other partners who are related to this partner. In this case, firms do not act as profit-maximizing entities, but rather as Guanxi-satisfying ones. Outdated production modes and product types might persist and are harmful for upgrading and innovation (Saxenian and Hsu, 2001).

One of the disadvantages of Guanxi is that it might damage the development of firm internal capability due to the limit of time and resources. While the Chinese enjoy the benefit of Guanxi, they also bear the Renqing burden, that is to say, they also take the reciprocal obligation and must repay it in the futher (Luo, 1997a). Therefore, the Guanxi network costs time and money. It is a complex weaving interpersonal net that requires constant monitor, investment and subtle utilization. As time and resources are limited, gain in Guanxi network improvement must lead to the lack of investment in other aspects such as managerial capability and technological capability. Su and Littlefield (2001) distinguish Guanxi into two forms: favor-seeking Guanxi and rent-seeking Guanxi. As discussed before, favor-seeking Guanxi

strengthens the continuing social interaction between firms and would contribute to knowledge transfer and innovation when the firms develop enough internal capacity to capitalize on it. However, rent-seeking Guanxi harms the overall efficiency of economies. Resource is distributed in accordance to Guanxi with government officials instead of capability and efficiency of the firms. This actually suppresses the firms' incentives to invest in managerial and technological upgrading, and leads to overinvestment in Guanxi network. As a result, Pareto efficiency of the whole economy would be reduced.

Therefore at last, it should be emphasized that the importance of internal absorptive capacity on using social proximity in a sustainable way. Only when the firms develop enough capacity to absorb, adapt and exploit the information and new knowledge, can social proximity such as Guanxi contribute to the innovation and growth of the firms in the long term.

4.2.3 Proximity for the SMEs in the Clusters

There is an on-going discussion on whether spatial fragmentation process and the development of global production network would undermine the localized external economies (Parsons, 1985; Storper, 1995; Coe *et al.*, 2004). The experience of "Third Italy" draw the scholars' attention again to the localized economies sustained among the small and medium sized firms (Piore and Sable, 1984). In South Italy, flexible and intertwined agglomeration of small and medium sized firms is able to stimulate the learning required for product and process innovation (Whitford and Potter, 2007). Capello (1999) demonstrates further that collective learning in the local scale is the main way of achieving new resources for SMEs. Owing to SME's prominent role in a clustering, it is important to discuss how SMEs undertake interactive learning because it is of great relevance to the formation of a regional innovation system in which reciprocal innovative synergies among SMEs feed the system with growth dynamism and resistance to violent market change owing to the cushion effect.

The factor influencing the ability and willingness of different sized firms to use proximity is twofold: 1) resource and capability restriction of small firms; 2) the lack of interest of large firms in exploiting minor profit.

- Resource and Capability restriction

Innovation activities require financial commitment on behalf of the firms to build up competences and skills through training, engineering activities and information

search (Goedhuys, 2005). Product innovation even requires non-deployable equipment investment which leads to asset specificity. The internal cash flow comes from the degree of market power a firm possesses, so that degree of vertical integration provides ample availability of capital (Armour and Teece, 1980). Moreover, the significant volume of production capacity of large firms enhances the negotiation power with customers, and it renders them not trap in one single customer. In China, OEM producers have to accept the "account receivable" capital chain mode owing to fierce competition based on flexibility (Smith and Schnucker, 1994), implying that availability of multiple customers is able to contribute to increasing internal cash flow. Therefore, large firms on the contrary own more resources to conduct internal knowledge creation such as purchasing specialized machines, skill training and R&D activities and are less willing to grasp advantage of socialized knowledge transfer and creation as they possess the management capability to control opportunism in the innovation process by internal activities.

On the contrary, small and medium sized firms are usually young and have not yet developed mature firm-specific routines and responding capabilities, especially in managing business and people. Due to the immature management capability, domestic firms are not able to internalize many functions and transactions within the firms to avoid external uncertainty as the large firms do. Furthermore, the constraint of internal cash flow makes the innovation cooperation such as sharing machines and key skills for SMEs indispensable. In this case, social proximity, embodied as Guanxi in China, displays as a favorable substitute for organizational proximity to build trust and control opportunism in the cooperation.

- Lack of interest of large firms in exploiting minor profit

Scherer (1998b) points out that an overlooked strength of small firms in exploiting innovation as the "excitement" of exploiting something new, which results from the sophistication of technological advance leading to myriad of narrow and detailed innovation such as on fabrication, material and minor components. Corporations with giant profit, on the contrary, feel less appeal in exploiting the profit of making too modest changes than small firms.

Nevertheless, the modest change in one part induces systematic change in the whole product series. By using social proximity, small and medium sized firms are able to work through technical problems and respond to the market change expeditiously through the interaction with users, service providers and other

knowledge-intensive organizations.

However, homogenous product lines or markets might harm the reciprocal principle of cross-organizational knowledge transfer and dynamic innovative synergy among SMEs. Once the socialized process of knowledge creation and innovation cannot be guaranteed, the survival and growth of small and medium sized firms is in danger. In this case, according to Capello (1999), regional production system remains in the phase of industrial district, where social proximity only strengthens trust in supplier-customer relationship and reduces transaction cost among them. The higher level of regional production system as an innovative milieu cannot be achieved because of the missing role of social proximity in promoting dynamic innovative synergies among local firms, especially the small and medium sized ones.

4.2.4 Brief Summary

For firms in latecomer countries, organizational proximity is of particular importance. In the early phase of development, the capability of local firms is not fully developed due to the weak industrial base, thus resulting in an ill functioning knowledge spillover mechanism in the local scale. In this phase, control and governance in the same organizational framework by foreign parent company or OEM customer is essential in organizing production in the region, and this becomes the main source for local firms to get codified and tacit knowledge, mostly in a passive way. However, organizational proximity in this phase is not able to trigger innovation with the absence of appropriate cognitive proximity between the foreign firms and local firms.

With the development of local production system, local firms have accumulated a certain level of capability which finally enables them to absorb and exploit new knowledge. In this circumstance, firms can either use organizational proximity to seize the profit opportunities of value chain upgrading with the sophistication of supply chain and technological diversification, or can they capitalize on social proximity to form reciprocal innovative synergy with organizationally distant partners that possess the appropriate cognitive distance. Particularly for small and medium sized firms, the collective learning facilitated by social proximity is essential for their survival and growth, and is also important for the development of a self-sustained local production system (Capello, 1999).

The use of organizational proximity and social proximity by firms are mutually reinforcing. On one hand, ability of local firms to use social proximity and transform it into innovative synergy and profit gives higher incentive for foreign firms to transfer more advanced technology and activities to their organizational proximate partners in developing countries. Moreover, this entitles the local firms and governments more bargaining power to negotiate with foreign partners, which results in easier and more stable manipulation of strategic coupling. On the other hand, new information on market and technology that pumps into the local system by firms using organizational proximity with geographically distant partners renders the local collective learning more dynamic (Bathelt *et al.*, 2004).

Figure 4.2 illustrates this conceptual process concerning with the role of organizational proximity and social proximity.

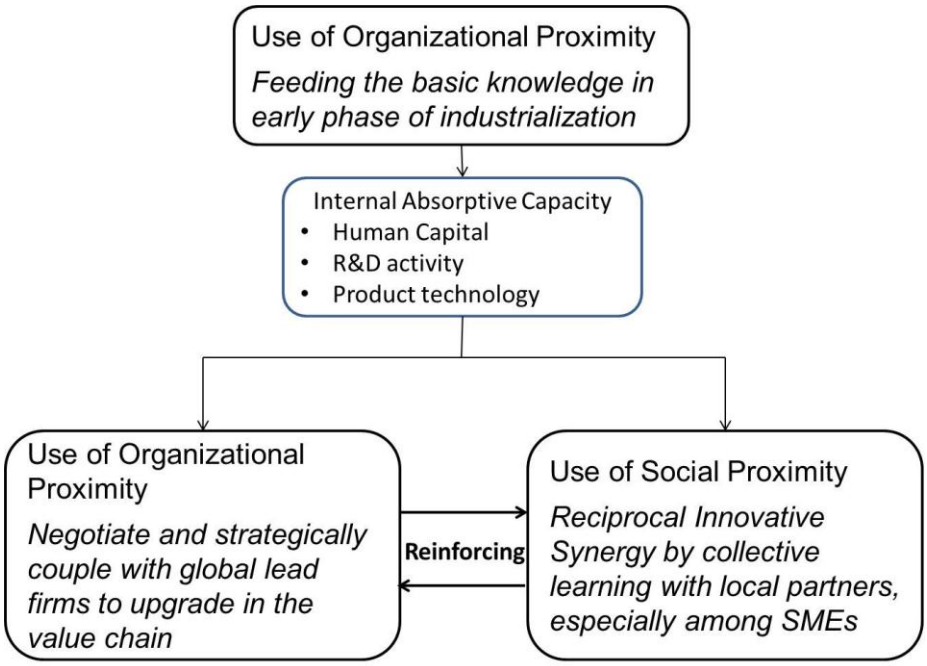


Figure 4.2 Dynamism of Proximity in Regional Development

Source: Own draft

Based on the discussion on the role of organizational proximity and social proximity on capability development and innovation for the firms and regions, I draw the following hypotheses:

Hypothesis 1: By developing absorptive capacity and strategic coupling within the global production network, it is possible for latecomer firms in emerging regions to capitalize on organizational proximity in order to foster innovation and

upgrading. However, firms that rely only on a vertical hierarchy with leading global firms to foster innovation have limited potential for upgrading their position in the value chain.

Hypothesis 2: Most Chinese firms are engaged in Guanxi networks, which is an ongoing mode of interaction for maintaining social proximity between business partners. Firms with limited capabilities and short-term strategies are only able to capitalize on Guanxi for low-cost and flexible production. On the other hand, in a mature regional innovation system, firms are capable of using social proximity to facilitate the complex interaction in the innovation process and to upgrade their position in the value chain.

Hypothesis 3: Small and medium sized firms are more oriented to use social proximity as a strategy for knowledge creation and innovation than large firms, and their capacity in using social proximity is the primary element of a well-functioning regional innovation system.

4.3 Absorptive Capacity in the Firm Level as Precondition of Interactive learning

Internal absorptive capacity and external interaction are complementary elements for successful learning (Cohen and Levinthal, 1990, Arora and Gambardella, 1990, Gambardella, 1992, Tripsas, 1997). Cohen and Levinthal's (1990) seminal work on absorptive capacity points out that certain capability should be developed to profit from external knowledge. Moreover, it does not only contribute to the successful absorption of external knowledge, but also promote the investment in exploring new domains of knowledge and new market. Cohen and Levinthal (1990: 137) implicitly elucidate the latter respect by saying that higher level of absorptive capacity enables the firms to be more sensitive and proactive to opportunities present in the technical and market environment.

Zahra and George (2002: 185) conceptualize absorptive capacity as "dynamic capability pertaining to knowledge creation and utilization that enhances a firm's ability to gain and sustain a competitive advantage", and it composes a process of acquisition, assimilation, transformation and exploitation. Absorptive capacity can be viewed as the cognitive structure of firms that support the interaction with external

partners, and Cohen and Levinthal (1990) identify this cognitive structure as the prior related knowledge of firms.

In this sense, absorptive capacity is closely related to the firm routine (Nelson and Winter, 1982), which refers to particular experience and know-how that the firm accumulates over time. Current routines does not only influence the strategies the firms adopt, the activities they take and the opportunities they perceive (Boschma, 2004), but also, in another way around, influence the efficiency of processing information and learning. As emphasized by Cohen and Levinthal (1990) in the discussion of absorptive capacity, it is rather an intangible concept and can be only indirectly measured. Nieto and Quevedo (2005) have comprehensively reviewed the empirical works on absorptive capacity, in which the measurements of absorptive capacity mainly include R&D activities and its linkage to basic research, patents, technical staff, product characteristics and management practice. In this section, I would introduce variables that are relevant and comparable among the firms in the context of latecomer firms. These variables constitute the cognitive structure of firms in perceiving innovation investment and fostering innovation outcomes. They are human capital, R&D investment and technological content of products.

4.3.1 Human capital

In macroeconomics, many scholars argue that skill should be accumulated at a high rate when technology is imported from outside in order to support sustained growth (Michaely *et al.*, 1991; Lall, 1992; Keller, 1996). However, human capital accumulation has been proved not to directly determine the economic growth rate (Benhabib and Spiegel, 1994). Rather, it influences the economic growth by attracting physical capital accumulation and affecting the speed of absorption of technology (Nelson *et al.*, 1966; Lucas, 1990).

Individual talent is the basic element in an organization. Beyond the individual capacities, what is more important for an organization is the sum of the individual capability, or, put it in another way, a collectively organizational learning process that aims to rightly allocate individual capabilities to tasks and maximize them. In this aspect, organizational routine and culture plays a key role in combining, managing and driving the mobilization of individual capability (Shein, 2004).

Departing from this argument, I relate human capital to the capabilities of technical staff, managerial staff and entrepreneurs. For technical staff, they directly

involve in production and technological innovation and their individual capabilities make up the core element of the cognitive structure of the firm. On the other hand, the managerial staff and entrepreneurs are responsible for the optimal allocation of individuals to tasks and also shoulder the role of gate-keeper for the organization.

Technical staff is the main actor to exchange the know-how trading with external partners to a large extent, because their knowledge in specific domain enables them to recognize and value new related knowledge (Carter, 1989). Technical staff does not only play a role in acquisition process, but is also determinant in assimilation, transformation and exploitation process, because they are the main carrier of tacit knowledge through years of team work. By team work, I mean that it is not only the individual capabilities of the technical staff that matters for the learning process, but also the common recognition of organizational codes and technological routines.

The collective learning and knowledge creation process between the technical staff also relies on the managerial capability to allocate the individual capabilities. Human resource management has been applied to define this capability and it has been also proved to exert a positive impact on innovative performance (Michie and Sheehan, 1999; Laursen and Foss, 2003). Vinding (2006) goes further to support the positive relationship between human resource management and radical innovation. Managerial staff's ability in fostering the organizational culture, optimizing the organizational structure and motivating the qualified staff is thus essential in regard to the assimilation, transformation and exploitation of external information and new knowledge. Moreover, they are also "boundary-spanning" actors between the departments and facilitate the transformation process of external knowledge within the firm (Allen, 1977; Cohen and Levinthal, 1990).

The human capital in the firm level does not only rely on the quality of the public educational system, but also on the internal development process. The public educational system mainly instructs generic knowledge that paves the way for the career development of graduates, and it is actually the firms' internal training efforts that manage the staff to collectively develop firm-specific competency and to achieve competitive advantage (Becker, 1964; Barney, 1991). Cohen and Levinthal (1990: 135) assert that the internal staff should be "competent in their fields and are familiar with the firms' idiosyncratic needs, organizational procedures, routines, complementary capabilities, and extramural relationships" in order to integrate complex external knowledge into the firms' activities. Thereby, the training effort in the firm plays a

more important role in implanting the codes and routines in the technical staff that facilitates the communication and exploiting process within the organization than enhancing the individual capabilities of technical staff. However, if the gain of productivity and performance does not exceed the training investment as well as the monitoring cost of "poached talents" (Williamson, 1975; Tsang *et al.*, 1991), the firms tend to invest less in internal development efforts and turn to the market.

Besides technical and managerial staff, Schumpeter's (1942) seminal work on innovation stresses the role of entrepreneur as the agent of "creative destruction", implying that they are active in introducing new product, new technology and new combination. Seeing from the perspective of a firm, the founder or CEO often assumes the tasks of initiating new product development by a holistic thinking of firm-specific capability, market trend and network availability. Higher educational level of entrepreneurs entitles them more capability to negotiate with external actors. Especially for latecomer firms, overseas educational and working background of entrepreneurs can bring about more opportunities of value chain upgrading by grasp of market trends and language and cultural skill in negotiating with global partners. Saxenian and Hsu (2001) found that US-educated Taiwanese has coordinated the process of reciprocal industrial upgrading between Silicon Valley and Hsinchu Park in Taiwan. Moreover, the CEOs often keep intense interaction with the companies and the business partners that they served before. Network relationships that the entrepreneurs have established in the past working experiences constitute valuable assets for their current entrepreneurial activities. Romijin and Albaladejo (2002) find a positive relationship between the founder's work experience in either multinational or large domestic firms and the firm's innovative capabilities in the UK.

4.3.2 R&D activities

Owing to continuity of knowledge transfer and tacitness of knowledge, knowledge can be only easily acquired, assimilated and improved when effort has been devoted to establishing the cognitive structural base in the related field. A certain level of human resource is the perquisite for the learning, and R&D departments play an important role in organizing the talents to conduct systematically collective learning.

R&D functions as a stable element of embedding new knowledge in routines of firms and transferring the tacit knowledge through the interaction with other departments. Thereby, R&D is the primary agent of organizational learning within the

firms. It is not only important in innovation, but also bears social rate of return by influencing the absorptive capacity of the firms (Griffith *et al.*, 2003). In Cohen and Levinthal's (1990) exploratory empirical investigation on absorptive capacity, R&D activity is assumed not only to generate new knowledge but also facilitate learning by building up the firms' absorptive capacity.

In developing countries where a significant technological gap with developed countries prevails in many technological fields, the main task of R&D activities is to absorb the advanced technology rather than conduct radical innovation. The essence of this argument lies in the fact that technology is not readily-made, it requires a certain level of capacity to apply it to full use. Arrow (1969)'s vivid example on jet plan suggests that after Britain sent the jet plans to America during the Second World War, it took ten months for the Americans to conform the plans to the American usage. Evenson and Westphal (1995) propose that technology transfer to relatively technologically backward countries should be assessed with the capability to make efficient use of them. The emphasis of R&D activity in developing countries is development rather than research. To be specifically, this includes absorbing the tacitness in the new knowledge, adapting it to the local condition and improving it with the combination of firm-specific routines. Therefore, the basic aim of R&D in developing countries is to absorb, adapt and exploit such as in activities like reverse engineering and minor design improvement.

By incorporating Schumpeter's (1942) framework that emphasizes the partially excludable nature of knowledge, the recent literature on income convergence suggest that catching up in developing countries could be realized by quality-augmenting innovation whose size depends on the distance from the technological frontier (Aghion and Howitt, 1998, Howitt, 2000). This is exactly where the R&D functions in latecomer firms should play a role. In essence, R&D activities reflect the latecomer firms' incentive to construct absorptive capacity to gain spillover effect from the higher-level of R&D activities in developed countries. Empirical works on economic growth in developing countries account total factor productivity (TFP) growth primarily to the effect of R&D spillovers from developed countries (Grossman and Helpman, 1990; Coe and Helpman, 1995; Grossman and Helpman, 2002). Meanwhile, some scholars find evidences to support the argument that foreign R&D spillover has greater effect on firms that undertake more R&D activities, which has greatly enhance the efficiency of applying the imported technology (Jaffe, 1986; Eaton *et al.*, 1998).

Griffith *et al.* (2000) further point out that the need and effect of R&D functions is even larger when technological gap is large.

To sum up, R&D activity matters for the latecomer firms in the way that it enhances the absorptive capacity to assimilate and apply the advanced technology, and enables the firms to efficiently use external knowledge to foster innovation. In more complex activities, the marginal effect of R&D increases when the learning efforts are demanding (Cohen and Levinthal, 1990). I will turn to this point in the next part.

4.3.3 Product technology

Productivity difference among industries (Cameron, 1996, Harrigan, 1999) implies that technology in specific industries is not neutral. In fact, technology varies in terms of the complexity and difficulty to decode it. For example, technology in standardized industries and low tech industries are more codifiable and is easier to be attained via market or through strict network relations. On the contrary, technology that is high-end and has not yet stabilized is more complex and tacit, requiring more communication in the knowledge transfer and more interaction in the knowledge creation process. Cohen and Levinthal (1990) gave a vivid example on this point, elaborating that a unit of knowledge advance in semiconductor industry is able to yield larger performance payoffs than in steel industry. Thereby, the current technological field that the firms are actively involved in influence the return of conscious investment on absorptive capacity such as R&D activities and training.

Firm's current technological fields confer the necessity to invest in absorptive capacity to enable the interactive learning with external partners. Meanwhile, the initial technological field, which can be defined as the technological level of the products when the firms start the business, constitutes the basic elements of the cognitive structure for further development. As absorptive capacity is actually closely related to the prior related knowledge of firms, it can be generated through direct involvement in related manufacturing operations (Rosenberg, 1982).In other words, the initial technological field determines the initial stock of knowledge and capital. For example, firm A started with producing hard disk is endowed with higher skill as well as sophisticated machinery than firm B started with producing portable disk. Therefore, the potential for further learning is higher in firm A.

The importance of initial knowledge stock is related to the path-dependent

accumulation path of firm routine. Firms in high-tech fields do not only possess higher endowment of absorptive capacity to process external complex knowledge, but also tend to form a higher expectation on the commercial value of latest technological advances (Cohen and Levinthal, 1990). This phenomenon has been termed as the "lock-out" effect as firms failed to invest in certain absorptive capacity in certain technological fields tend to be discarded out of the profit room from the rapid technological opportunities in that specific field (Cohen and Levinthal, 1994).

Nevertheless, the lock-out effect occurs to the so-called high-tech industries when the technological paradigm in the industry changes dramatically in a new round of technological cycle. The Swiss watch industry, for instance, demonstrates the organizational inertia in the face of technological base changes from mechanics to electronics (Glasmeier, 1991). In times of technological discontinuity, there are opportunities for the technological latecomers to forge ahead as they do not have to invest a lot to unlearn the previous knowledge and routines. On the other way around, the previous technological leaders have to invest more to incorporate new skills and knowledge into the ole systems of production.

The initial technological fields do not only determine the prospect of future learning owing to its path-dependent nature, but also take effect in attracting more advanced technological spillover from the global frontier firms. This is because that the production experiences of firms define the opportunity of wider cooperation and alliances with other firms. Especially for the latecomer firms, the large MNCs tend to identify those firms that have recorded remarkable performance profiles in specific related technological fields as their strategic suppliers or even business partners (Wang and Blomstrom, 1992).

4.3.4 Brief Summary

Figure 4.3 summarizes the discussion above on the sources of a firm's absorptive capacity, which is necessary for the use of external knowledge. These components are interrelated with each other and jointly influence on firms incentive, aspiration and capability in assimilating, transforming and exploiting the external knowledge. Hereby, the following hypothesis can be concluded:

Hypothesis 4: The higher absorptive capacity the firms possess, the easier they can understand and communicate with external actors in the knowledge transfer

process, and thus the more they tend to interact with external actors to foster innovation within the firms.

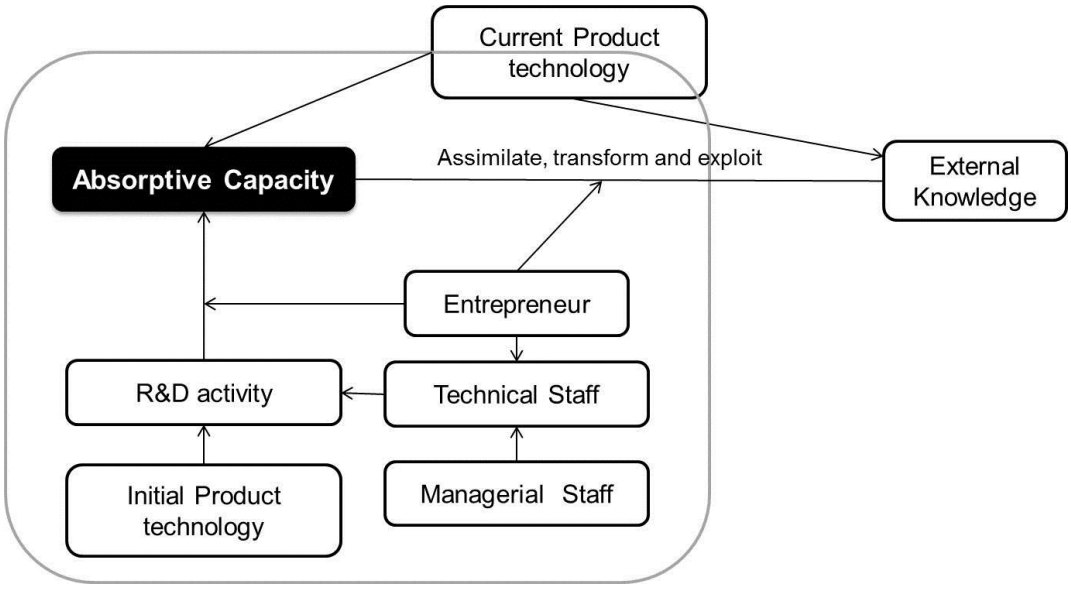


Figure 4.3 Sources of a Firm's Absorptive Capacity

Sources: Own draft

What still remains unclear in the relationship between absorptive capacity and interactive learning with external partners is its impact on the use of proximity in interactive learning activities. As absorptive capacity is embodied as different combination of the various components and is thus idiosyncratic among the firms, it would be fairly mechanic to analyze the optimal level of absorptive capacity. On the other way around, it would be more meaningful to consider the specific components of absorptive capacity that support the use of different proximities in order to sustain trustful and effective interactive learning activities. To be more specific, the chapter would like to take the exploratory step to investigate on the specific components of absorptive capacity that support the use of organizational proximity as well as social proximity in the interactive learning Answers to this inquiry are able to shed light on the conscious investment on absorptive capacity if a firm is to organize the interactive learning with organizationally proximate partners and socially proximate partners.

4.4 Operationalization of Analysis

The electronics industry in the Pearl River Delta, China, has been selected as the research area for this study. Because the investigation focuses on the electronics industry in an export-oriented region, geographical proximity is guaranteed due to the co-location of the firms in the same mega-urban area. I, however, focus on the role of social proximity, i.e. embedded in Guanxi networks between individuals, as well as organizational proximity to global firms in fostering product innovation. These two forms of proximity can be addressed by conscious firm strategies, and can thus be achieved through the efforts of individual firms. In contrast, institutional proximity is not discussed, since the institutional environment is not yet stable enough for firms to rely on it, and individual firms are not able to influence the institutional setting through their own efforts in the short term.

The empirical data used to answer the research question was taken from a standardized survey of electronics firms in the Pearl River Delta, Guangdong Province, China. Bellandi and Tommaso (2005) points out that the industrial development in Guangdong Province is the subtle mixture of global network, public governance and the unexplored socio-cultural contexts. In this chapter, survey data in the firm level will be used to explore the role of socio-cultural factors, i.e., social proximity in fostering innovation.

The sample and the primary questions applied in this chapter is the same as the one in Chapter 3. However, the ways to analyze the dataset differ owing to different research aims. In Chapter 3, the clustering procedure aims to reveal different firm clusters in the degree of undertaking interactive learning activities and examine the effect of interactive learning on innovation outcomes in a general term. This chapter goes further to explore the different behavioral patterns among the firms in undertaking interactive learning. As a result, it aims to identify firms capitalizing on different proximity in the interactive learning to foster innovation and how this behavioral pattern relates to the firms characteristics such as size and absorptive capacity.

Table 4.3 presented the dimension of the indicators, of which related to the previous hypothesis on the use of proximity in the interactive learning.

Table 4.3 Indicators of Proximity Use in Interactive Learning

		Remarks
New Product Ideas	Internal Efforts	*Own development of ideas*; Self Absorption and Learning through *license purchasing and reverse engineering*
	With organizationally proximate partners	Interacting with *parent companies & foreign customers*
	With organizationally distant partners	Interacting with *domestic customers, foreign customers, universities, research institutions and sales agents*
Obtaining Codified Knowledge	Internal Efforts	Self-purchasing of equipment and software
	With organizationally proximate partners	Interacting with *parent companies* & *foreign customers*
	With organizationally distant partners	Interacting with *domestic customers & foreign customers*
Obtaining Tacit Knowledge	With organizationally proximate partners	Receiving training and know-how from people sent *by parent company & foreign customers*
	With organizationally distant partners	Receiving training and know-how from people sent *by domestic customers and foreign customers*; Sending staff *to domestic customers or domestic lead firms, foreign customers or foreign lead firms, and universities* for training
Interaction Mode	Informal Guanxi Network	Interacting through Guanxi, for example gaining information on the reputation and capacity of innovation partners from other *business partners, relatives and friends* in the innovation process
	Active Searching	Searching for information on partners *via Internet, exhibition and sales agents* in the innovation process

Source: Own Survey Questionnaire (See Appendix A, Part C, Question 27-30)

In the questionnaire, it is not able identify the interaction mode with each business partner in each specific innovation process. If so, the matrix of questionnaires would be too complex for the firms to answer. In order to ensure the success of the survey, only generable information on interaction way with business partners can be identified. However, it is considered that by differentiating firm with the type such as parent companies, foreign customers, domestic customers and external knowledge institutes, information on the proximity use can be preliminarily attained. As discussed in the theoretical part on the role of proximity in fostering interactive

learning, firms either interact with organizationally proximate partners such as parent company or strictly controlled foreign customers, or they establish social proximity with organizationally distant partners to ensure trust and understanding in the process of interactive learning. Thereby, the social proximity with domestic customers and external institutes can substitute the lack of organizational proximity in some degree. Combined with the general question on interaction mode with all business partners, insight into the degree of proximity use in innovation process can be secured.

From Table 3.2, 3.3 and 3.4 in Chapter 3, it is shown that the electronics firms in the Pearl River Delta seldom resort to the parent companies for innovation ideas and tacit knowledge. The interaction with foreign firms also weighs less than that with domestic customers. Although the data shows a decreasing intensity of using organizational proximity in the whole sample, there should be a group of firms that still rely more on organizational proximity than other firm in innovation activities. Thereby, measures should be done to extract the comparative degree of using organizational proximity with parent companies and foreign customers and social proximity with other organizationally distant partners. Figure 4.4 shows the operationalization of the analysis that makes the comparison of proximity possible.

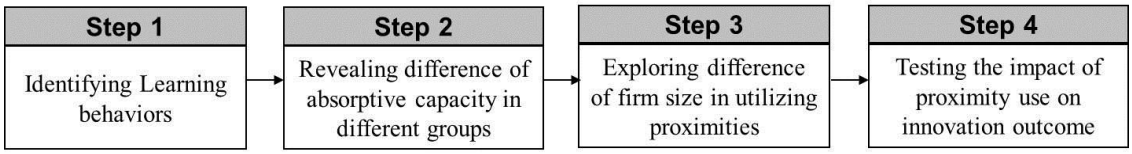


Figure 4.4 Operationalization of Analysis

Source: Own draft

4.5 Empirical Evidence

4.5.1 Innovation Behavior of Electronics firms in the Pearl River Delta

Factor analysis is firstly applied to extract the latent variables among the variables that investigate the innovation behaviors of firms in the product innovation process, as shown by Table 3-1. In factor analysis, factor scores of each latent variable are calculated for each case based on the regression on all variables to the latent variables. The factor scores are all standardized value, which reflects the comparative value

compared to the mean of all cases. Therefore, data processing with factor analysis before the cluster analysis contributes to the aim of this chapter in the way that the difference between the variables are reduced while only difference between the cases are analyzed to bear the clustering results. Translating this methodological specificity into the empirical implication in this chapter, it means that the following clustering would base the analysis mostly on the difference among the cases in regard to the scope of interactive learning instead of the intensity of interactive learning. Moreover, factor analysis is able to explain complex phenomena in regard to the wide scope of interactive learning by extracting the main factors.

Table 4.4-4.7 shows the result of factor analysis. In statistical term, the result is satisfactory because the derived factors in each group are able to explain over 60% of variance of the original sample.

In respect to the source of new product ideas (Table 4.4), three main factors are concluded, which explain 60% of the total sample variance. The three factors also bear theoretical meaning. The first factor implies that the firms interact more with the external partners such as domestic customers, universities, research institutions and sales agents to trigger new innovative ideas. These external partners bear little organizational proximity with the firms and require other proximities to support the trust-based interactive learning process. From the explained variance, the first latent factor, i.e. interacting with external partners as a way to trigger innovation ideas is the most important channel that the electronics firms apply in the Pearl River Delta. The second factor have more weigh for own idea generation, reverse engineering and product license purchasing as the way to generate new innovation ideas. These activities require more input of internal resources as well as higher capability of firms to absorb or even creatively recombine the knowledge embodied in the licensed product or advanced samples. The third factor put more weighs on the interaction with parent companies and the foreign customers, which is more powerful in governance and bears closer organizational proximity, to get the new product ideas. Because of the unbalanced power relation in regard to capabilities, getting new product ideas in this way is rather passive and mainly from the commands. On the other way, getting new product ideas from the domestic customers, as indicated by the first factor, might be more active and interactive due to the balanced power and capability. The assumption behind this conclusion is that local firms are latecomers so that they are more in the same level of technological capabilities and market knowledge compared

to that with foreign firms.

Table 4.4 Factor analysis of New Product Idea (PI)

	Factors		
	NPI_external partners	NPI_internal efforts	NPI_parent comp. & foreign customers
1) market report of sales agents	**0.78**	0.22	0.06
2) Orders from domestic customers	**0.74**	-0.09	0.10
3) Market report of university and research institution	**0.60**	0.41	0.20
4) Own idea generation	-0.03	**0.79**	-0.17
5) Reverse engineering	0.13	**0.58**	0.22
6) Purchase product licenses	0.18	**0.54**	0.51
7) Orders from parent company	0.04	0.11	**0.87**
8) Orders from foreign customers	0.46	-0.09	**0.56**
Explained variance	33%	15%	12%
Total explained variance	60%		

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

In respect to getting codified knowledge in the process of product innovation (Table 4.5), three factors are derived, and they explain 85% variance of the total sample. Note that codified knowledge here refers to knowledge embodied in equipment, machinery and operational software. The first factor implies getting equipment from domestic and foreign customer. The second factor implies that firms rely more on the very close organizational proximity (parent company) to get support of required equipment in the process of product innovation. The last factor implies other ways of getting codified knowledge. In the questionnaire, firms can answer openly through which channel they actually get the equipment, and 85% of the firms answer “self-own” of “self-purchase”, which bears a more internal characteristic.

Table 4.5 Factor analysis of Getting Codified Knowledge (CK)

	Factors		
	NPCK_customer	NPCK_parent comp.	NPCK_self purchase
1) Acquisition from domestic customer	**0.86**	-0.21	0.05
2) Acquisition from foreign customer	**0.74**	0.41	-0.03
3) Acquisition from parent company	0.00	**0.94**	0.04
4) others	0.02	0.04	**0.99**
Explained variance	34%	27%	24%
Total explained variance	85%		

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

In respect to getting tacit knowledge in the process of product innovation (Table 4.6), also three factors are derived, which explain 74% variance of the total sample. It should be noted that tacit knowledge here refers to technical experiences and know-how that is easier to be understood and absorbed through face-to-face interaction. The first factor distinguishes itself from the other two factors, since it implies a more active strategy of searching tacit knowledge, i.e. the firms send the employees to other firms or universities to learn technical experience that is needed to guarantee the success of innovation. The second factor implies a passive way of getting required know-how and technical experience in the product innovation process, in which the firms are being taught and instructed from the engineers sent by the domestic customer or foreign customer. Similarly, the third factor implies getting tacit knowledge mainly from the parent company. In theory, the accessibility of tacit knowledge increases from the first factor to the last one.

Table 4.6 Factor analysis of Getting Tacit Knowledge (TK)

	Factors		
	NPTK_active searching	NPTK_passive from customer	NPTK_passive from parent comp.
1) Engineers sent to universities	**0.85**	0.13	0.09
2)Engineers sent to domestic lead firms or customers	**0.79**	0.20	-0.11
3)Engineers sent to foreign lead firms or customers	**0.60**	0.42	0.31
4) Engineers sent by domestic customer	0.18	**0.85**	-0.13
5) Engineers sent by foreign customer	0.24	**0.78**	0.29
6) Engineers sent by parent company	0.03	0.05	**0.94**
Explained variance	44%	17%	13%
Total explained variance	74%		

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

When interacting with different actors in the above aspects in the process of product innovation, the interaction way can be either formal or informal. Firms can formally conduct active searching through exhibitions, internet or sales agents to get into and keep contact with the interacting actors. It is assumed that interaction in this way bears an arms-to-length market relationship. Besides, they can also interact with them through the informal Guanxi network, such as recommendation from business

partner, friends and relatives, which bears a reciprocal favor exchange and responsibility in traditional Chinese society. Table 4.7 shows a dichotomy dimension of formal and informal way of interaction is derived, which explains 79% of variance of the total sample. Particularly, the informal interaction way explained only half of the variance.

Table 4.7 Factor analysis of Interaction Way (IW)

	Factors	
	NPInteraction _informal	NPInteraction _formal searching
1) Personal contacts (recommendation from family members and friends)	**0.88**	-0.01
2) Business contacts (e.g. recommendation from partners)	**0.73**	0.31
3) Active searching (e.g. exhibitions, internet, sales agent, etc.)	0.13	**0.97**
Explained variance	52%	27%
Total explained variance	79%	

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

By means of the factor analysis, different dimensions of proximity for the interaction with different players were identified. The small explained variances in factors concerned about the interaction with parent companies or foreign customers correspond to the results shown by Table 3.2, 3.3 and 3.4 in last chapter, indicating the decreasing intensity of electronics firms to use organizational proximity in the interactive learning. Instead, they tend to interact with external partners beyond the organizational hierarchy, for example domestic customers, universities, research institutions and sales agents, to get new ideas and required knowledge. Moreover, it is proved that Guanxi networks are the major facilitator for interaction during innovation processes. The overall result of the factor analysis is summarized in Table 4.8.

Table 4.8 Results of Factor Analysis

		Remarks	Explained variance of each factor	Total explained variance
New Product Ideas	NPI_external partners	Interacting with *domestic customers, universities, research institutions and sales agents* to gain innovation ideas	33%	60%
	NPI_internal efforts	Making *internal learning efforts* such as own ideas, license purchasing and reverse engineering	15%	
	NPI_parent comp. & foreign customers	Relying on parent companies or foreign customers to gain innovation ideas	12%	
Obtaining Codified Knowledge	NPCK_customer	Interacting with *foreign and domestic customers* to get codified knowledge	34%	85%
	NPCK_parent comp.	Interacting with *parent companies* to get codified knowledge	27%	
	NPCK_self purchase	Purchase equipment self	24%	
Obtaining Tacit Knowledge	NPTK_active learning	Sending staff *to business partners* for training	44%	74%
	NPTK_passive from customer	Receiving training and know-how from people sent *by domestic and foreign customers*	17%	
	NPTK_passive from parent comp.	Receiving training and know-how from people sent *by parent company*	13%	
Interaction Method	NPInteraction _informal	Interacting with innovation partners *within Guanxi networks*	52%	79%
	NPInteraction _formal searching	Interacting with innovation partners by *searching via Internet and exhibition*	27%	

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

After the factor analysis, a cluster analysis uses the latent variables derived from previous factor analysis to identify different patterns of capitalizing on social and organizational proximity. In cluster analysis, there is rarely one single best solution. A good cluster analysis should be at first use as few clusters as possible and secondly capture all statistically and empirically important clusters. I follow a four-step procedure to ensure the internal validity of the clustering result (Delmar et al, 2003).

Step 1: Hierarchical clustering with Ward's method and Euclidean distances was run to assess the possible clustering results. In this step, I came with 2 to 6 cluster solutions and derived each centroid from each cluster solutions. Clustering results in this step serve as the try-out sample to theoretically assess the optimum number of clusters based on interpretability.

Step 2: I use the centroids derived in the first step to perform the K-means cluster. The results of K-means cluster serve as a hold-out sample, for which I would use to

validate the results from the try-out sample.

Step 3: Hold-out sample would be compared with try-out sample with means of cross tabulation. A significant level in Lambda lower than 0.05 is considered to be able to verify the relative stability of the cluster results across samples, accepting the null hypothesis that the two samples are closely correlated. Under this confidence level (0.05) the solution stability can be assured and the clustering solution can be selected based on parsimonious interpretability.

Table 4.9 Cross Tabulation between Try-out sample and Hold-out sample

	Lamda value	Significance level
2-clusters solution	0.577	0.088
3-clusters solution	0.618	0.047
4-clusters solution	0.723	0.038
5-clusters solution	0.694	0.038
6-clusters solution	0.708	0.035

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

Table 4.9 shows the results of cross tabulation. After running these two procedures, three clusters are concluded as an internally stable and easily interpreted solution, at best explaining the innovation behaviors using different proximities in a theoretical sound and parsimonious way.

Table 4.10 Results of Cluster Analysis (Ward's method/Squared Euclidean distance)

	Socially active innovator	**Organizationally dependent innovator**	**Lame innovator**
NPI_external partner	**0.54**	**0.25**	-0.32
NPI_internal	**0.52**	0.07	-0.31
NPCK_customer	**0.60**	-0.15	-0.34
NPTK_passive from customer	**0.46**	0.07	-0.22
NPTK_active learning	**0.58**	-0.12	-0.35
NPInteraction_informal	**0.60**	-0.06	-0.33
NPInteraction_formal searching	**0.26**	-0.01	-0.17
NPI_parent comp. & foreign	-0.11	**1.01**	-0.12
NPCK_parent comp.	-0.38	**1.96**	-0.27
NPCK_self purchase	-0.17	**0.12**	0.10
NPTK_passive from parent comp.	-0.47	**2.06**	-0.16
Number	*104*	*41*	*171*

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

Table 4.10 demonstrates the results of our cluster analysis, which differentiates between three types of innovation behavior related to the capacity of capitalizing on social and organizational proximity in the process of product innovation. The results correspond rather well with our conceptual considerations.

- **Socially active innovator:** Firms in this group interact frequently with external partners in combination with their internal capability. With regard to obtaining codified and tacit knowledge in the product innovation process, firms of this kind tend to rely more on customers, and use the active strategy of sending people to business partners for acquiring tacit knowledge. In the interaction process with these partners, firms in this category flexibly combine formal active searching and informal networks (Guanxi with family members, friends and business partners) when interacting with partners in the innovation process. Although it is not possible to specify exactly which interaction method is applied by the firms when interacting with each partner (because the related matrix would be too complex to be answered by the firms), it is possible to conclude indirectly that firms in this group rely on social proximity to external partners in general during the process of product innovation to a greater degree than firms in the other two clusters. They are actually socially active innovators, and social proximity is not only used as a way of acquiring codified and tacit knowledge by interacting with external partners, but also as a way of triggering new product ideas, which is a feature of capable firms in a well-functioning regional innovation system.

  It is worth mentioning that although these firms are already able to extend the scope of interactive learning in the innovation process to capitalize further on social proximity, they still rely on organizational proximity to foreign customers to a certain degree in order to acquire codified and tacit knowledge, they. This again supports the mutual reinforcing effect of social proximity and organizational proximity. Social active innovator tend apply mixed strategies to use proximity to facilitate interactive learning.
- **Organizationally dependent innovator:** In contrast, organizationally dependent innovators rely heavily on organizational proximity to gain access to and absorb knowledge. They turn to their parent companies to obtain codified and tacit knowledge in the process of product innovation, i.e. in a more passive way due to the hierarchical control. The new product ideas originate mainly from parent companies as well as from powerful foreign customers.

What is again noteworthy is that organizational dependent innovators show a certain tendency to interact with external partners to prompt product innovation, although with a lower degree than socially active innovators. However, the much lower value in informal interactions indicates that these firms are not able to capitalize on social proximity to foster innovation as their socially active counterparts. Moreover, their method of interacting with innovative partners is not characterized by any particular feature, which indicates a more passive attitude towards product innovation compared to socially active innovators.

- **Lame innovator:** Compared to the previous two kinds of firms, lame innovators have low values for all the indicators that are related to product innovation. Lame innovators are not actively involved in triggering new ideas of innovation, nor do they strive to search for codified and tacit knowledge, which is important for positive product innovation outcome. Moreover, they are quite vague and unsettled in their ways of interacting with partners in the innovation process. In short, they are not able to interact with external players to initiate innovation and do not have the capacity to organize internal learning.

A look at the number of firms in each cluster shows that the number of lame innovators exceeds the sum of socially active and organizationally dependent innovators in our sample. This is proof of the immature internal absorptive capacity of most firms in the Pearl River Delta to benefit from external interaction in order to trigger innovation. However, the number of socially active innovators is two times higher than the number of organizationally dependent innovators. This seems to be an indication of an maturing regional innovation system in the Pearl River Delta, where some local firms are capable of benefiting from localized knowledge sources by capitalizing on informal social relations. But it also reflects the difficulty of most firms in the Pearl River Delta to ’couple strategically’ with global firms to upgrade their position in the value chain. By studying the relocation issue of Taiwanese Personal Computer firms, Yang (2009) also pointed out that Taiwanese firms in the Pearl River Delta are less oriented towards the strategic coupling of local and global knowledge sources than their counterparts in the Yangtze River Delta.

The validation of the clustering result is further supported by external validity. If the clustering discriminates between variables not included in the clustering procedure, the clustering result is likely to represent distinct empirical categories. The clusters

identified are then compared with respect to performance indicators such as sales growth, export orientation and product innovation outcomes.

Table 4.11 presents differences in sales growth, export orientation and product innovation outcomes between the clusters. Besides insignificant differences for the new product rate and functional expansion performance between each of the groups, at least one pair of groups differs significantly from another. This again validates the explanatory power of the three clusters.

Table 4.11 Performance of different Innovating Groups (T test of Samples)

Note: Group 1- Socially active innovator; Group 2- Organizationally dependent innovator; Group 3 – Lame innovator.

Sales growth in first half of 2009		Group 1	Group 2		Group 1	Group 3		Group 2	Group 3
	Mean	**20.9**	**-4.23**	Mean	20.9	24.4	Mean	**-4.23**	**24.4**
	Sig.[1]	**0.036**		Sig.	0.601		Sig.	**0.023**	
Foreign market share		Group 1	Group 2		Group 1	Group 3		Group 2	Group 3
	Mean	**36.3**	**55.4**	Mean	**36.3**	**44.4**	Mean	**55.4**	**44.4**
	Sig.	**0.003**		Sig.	**0.064**		Sig.	**0.084**	
New Product rate		Group 1	Group 2		Group 1	Group 3		Group 2	Group 3
	Mean	36.9	33.3	Mean	36.9	37.6	Mean	33.3	37.6
	Sig.	0.422		Sig.	0.815		Sig.	0.360	
Quality Improvement		Group 1	Group 2		Group 1	Group 3		Group 2	Group 3
	Mean	4.24	4.27	Mean	**4.24**	**4.01**	Mean	4.27	4.01
	Sig.	0.844		Sig.	**0.056**		Sig.	0.111	
Function Expansion		Group 1	Group 2		Group 1	Group 3		Group 2	Group 3
	Mean	3.84	3.80	Mean	3.84	3.62	Mean	3.80	3.62
	Sig.	0.826		Sig.	0.125		Sig.	0.388	
Product Upgrading		Group 1	Group 2		Group 1	Group 3		Group 2	Group 3
	Mean	3.79	3.95	Mean	**3.79**	**3.52**	Mean	**3.95**	**3.52**
	Sig.	0.442		Sig.	**0.087**		Sig.	**0.030**	

[1] Significance level of the difference between the mean value of the comparing groups

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

- Differences between organizationally dependent innovators and the other two groups

Almost 58% of the organizationally dependent innovators in our sample involve foreign ownership, while the share is only 30% among socially active innovators and 38% among lame innovators. This indicates that organizationally dependent innovators are more closely linked to the global production network. This is further substantiated by their outstanding export performance compared to the other two

groups (Table 4.11). However, sales growth after the financial crisis is negative and significantly lower than that of socially active innovators and even lame innovators. This suggests that the loose social embeddedness with business partners leads to a highly vulnerable and externally dependent mode of upgrading. With regard to product innovation, organizationally dependent innovators are better able to upgrade the product category (e.g. from mp3 to mp4) by integrating within the global value chain compared to the lame innovators. However, they do not outperform the lame innovators in other aspects of product innovation, which suggests that depending solely on global production networks narrows the scope of product innovation.

- Differences between socially active innovators and lame innovators

The two groups represent a high share of domestic-oriented firms, especially the socially active innovators, whose export share is only around 36%. They are all able to reach moderate sales growth even in the face of the crisis. However, socially active innovators outperform lame innovators in many aspects of product innovation, such as quality improvement and product upgrading facilitated by the capacity to take advantage of informal social relations as well as some degree of organizational proximity to foreign customers in order to foster innovation.

Lame innovators represent the conventional producers in the Pearl River Delta. They are able to respond to market needs with low-cost and flexible production by taking advantage of informal relations with family members and friends. However, their lower absorptive capacity restricts them to use informal social relations to foster innovation and upgrading. These firms represent the primary bottleneck for a shift in industrial development towards regional upgrading in the Pearl River Delta.

4.5.2 Absorptive Capacity and Learning Behaviors

After the identification of different learning behaviors, the analysis aims to further analyze the relationship between the internal absorptive capacity and the choice of proximity use. The hypothesis discussed in the third part suggests that certain level of absorptive capacity is the basic perquisite of interactive learning, which helps in effective communication in the knowledge transfer process as well as absorbing and exploiting the external knowledge. Sources of absorptive capacity are defined in this study as human capital, R&D activities and product technology.

According to hypothesis four, internal absorptive capacity, which is embodied as

the level of human resources, R&D activity and product technology, defines the capacity of firms to understand and communicate with external actors in the knowledge transfer process, as well as possibility of using proximities to foster innovation. Table 4.12 demonstrates the definitions of each elements of internal absorptive capacity.

Table 4.12 Indicators of Absorptive Capacity

	Indicators	Description
Human Resource	Level of technical staff	Percentage of technical staff that have bachelor degree or above *multiplied by* training frequency
	Level of Managerial staff	Percentage of managerial staff that have bachelor degree or above *multiplied by* training frequency
	Training expenses in 2007	Expenses on staff training in the year 2007
	CEO Education	1 as below bachelor degree 2 as bachelor degree 3 as graduate degree (master or doctor) 4 as bachelor or above combined with overseas experience
	CEO Work Experience	0 as no former working experience 1 as private sector working experience only 2 as public sector working experience (might involve in private sector once) 3 as overseas working experience
R&D activities	Technology Center (R&D Center)	1 as having technology center (R&D center), 0 as not
	Design Capability	1 as having product design capability, 0 as not
	Development Capability	1 as having product development capability, 0 as not
Product technology	Current Product Technology	Defined according to International Standard Industrial Classification of all Economic Activities, Rev 3[1], 1 as initial product embodying high technology, 0 as initial product embodying low and medium technology
	Initial Product Technology	Defined according to International Standard Industrial Classification of all Economic Activities, Rev 3[1], 1 as current product embodying high technology, 0 as current product embodying low and medium technology

1. Specific classification of products into the different levels could be referred to Appendix C.

Source: Own Survey Questionnaire (See Appendix A)

The construction of the indicators of absorptive capacity is based on the theoretical discussion in section 4.3. As for the human capital, educational level of the technical staff and managerial staff serves as the base of the rate of human capital accumulation. With the training efforts, the human capital accumulates as the capacity of absorbing and exploiting new knowledge to the need of the firms' development is enhanced. The training effort is formulated as the frequency of training: 1 suggests only once in the beginning of career, 2 suggests training that is more often but on an

irregular basis, and 3 suggests regular and systematic training. The percentage of technological or managerial staff that is bachelor degree or above would be multiplied by their respective training frequency to signify the level of human capital to absorb, apply and exploit knowledge. In addition, training expenses, CEO education and CEO work experience would be measured.

In the next step, the difference of these capabilities among the three different innovating groups is tested, which provide answers to the question: Which components of absorptive capacity enable a firm to conduct extra-learning using either organizational proximity or social proximity in product innovation process?

In SPSS procedure, I firstly apply independent samples T test to examine whether there is significant difference between the mean values of absorptive capacity among the each pairs of innovating groups. The significance level indicate that the difference between the mean value of the comparing groups is significantly (at least at 90% level) greater than 0.

Table 4.13 shows the results of independent samples T test of each 2 groups for human capital. The insignificant difference of all indicators of human capital between socially active innovator and lame innovators demonstrate that human capital is not the determinant factor for the use of social proximity to undertake interactive learning.

Table 4.13 Human Capital of different Groups (T test of Samples' Mean)

Note: Group 1- Socially active innovator; Group 2- Organizationally dependent innovator; Group 3 – Lame innovator.

Level of Technical staff (%)		Group 1	Group 2		Group 1	Group 3		Group 2	Group 3
	Mean	75.8	90.4	Mean	75.8	69.6	Mean	90.4	69.6
	Sig.[1]	0.337		Sig.	0.552		Sig.	0.144	
Level of Managerial staff (%)		Group 1	Group 2		Group 1	Group 3		Group 2	Group 3
	Mean	**81.6**	**110.0**	Mean	81.6	83.4	Mean	**110.0**	**83.4**
	Sig.	**0.064**		Sig.	0.873		Sig.	**0.077**	
Training expenses in 2007 (Unit: Yuan)		Group 1	Group 2		Group 1	Group 3		Group 2	Group 3
	Mean	**93765**	**755258**	Mean	93765	146748	Mean	**755258**	**146748**
	Sig.	**0.047**		Sig.	0.332		Sig.	**0.067**	
CEO Education		Group 1	Group 2		Group 1	Group 3		Group 2	Group 3
	Mean	**2.54**	**2.88**	Mean	2.54	2.46	Mean	**2.88**	**2.46**
	Sig.	**0.075**		Sig.	0.500		Sig.	**0.019**	

[1] Significance level of the difference between the mean value of the comparing groups

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

What stands out from the result in Table 4.13 is the significant higher level of managerial staff level, CEO education and staff training expenses for organizationally dependent innovator compared to the socially active innovator and lame innovator. This might be attributed to the capability of high-level managerial staff and entrepreneurs to enable "strategic coupling" with global firms. Thereby, when sophistication of global value chain allows co-evolvement and upgrading of suppliers and subsidiaries in latecomer countries, the global lead firms tend to identify firms with higher human capital as the strategic partners.

From Table 4.14, it is found that firms that undertake interactive learning have a slightly higher tendency to organize R&D activities than firms that do not undertake interactive learning (lame innovator), but the differences are not in a significant level.

Table 4.14 R&D Activities of different Groups (T test of Samples' Mean)

Note: Group 1- Socially active innovator; Group 2- Organizationally dependent innovator; Group 3 – Lame innovator.

Technology Center (R&D Center)		Group 1	Group 2		Group 1	Group 3		Group 2	Group 3
	Mean	0.66	0.68	Mean	0.66	0.62	Mean	0.68	0.62
	Sig.	0.818		Sig.	0.430		Sig.	0.422	
Design Capability		Group 1	Group 2		Group 1	Group 3		Group 2	Group 3
	Mean	0.77	0.76	Mean	0.77	0.75	Mean	0.76	0.75
	Sig.	0.868		Sig.	0.700		Sig.	0.921	
Development Capability		Group 1	Group 2		Group 1	Group 3		Group 2	Group 3
	Mean	0.79	0.73	Mean	0.79	0.70	Mean	0.73	0.70
	Sig.	0.466		Sig.	0.106		Sig.	0.707	

[1] Significance level of the difference between the mean value of the comparing groups

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

Cohen and Levinthal's (1990) finding on R&D's function in creating and exploiting new knowledge is not supported with the results in Table 4.14. The circumstantial role of R&D activities in contributing to the development of absorptive capacity among the electronics firms in the Pearl River Delta can be explained from two respects. Firstly, the overall stock of knowledge generated by systematic accumulation of R&D activities might be too small to generate the absorptive capability that is required for effective knowledge exchange with the external partners. Although for the survey sample, the average durations of firms that have possessed the design capability and development capability are 9.6 years and 8.9 years

respectively, the statistical data in the Guangdong province shows that R&D expenses just pick its accelerating rate after 2005 (Figure 4.5). Secondly, R&D activities are not strategically organized so that knowledge accumulation is not continual and systemic to guarantee the building up of sufficient absorptive capacity. Moreover, as demonstrated by Table 4.15, the R&D expenses in Guangdong Province is extremely concentrated in investment in test and development, which might not include reflection on the long-term strategy of technological capability accumulation and just responds quickly to the market trends. In the analysis by Cohen and Levinthal (1990), R&D refers to more basic research activities that are able to prepare the firms with general background knowledge to exploit rapidly new scientific knowledge.

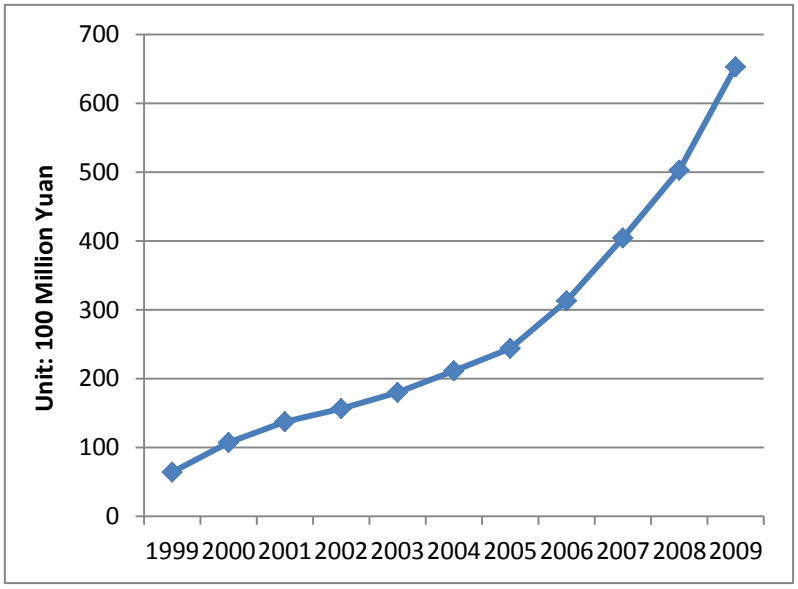


Figure 4.5 R&D Expenses in Guangdong Province (1999-2009)

Source: Statistical Bulletin of China Technology Expenses (1999-2009)

Table 4.15 National Comparison of Technological Indicators (2008)

	National average	Guangdong
R&D expense (percentage in GDP)	1.5%	1.4%
# Investment in Basic Research (%)	5%	1.4%
# Investment in Application Research (%)	12.5%	1.6%
# Investment in Test & Development (%)	82.5%	97%

Sources: China Statistical Yearbook 2009 and Guangdong Statistical Yearbook 2009

Finally, it can be detected that for the survey sample of electronics firms in the Pearl River Delta, China, only the product technology differentiate the firms that undertake interactive learning (socially active innovator and organizationally dependent innovator) from the firms that do not (lame innovator). Table 4.16 shows that firms that either capitalize on social proximity or organizational proximity to foster innovation have a significantly higher percentage of production experiences and current practices in high-tech fields than the lame innovators. This indicates that for the electronics firms in the Pearl River Delta, interactive learning is practiced more by the firms currently and once involved in high-tech technological fields owing to their contribution to the absorptive capacity.

Table 4.16 Product technology of different Groups (T test of Samples' Mean)

Note: Group 1- Socially active innovator; Group 2- Organizationally dependent innovator; Group 3 – Lame innovator.

Current Product Technology		Group 1	Group 2		Group 1	Group 3		Group 2	Group 3
	Mean	0.19	0.24	Mean	**0.19**	**0.10**	Mean	**0.24**	**0.10**
	Sig.	0.493		Sig.	**0.041**		Sig.	**0.049**	
Initial Product Technology		Group 1	Group 2		Group 1	Group 3		Group 2	Group 3
	Mean	0.19	0.20	Mean	**0.19**	**0.07**	Mean	**0.20**	**0.07**
	Sig.	0.853		Sig.	**0.009**		Sig.	**0.060**	

[1] Significance level of the difference between the mean value of the comparing groups

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

As the independent sample t-test mainly applies to comparison of mean values, chi-square is run again for categorical data in human capital and product technology to validate the robustness of the results. Especially for the CEO work experience, there is no ordered scale in the definition, and distribution test would be then more appropriate than mean test.

Chi-square test for the frequency distribution of CEO education among three innovating firms shows that CEOs in organizationally dependent firms tend to have more overseas educational background, albeit the difference with other two groups is not in a significant level (See Table 4.17).

Table 4.17 Distribution of CEO Education among the Innovating Groups

		Innovating Groups			Total
		Socially active innovator	Organizationally dependent innovator	Lame innovator	
CEO Education	below bachelor	12 (12%)	5 (12%)	25 (15%)	42 (14%)
	bachelor	45 (45%)	11 (27%)	74 (45%)	130 (42%)
	graduate degree	21 (21%)	9 (22%)	31 (19%)	61 (20%)
	bachelor or above combined with overseas experience	23 (23%)	16 (39%)	35 (21%)	74 (24%)
Total		101	41	165	307
χ^2=7.92, p=0.244					

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

Table 4.18 Distribution of CEO Working Experience among the Innovating Groups

		Innovating Groups			Total
		Socially active innovator	Organizationally dependent innovator	Lame innovator	
CEO Working Experience	No former working experience	11 (11%)	11 (27%)	24 (15%)	46 (15%)
	Domestic private sector	49 (48%)	5 (12%)	54 (32%)	108 (35%)
	Domestic public sector	26 (25%)	7 (18%)	44 (26%)	77 (25%)
	Overseas working experience	17 (16%)	17 (43%)	45 (27%)	79 (25%)
Total		103	40	167	310
χ^2=25.341, p=0.000					

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

Table 4.18 further supports the result of Table 4.17 and shows that organizationally dependent innovators tend to have more CEOs with overseas working experience. For the successful strategic coupling process with global partners, the network capital and market knowledge that the CEO has accumulated in the working period account more than the knowledge that they learned in the campus. The result corresponds to Saxenian and Hsu's (2001) work on "technological community", in which the Taiwanese entrepreneurs with US educating and working experience play important role in technology transfer and inter-firm collaborations between Silicon Valley and Hsinchu High-tech Park.

The significant level of Chi-square test in Table 4.19 upholds the results in Table 4.16. Again, the more complex components in high-tech products require more interactive process between users and producers and also with other organizations

than the standardized and low-tech products. Thereby, as demonstrated by Table 4.19, the socially active innovators and organizationally dependent innovators have higher percentage of high-tech products. Moreover, socially active innovators and organizationally dependent innovators have significantly higher share of high-tech endowed firms compared to the lame innovator group and even the whole sample (See Table 4.20). As discussed before, the production experience in high-tech fields prepares the firms to undertake interactive learning with sharable knowledge with other business partners. Overall, this result supports the fourth hypothesis that higher level of absorptive capacity boosts the interactive learning activities, despite of the fact that only product technology serves as the valid component of absorptive capacity in this respect.

Table 4.19 Distribution of Current Product Technology among the Innovating Groups

		Innovating Groups			Total
		Socially active innovator	Organizationally dependent innovator	Lame innovator	
Current Product Technology	low and medium tech	84 (82%)	31 (76%)	154 (90%)	269 (85%)
	high tech	20 (18%)	10 (24%)	17 (10%)	47 (15%)
Total		104	41	171	316
x^2=7.778, p=0.020					

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

Table 4.20 Distribution of Initial Product Technology among the Innovating Groups

		Innovating Groups			Total
		Socially active innovator	Organizationally dependent innovator	Lame innovator	
Initial Product Technology	low and medium tech	83 (81%)	32 (80%)	158 (93%)	273 (88%)
	high tech	19 (19%)	8 (20%)	12 (7%)	39 (12%)
Total		102	40	170	312
x^2=10.160, p=0.006					

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

All together, the results suggest that firms that undertake interactive learning differ from the lame innovator significantly in terms of initial product technology and current product technology. Firms that have managerial staff with high education

background combining with frequent training are better at using organizational proximity to foster product innovation. Moreover, it is interesting to find that overseas background CEO has a large share in organizationally dependent firm group, which indicates their role in bridging the local-global interaction in technological and market fields. OECD (2005) also points out the role of entrepreneur and their attitudes towards innovation deserve further investigation in the context of latecomer countries. Nevertheless, this study fails to find out the role of R&D activities in shaping the sufficient absorptive capacity for interactive learning, which might be attributed to the general indicators.

4.5.3 The SMEs' use of Proximity

In this section, chi-square test will be applied to explore the significance of the difference between large and small firms in using proximity in the product innovation process, aiming to provide answers to the question: What is the difference of SMEs in terms of using proximity compared to large firms?

Table 4.21 Difference of Innovating behaviors between large firms and SMEs

Firm Size[1]	Socially active innovator	Organizationally dependent innovator	Lame innovator	Total
Small and medium sized firms	99 (34%)	29 (10%)	161 (56%)	289
Large firms	5 (19%)	11 (42%)	10 (39%)	26
Total	104 (33%)	40 (13%)	171 (54%)	315
$\chi^2=22.504, p=0.000$				

1 According to Chinese statistical standard on firm size in terms of sale, firms that have with no less 300 million Yuan sales and no less than 2000 employee are assigned as large firms.

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

Firstly, the overall pattern of innovating behaviors is observed by chi-square test (Table 4.21). It is shown that firm size does significantly influence the innovating behaviors. Small and medium sized firms normally lack the resources and capability to undertake external learning activities that contributes to the innovation process. Moreover, if small and medium sized firms are to undertake external learning activities, they tend to interact with the business partners through the use of social proximity to gain reliable information and support.

Table 4.22 Difference of Proximity use between large firms and SMEs

Firm Size[1]	Socially active innovator	Organizationally dependent innovator	Total
Small and medium sized firms	99 (77%)	29 (23%)	128
Large firms	5(31%)	11 (69%)	16
Total	104 (72%)	40 (28%)	144
$\chi^2=15.062, p=0.000$			

1 According to Chinese statistical standard on firm size in terms of sale, firms that have with no less 300 million Yuan sales and no less than 2000 employee are assigned as large firms.

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

Concentrating further on the firms that apply either operational proximity or social proximity in the product innovation process, Table 4.22 intensify the pattern on the tendency of small and medium sized firms to apply social proximity in the interactive learning process. The empirical result here supports the third hypothesis that small and medium sized firms tend to use more social proximity than large firms due to limit of internal resources and capabilities.

In the previous section, it is concluded that higher level of human capital confers the preference of organizational proximity over social proximity in the interactive learning activities. Furthermore, it has been pointed out in section 4.2.3 the lack of pecuniary resources of SMEs lead to the underinvestment in skill training, which results in the management incapability to internalize transactions within the firm boundary to avoid uncertainty.

Table 4.23 Difference of Human Capital between large firms and SMEs (T-test)

Level of Technical staff (%)		Small and medium sized firms	Large firms
	Mean	70.7	137.2
	Sig.[1]	0.000	
Level of Managerial staff (%)		Small and medium sized firms	Large firms
	Mean	84.7	121.8
	Sig.	0.024	
Training expenses in 2007 (Unit: Yuan)		Small and medium sized firms	Large firms
	Mean	149428	4332045
	Sig.	0.260	

1. Significance level of the difference between the mean value of the comparing groups

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

Table 4.23 shows the difference between small and medium-sized firms and large firms in terms of human capital. Overall, one can see that small and medium sized firms own much less highly educated technical staff and managerial staff compared to the large firms. Furthermore, the investment in staff training is smaller for SMEs than large firms, although not in a significant level in the survey sample.

With regard to educational level of entrepreneurs, SMEs' CEOs concentrate more in the lower end of educational level compared to the large firms (See Table 4.24). Nevertheless, it is worth to mention that SME's CEOs are more experienced than large firms' CEOs in the domestic business sector (See Table 4.25). The Guanxi networks with a wide range of businessmen that the SME's CEOs have established in the past working experience might be one of the important factors for their orientation towards the use of social proximity in the product innovation process. In contrast, the richer work experience of large firm's CEOs in overseas business sector assist them in the interaction with global partners within organizational proximity.

Table 4.24 Difference of CEO education between large firms and SMEs

		Small and medium sized firms	Large firms	Total
CEO Education	below bachelor	50 (16%)	2 (7%)	52 (15%)
	bachelor	140 (44%)	4 (14%)	144 (42%)
	graduate degree	60 (19%)	9 (31%)	69 (20%)
	bachelor or above combined with overseas experience	67 (21%)	14 (48%)	81 (23%)
Total		317	29	346
χ^2=17.594, p=0.001				

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

Table 4.25 Difference of CEO work experience between large firms and SMEs

		Small and medium sized firms	Large firms	Total
CEO Working Experience	No former working experience	42 (13%)	7 (24%)	49 (14%)
	Domestic private sector	120 (37%)	5 (17%)	125 (36%)
	Domestic public sector	79 (25%)	6 (21%)	85 (24%)
	Overseas working experience	80 (25%)	11 (38%)	91 (26%)
Total		321	29	350
χ^2=7.242, p=0.065				

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

Overall, the use of social proximity in product innovation by small and medium sized firms in the Pearl River Delta signifies the shaping of reciprocal and dynamic innovation synergy among the clustered SMEs. However, the smaller share of interactive learners in the small and medium sized firm groups (See Table 4.21) narrows the perspective of growing stock and further exploitation of complementary knowledge in the regional scale.

4.5.4 Impact of the use of proximity on product innovation outcome

Forbes and Wield (2002) show the firms' performance is determined by dynamic interaction of three aspects: the endowments of the firms, the channel of acquiring external knowledge and the learning efforts. Following this logic and the above theoretical discussion, a regression analysis is applied to explore the exact relationship of the proximities and product innovation outcome by controlling for firm-specific characteristics such as size, ownership, age and internal absorptive capacity.

Dependent variable:

The dependent variable in the regression model is product innovation outcome. For survey data, especially in developing countries, it is always difficult to obtain an exact and objective measurement of new products that is reliable and comparable. Therefore, subjective measurement is taken, in which the firms are asked to evaluate the degree of improvement on product function expansion and product categories upgrading (on a scale of 1 to 5 with increasing degrees of improvement). The dependent variable in the regression is the average score of these three items.

A shortcoming of this variable is that it has a bound value of 1 to 5. The problem here is that it is based on a subjective evaluation, and that those firms that marked the same score might not be completely similar in their achievement. Figure 4.6 shows the distribution of the composite score of innovation outcome. The censoring of the data set can be clearly seen, since there are far more cases with scores of 4 to 5, which is to be expected in questionnaire answers because the firms all attempt to make a good impression. With this particular issue of censored data, OLS regression provides inconsistent estimates of the parameters (Long 1997). Therefore, a tobit regression is applied which is unaffected by this issue.

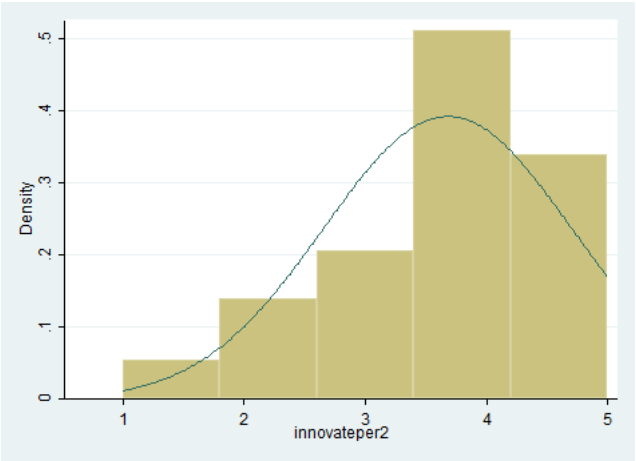


Figure 4.6 Histogram distribution of product innovation outcome

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

Independent variables:

The independent variables applied in the tobit regression on innovation outcome is demonstrated in Table 4. 26.

Table 4.26 Independent variables in Product Innovation outcome Regression

	Indicators	Description
Firm Characteristics	Size	Defined according to Chinese firm size standard, 1 as large firms with no less 300 million Yuan sales and no less than 2000 employee, otherwise as small and medium-sized with the value of 0
	Ownership	1 as firms with foreign participation (wholly owned or joint venture), 0 as firms with 100% domestic participation
	Age	Years since establishment of the firm
Absorptive Capacity	Level of technical staff	Percentage of technical staff that have bachelor degree or above *multiplied by* training frequency
	Level of Managerial staff	Percentage of managerial staff that have bachelor degree or above *multiplied by* training frequency
	CEO Education	1 as CEO below bachelor degree 2 as CEO with bachelor degree 3 as CEO with graduate degree (master or doctor) 4 as CEO with bachelor or above combined with overseas experience
	Development Capability	1 as having product development capability, 0 as not
	Initial Product Technology	Defined according to International Standard Industrial Classification of all Economic Activities, Rev 3[1], 1 as producing low-tech products when starting business, 2 as producing medium-tech products when starting business; 3 as producing high-tech products when starting business
Innovation Behavior	Behavior of using different proximities	Defined by the cluster analysis in the next part; included in the model as a series of dummy variables.

1. Specific classification of products into the different levels could be referred to Appendix C.

Source: Own Survey Questionnaire (See Appendix A)

1) Firm Characteristics

Firm characteristics such as firm size, firm ownership and firm age are applied to control the variations in the regression.

2) Absorptive capacity

- Human resource: The level of technical staff and managerial staff is applied as the proxy for human capital as an important component of internal absorptive capacity (Also See Table 4.19). Besides, the regression also applies the educational background of the CEO as an impacting factor on innovation outcomes. Leibenstein (1968) points out that in imperfect factor markets, entrepreneurs tend to carry out many activities for the survival and growth of the enterprise by themselves, such as searching and evaluating economic opportunities, taking ultimate responsibility for technical absorption and management, as well as marshaling financial resources. In our sample, 92% of the firms are small and medium sized and about 80% of employees are only involved in production. The poor endowment in resources and skill determines that entrepreneurs shoulder most of the responsibilities in the process of product innovation. As proxy of CEO work experiences does not take an ordered nature as the CEO education, it is not included in the regression.
- R&D activities: In order to avoid the issue of collinearity, only development capability (See Table 4.19) enters into the regression function as a proxy of the presence of R&D activities.
- Initial technological level of main product: In the regression analysis, product technology is further classified into three levels, i.e. low tech, medium tech and high tech. This categorical variable would be included in the model as a series of dummy variables. As current product technology displays high correlation (0.824) with the initial product technology, it is not included in the regression.

3) Innovation behavior: Innovation behavior which is defined by the cluster analysis before would be applied as indicator here. Again, this categorical variable would be included in the model as a series of dummy variables in the Tobit regression.

Table 4.27 shows the results of the Tobit regression with innovation outcome as the dependent variable and innovation behavior and other control variables as

independent variables. The results of the cluster analysis are used to define the innovation behavior as: 1 - socially active innovators, 2 - organizationally dependent innovators and 3 - lame innovators.

Table 4.27 Tobit regression on innovation outcome

Independent variables		*（1）Product Innovation outcome*[1] *（Average score of evaluation）*		*（2）Product Innovation outcome*[1] *（Average score of evaluation）*
Constant		3.01*** (0.282)[6]		2.64*** (0.281)
Level of technical staff		0.0006 (0.001)		0.0006 (0.001)
Level of Managerial staff		0.0008 (0.001)		0.0008 (0.001)
CEO Education		0.16** (0.065)		0.16** (0.065)
Development Capability		0.52*** (0.188)		0.52*** (0.188)
Initial Product Technology	Medium tech vs. low tech[2]	0.19 (0.174)		0.19 (0.174)
	High tech vs. low tech[2]	0.54** (0.251)		0.54** (0.251)
	Overall effect[5]	—*		—*
Ownership		-0.26** (0.127)		-0.26** (0.127)
Firm Size		-0.12 (0.293)		-0.12 (0.293)
Firm Age		0.005 (0.010)		0.005 (0.010)
Innovation Behavior	Organizationally dependent vs. socially active[3]	-0.15 (0.246)	Organizationally dependent vs. lame[4]	0.23 (0.234)
	Lame vs. socially active[3]	-0.37** (0.170)	Socially active vs. lame[4]	0.37** (0.170)
	Overall effect[5]	—*		—*
Prob > chi2		0.0006		0.0006
Pseudo R square		0.047		0.047
Number of Observations		233		233

1 Product innovation outcome refers to improvement in product quality, product function and product categorical upgrading.
2 Initial product as low tech as the default group, which means low tech as 0, the other as 1;
3 Socially active innovator as the default group, which means socially active innovator as 0, the other as 1;
4 Lame innovator as the default group, which means lame innovator as 0, the other as 1;
5 T test of whether the overall effect of the categorical variable is statistically significant.
6 Standard errors in parentheses; *p<0.10, **p<0.05, ***p<0.01.

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

The chi-square likelihood ratio has a p-value of 0.009, which tells us that the model as a whole fits significantly better than an empty model. Moreover, the distribution of the residuals obey the normal rule, which indicates that heterokedastic issue, that might tortures the results of Tobit model, does not exist (Figure 4.7).

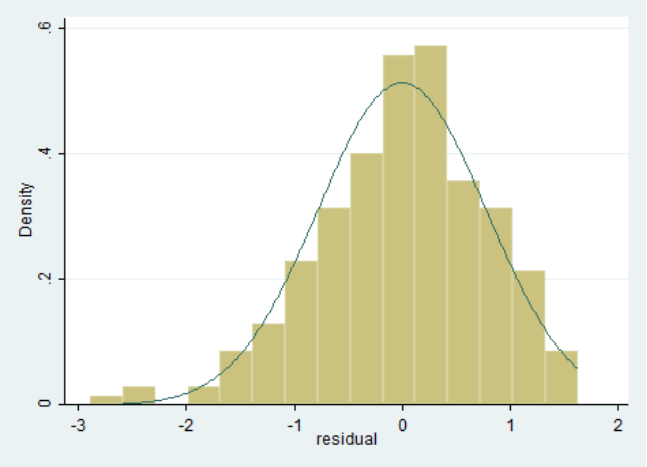


Figure 4.7 Histogram distribution of model residuals

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

Among the variables of absorptive capacity, CEO education, development capabilities and product technology jointly constitute the primary elements of internal absorptive capacity to foster innovation. For the small and medium sized firms, the CEO acts as a gatekeeper for choosing technologies, new market opportunities and business networks. Furthermore, firms that are able to develop product on their own have better innovation outcomes. If firms initially produced high-tech products, i.e. they have accumulated production experience and related capabilities in the high-tech fields, they tend to perform better in product innovation than firms starting with low-tech production. For medium-tech endowed firms, this effect is smaller and insignificant. Lastly, it should be noted that foreign participated firms (wholly-owned or joint venture) have worse innovation outcomes than domestic firms if all other variables are held constant. This result also supports the argument in Chapter 3 (See Table 3.9) that foreign firms are not active in incremental product innovation activities. Their focus might be more on high-scale R&D activities or patenting. As the survey fails to identify the R&D activities in a meaningful way due to the lack of investigation on detailed composition and quality of R&D activities, it should become the focus of future research.

The main focus of the research question is the impact of the use of proximity on product innovation outcome. Equation 1 and equation 2 are quite similar, with the exception that the default group of each dummy variable in the innovation behavior category is adjusted to compare the impact of each type of innovation behavior on innovation outcome. If control variables for firm characteristics and absorptive

capacity are all held at a constant level in the model, socially active innovators possess a better product innovation outcome than lame innovators in a significant level of 0.02, while organizationally dependent innovators do not outperform the lame innovator in a significant way.

This verifies the third hypothesis that social proximity is an asset that firms are able to capitalize on in complex innovation processes. With the development of local capabilities in the Pearl River Delta after thirty years of industrialization, firms are gradually accumulating the capacity to capitalize on social proximity to foster product innovation and upgrading. Nevertheless, it also suggests that firms that apply the strategies of capitalizing on organizational proximity to foster innovation encounter the difficulty of achieving satisfied innovation outcomes, which corresponds to the comparison of performance between these two groups as demonstrated in Table 4.11. The limited potential for upgrading the position in the value chain is revealed for organizationally dependent innovators, supporting the first hypothesis that is proposed in section 4.2.

Nevertheless, it is necessary to cautiously examine the magnitude of improvement by applying social proximity in interactive learning. The coefficient in model 1 and model 2 all points to 0.37 degree of improvement on the average score of evaluation on production function expansion and category upgrading. To put it into practical interpretation, it means that applying social proximity in interactive learning promotes the innovation outcome either in function expansion or category upgrading by nearly one degree (e.g. from not significant to a little significant or from significant to very significant). In short, the achievement made by applying social proximity compared to applying nothing is rather small. Moreover, socially active innovators, which interact with domestic customers and other knowledge institutions in the process of product innovation, do not differ significantly from organizationally dependent innovators in terms of product innovation outcome. Even though organizationally dependent innovators were hit harder by the recent slump in global demand than socially active innovators, their innovation outcome does not differ in a substantial (only 0.01) and significant way compared to the socially active innovators.

This result implies an intriguing feature of the recent development stage of the regional innovation system in the Pearl River Delta. Although socially active firms are emerging in this region, which altogether increases dynamic innovative synergies on the local scale, their capacity to transform fully this social asset into a high innovation

outcome is not yet sufficient. This underpins the instability of innovative synergies in emerging regions where small achievements are not sufficient to compensate for the risk and cost related to innovation activities. It might be attributed to the fact that trust building needs time, especially in innovation activities that are highly complex and risky and involve high level of spillover effect. All in all, a regional innovation system is just burgeoning in the Pearl River Delta, and is calling upon a stable and efficient governance infrastructure to be in place to strengthen and stabilize the interactive learning in the business sector.

4.6 Discussion and Conclusion

Proximity is a direct and simple concept dealing with the issue of learning and innovation. As Massard and Mehier (2009) suggest, it provides the measurement of accessibility other than the concept of externality as just being there. Relational space based on rules, contract and informal social interaction has been taken into comprehensive consideration.

The fact that the local firms are interested and able to capitalize on social proximity to foster innovation signifies the maturing of a regional innovation system. Moreover, the use of organizational proximity feeds dynamism into the local production system as a way to avoid negative lock-in effect. In the context of China, where low-cost is the common strategy and innovation capability is doubted, this chapter firstly gives the theoretical implication on the role of proximity in fostering innovation activities when sufficient absorptive capacity is ensured.

By examining the questionnaire data collected for the electronics industry in the Pearl River Delta, China, the following trends are captured in this electronics cluster. First, as organizational proximity is taking on the limitation in respect to innovation, the electronics firms have extended the use of social proximity from low-cost production activities to undertake interactive learning in the product innovation process. Despite of the formation of a group of socially active firms, the effect of social proximity in fostering fruitful interactive learning is still limited. Second, current practice and past experience in high-tech fields have been identified for the electronics firms in the Pearl River Delta as the important elements in shaping the absorptive capacity to enable the effective communication with external partners. Meanwhile, higher level of human capital such as highly educated and trained

managerial staff and overseas background CEO is able to facilitate the interactive learning embedded within organizational proximity than surpasses geographical boundary. Third, small and medium sized firms are more obliged and interested in using social proximity than large firms due to the constraint of human resources.

The line of thinking - that social capital is an important asset for organizing interactive learning and markets - is well revisited by the institutional and cultural turn in many disciplines. In new growth theory, productive new ideas are endogenously shaped by institutional contexts (Romer, 1986). The approach of innovation systems proposes that social capital induces widely spread interactive learning in the whole economy, hence creating more net wealth (Lundvall, 2005). Likewise, the new institutionalism in economic geography embraces again the context-dependent epistemology, considering the possibility that various social institutions in places determine the evolution of economic landscape (Clark *et al.*, 2003). As demonstrated by the empirical investigation in this chapter, the informal Guanxi networks in the Chinese context are important social assets that the firms can take advantage of in ensuring effective interactive learning.

Ever since the global recession, governments at different levels (province, city, districts) in the Pearl River Delta feel that the strategy of low-cost production is losing its competitive edge and fiercely promote industrial upgrading and innovation. Empirical evidences in this chapter point out that industrial upgrading to high-tech fields should become the policy-focus because it is the precondition of active interactive learning and the formation of a dynamic regional innovation system. It is intriguing to see that some electronics firms are now capable to explore the local knowledge sources within the informal Guanxi network. However, their capacity to fully transform the informal social asset into higher output and performance is not yet mature. In this aspect, governments can support firms to realize more profit related to high innovation performance by the means of providing innovation funds to resource-limited SMEs and regulating the domestic market that stabilize the reciprocal exchange among the firms.

Theoretical literature has discussed a lot on the issue of proximity and its relationship with learning and behaviors, but the empirical support is not yet sufficient to support its role in innovation in different contexts, especially that of developing countries. This chapter takes the step in measuring the use of two most relevant proximities – organizational proximity and social proximity – in the context of China,

and adopts a comprehensive view by relating the external-oriented interactive learning behavior to the internal absorptive capacity. By responding to the call of bridging the scales of knowledge transfer and learning in the global and local scale (Bunnell and Coe, 2001; Asheim and Isaksen, 2002; Freeman, 2002; Fromhold-Eisebith, 2007), the chapter has thrown light on the role of proximity in both scales in attaining trust and understanding in the process of interactive learning

However, the complementary role of organizational proximity with global partners and social proximity with local partners is not simple. Actually, as demonstrated by Humphrey and Schmitz (2002), different degree of organizational proximity, i.e. different ways of insertion into the global production system, influence the local upgrading strategies. Therefore, qualitative studies such as company interview should be conducted to further give insight into the strategic combination of different proximities to achieve the optimal innovation outcome. Moreover, components of absorptive capacity should be further investigated to better understand its relationship with external learning activities. In particular, the exploratory nature of this study points to a more refined design of the R&D indicator in the Chinese context, in which its content and implication is different from that in developed countries.

5 From Globalized Production Systems to Regional Innovation Systems:

Governance and Innovation in Shenzhen and Dongguan, China

Abstract: Governance constitutes elementary supportive infrastructure of regional innovation system. This chapter extends the evolutionary lens of governance into production system and examines the impact of its evolving manner into regional innovation system on fostering innovation activities. Drawing on the empirical substances in Shenzhen and Dongguan, China, the chapter shows that dirigiste globalized production system in Shenzhen has evolved to a higher level of interactive regional innovation system than the grassroots globalized production system in Dongguan, where innovation is still passively managed by global players. Finally, policy implication is discussed on the construction of regional innovation system under different governance modalities.

Keywords: Regional Innovation System; Evolution; Dirigiste Governance; Grassroots Governance

5.1 Introduction

The concept of regional innovation system, which derived from the national innovation system literature, takes institutional and organizational dimension in the territorial level into consideration of innovation activities (Cooke *et al.*, 1997; Howells, 1999; Cooke, 2001; Revilla Diez, 2002; Morgan, 2004; Asheim and Coenen, 2005). In the analytical framework of a regional innovation system, the institutions and organization are extended as the governance infrastructure that facilitates cooperation, organize interaction, reduces uncertainty and cuts transaction cost, enabling the business sector to compete more competitively (Cooke, 1992; Revilla Diez, 2009; Cooke *et al.*, 1998).

Cooke (1992) proposes three modalities of governance supporting the business inter-relationships: grassroots governance, network governance and dirigiste governance. These three modalities of governance differ in the degree of policy intervention as well as the relationship with knowledge-intensive organizations in

different scales. Cooke *et al.* (2004) revisit the regional innovation system first proposed in a systemic way in late 1990s (Braczyk *et al.*, 1998) with an evolutionary perspective in the face of monumental economic shift and uncertainty. In the practice of many regional innovation systems around the world, the governance infrastructure evolves according to the needs of market change and industrial organizational restructuring, aiming at generating more dynamic regional growth mechanisms.

When this line of thinking on evolving governance infrastructure extends to the context of latecomer countries, where the regional innovation system is itself burgeoning from the production system relying heavily on integration into the lower-end of global production networks facing rising factor prices and upgrading pressure, the evolutionary lens should be expanded beyond the scope of regional innovation systems. That is to say, the focus on the evolution of governance infrastructure should be put on the transition from governance that supports initial industrialization to governance that supports the innovation activities.

This chapter aims to understand how different governance infrastructure influence upon the development of regional innovation systems by investigating two cities in South China where initial industrialization has been supported with different modalities of governance following the introduction of the opening policy. In Shenzhen, the governance supporting industrialization is rather dirigiste, characterized by a state-oriented involvement of economic development with ex-ante strategic policy support. In Dongugan, however, governance that supports industrialization is grassroots, characterized by flexible institutions organized mainly by town and village authorities that are favorable for overseas Chinese investment based on Guanxi (Leung, 1993; Yang, 2010).

Thanks to the state initiative to develop electronics production at the very beginning of the establishment of special economic zone, the electronics industry gained a first mover advantage in Shenzhen compared to Dongguan, despite the fact that both faced opportunities for an industrial shift of the processing function to low-cost areas. Dongguan then followed up when the electronics industry replaced the old primary textile industries in the 1990s. With the rising land and labor prices as well as the fierce competition from other low-cost areas, policy reaction was initiated at various levels of government, aiming to form a network governance to support the upgrading and innovation activities of the firms and regions.

However, the empirical analysis of an electronics firm survey conducted in late

2009 reveals different business innovation pattern in Shenzhen and Dongguan. In Shenzhen, the regional innovation system displays an interactive feature. Firms are capable of interacting with a wide range of external partners to promote innovation outcomes. In contrast, the regional innovation system in Dongguan is heavily dependent on global lead firms. The scope of interaction and learning related to innovation among Dongguan firms is limited to tacit knowledge from organizationally proximate parent companies and foreign customers.

This different pattern of business innovation can be explained with two aspects of governance infrastructure from an evolutionary perspective: endowments of innovation supported resources (Martin, 1999) and the negative lock-in effect induced by competency trap and vested interest (Hudson, 1994). In other words, the successful transition from industrialization-led governance to innovation-supported governance depends on the competence in accumulating and mobilizing the innovation-related resources.

The remainder of the chapter is organized as follows. The second section elucidates governance infrastructure in production and innovation systems. Moreover, theoretical discussion from an evolutionary perspective will be provided on what facilitates or handicaps the evolution of governance infrastructure for low-end production to support of innovation. The third section presents the survey design of the comparative investigation into the feature and level of the regional innovation system under different governance modalities. The fourth section depicts the governance infrastructure in Shenzhen and Dongguan in the initial industrialization phase and the transitional phase. Overall descriptive innovation indicators for Shenzhen and Dongguan are displayed in the fifth section. In the sixth section, empirical results are demonstrated based on questionnaire data from electronics firms in order to explore innovation pattern in Shenzhen and Dongguan. Finally, the chapter concludes and discusses the policy implication derived from the cases in Shenzhen and Dongguan.

5.2 Evolutionary Regional Innovation System and Governance Infrastructure

5.2.1 Evolution of Governance Infrastructure: Content and Typology

Governance consists of relations of power and structures of decision-making to coordinate the input-output production system (Storper and Harrison, 1991). Reform

of governance has been found to be the catalyst of rapid industrialization in latecomer countries (Goldsmith, 2007). In latecomer countries, the governance has been adjusted and developed to match the external needs due to the great dependency on external market and technology. Successful operational outcome depends on the institutional fit between local politics and transnational corporation (Yeung, 2000).

Governance aiming at launch industrialization covers three aspects, as shown by Table 5.1. The governance in production system has no explicit innovation content, in which the focus is mainly on initiating the growth of production activities and support it with various measures. The organizations that carry out these tasks in the old production system might refer to government functional offices, industrial associations, folk unions and state-owned large companies.

When the spatially specialized entity evolves into an innovation system, the governance should co-evolve and adjust the focus to supporting innovation activities. To secure systematic learning and innovation synergies that occurs externally of the firm boundary, governance plays an important role in providing access to information, ensuring credibility, coordinating collective actions and even creating a learning atmosphere (Dalum *et al.*, 1992; Sweeney, 1995; Amin, 1999; Haggard, 2004).

Table 5.1 Governance Content in Production System and Innovation System

	Production System	Innovation System
Institutional competence	Capacity to design and execute industrial development policies	Capacity to organize technology transfer
		(local, regional, …) science and technology program
Supported infrastructure	Hard infrastructure such as roads, electricity, port, etc.	Density and quality of infrastructures for innovation such as universities, research institutes, technology transfer agencies, consultants and skill-development and training agencies
	Soft infrastructure such as administrative services to assist the firms	Control or shared execution of part of strategic infrastructures
Financing & Budget	Capacity to impose taxes	Accessibility for firms to capital market
	Autonomy for public spending	High level of financial intermediaries

Source: Summarization based on Cooke *et al.* (1997)

In accordance with the governance elements in production system, Cooke *et al.* (1997)' outline the governance dimension in regional innovation systems as follows: 1) Institutional competence to organize technology transfer and launch science and technology programs; 2) Supported infrastructure to enhance the capacity of

innovation and extend the scope of interactive learning; 3) Financial and budgetary capacity to reduce innovation-related uncertainty and risk as well as mobilize innovation-related resources.

Institutional Competence

In a globalizing economy, institutional setup should co-evolve and echo with the external industrial trend in national and global level such as vertical disintegration and division of labor. Due to the great dependency of latecomer countries on market in external market, the institutional setup has been adjusted and developed in response to match the external needs. Yeung (2000) elucidates that "institutional fit" between local politics and transnational corporation should be achieved to successful operational outcome. Therefore, the external market and trend of industrial organization should be born in mind when institutional competence is taken into consideration.

Institution is also embodied as the capacity of innovation policy to strategically identify new and related industries that might trigger and extend the scope of interactive learning and systematic innovation. The trigger effect of new and related industries is verified by the Jacobs externality (Jacob, 1969) and Boschma and Iammarino's (2009) relatedness of knowledge. Demonstrated by the research over regional innovation system in Europe and America, strong innovative performance is mostly accompanied by strongly developed territorial administration which involves the intervention of public organizations (Cooke, 2001). This aspect of institution capacity is of great relevance in rapidly industrialization context in China where new industries are introduced and induced by government policies aiming at attracting FDI.

Supported Infrastructure

Firms and related institutes are important components of the innovation capacity in the system of innovation. Although in regional innovation system, the scope of institutions goes beyond the knowledge-intensive ones and pay attention to all institutions that define the way innovation actors interact, the density and quality of knowledge-intensive institutions are important for systematic relations to take shape. As innovation-induced interaction and learning requires the complementary knowledge and sufficient internal absorptive capacity among the various actors, institutions, especially the knowledge-related ones such as universities, research institutes, technology transfer agencies, consultants and skill-development agencies

expand the scope of complementary knowledge and interactive learning that the innovative firms are able to draw upon to foster innovation (Asheim and Isaksen, 2002; Asheim and Coenen, 2005).

Among these innovation infrastructures, innovative firms are the core element. It is actually the willingness and capacity to interact with external partners that determines the degree of systematic innovation. From an evolutionary view, the knowledge base of a place influences the entrepreneurial capacity and human capital that are all closely related to the innovativeness of firms in the developmental path.

Financial and Budgetary Capacity

Innovation activities bear uncertainty and risk on the return of huge amount of capital investment on equipment, training, marketing, etc. Firms, especially small and medium ones, are able to conduct innovation more thoroughly when it is easy and efficient for them to resort to external financing.

In territorial level, the autonomy of financial and budgetary capacity is elementary for the incentive to develop innovation infrastructure and institutional competence. Other than direct financing such as funds and loans, institution in the limited territorial scale can be used to minimize the uncertainties between the lenders and borrowers by informal social orders or formal regulations. In this aspect, information sharing is important in successful financing activities (Cooke *et al.*, 1997).

In terms of governance content, three typologies of regional innovation systems can be drawn according to (Braczyk *et al.*, 1998): the grassroots, network and dirigiste governance modalities.

1）Grassroots RIS

In terms of institutional competence in this modality, the initiation process of technology transfer and technology programs are organized at the town or district level, and degree of supra-local co-ordination is low because of the localized nature of organization. In terms of supported infrastructure, the research competence is highly applied or near-market. Moreover, the level of technical specialization will be low, lacking finely honed expertise. Funding in grassroots RIS comprises a mix of capital, grants and loans from local banks, local government and possibly local Chamber of Commerce.

2）Network RIS

In terms of institutional competence in this modality, initiation process of technology transfer and technology programs are organized in multi-levels, encompassing local, regional, federal and supranational levels. Also, system coordination is high because of the large number of stakeholders and the presence of associations, fora, industry clubs and the like. In terms of supported infrastructure, the research competence is a mix of both pure and applied knowledge geared to the needs of large and small firms. Funding in network RIS is guided by agreement among banks, government agencies and firms at various levels such as national, regional and local.

3）Dirigiste RIS

In terms of institutional competence in this modality, initiation process of technology transfer and technology programs is a product of central government policies, and the degree of coordination is high since it is state-run. In terms of supported infrastructure, research is rather basic or fundamental and relates more to the needs of larger (possibly state-owned) firms. Funding in dirigiste RIS is largely centrally determined although the agencies may have decentralized locations in the regions.

The innovation governance supports the firms with diverse posture in the market place with producers and customers, ranging from a global to a local reach (Braczyk *et al.*, 1998). Firms could organize production and innovation in accordance with the governance support in a localized, interactive and globalized manner. The evolutionary investigation of most case regions in Cooke *et al.*(2004) indicate a trend towards interactive business innovation, which responds to the emphasis on interactive learning and systematic innovation in modern innovation theories (Cooke *et al.*, 1997; Howells, 1999; Revilla Diez, 2000; Asheim and Coenen, 2005; Lundvall, 1992). In interactive business innovation, a high degree of association has been formed vertically and horizontally with both global and local reach. In this way, innovative synergy forms gradually, hatching the knowledge spillover and spatial dynamic externalities among firms.

This chapter focuses the analysis on two cities in coastal South China, where the production system in the initial industrialization phase is dominated by global corporations with clustered supply chain of dependent SMEs. What is more, since the

advent of the opening policy in the late 1970s, the central government has either been directly involved in economic development, such as establishing economic special zones, or has implicitly encouraged the bottom-up development, mainly by releasing more economic developmental autonomy to local governments. Therefore, the theoretical discussion in the following session centers around the dynamics and inertia faced by the evolution of grassroots globalized production system and dirigiste globalized production system towards a well-functioning innovation system. In Figure 5.1, the evolutionary paths of the grassroots globalized production system in Dongguan towards an innovation system, as well as that of the dirigiste globalized production system in Shenzhen towards an innovation system, are shown. The following theoretical discussion and empirical investigation would justify this finding.

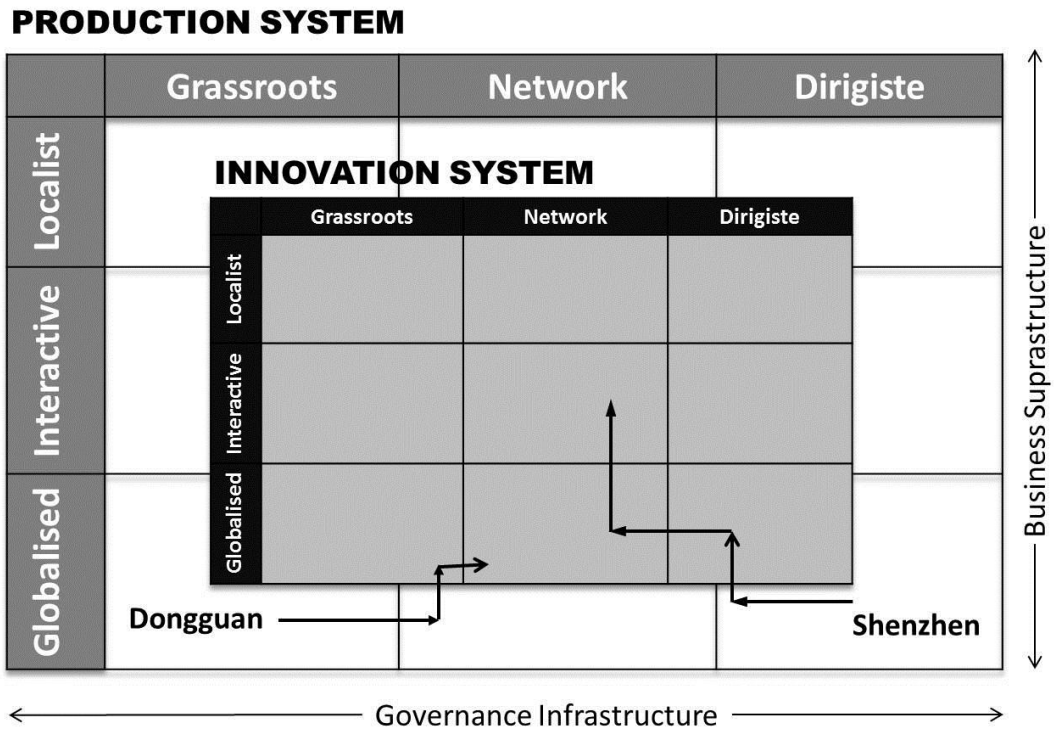


Figure 5.1 Evolution from Production System to Innovation System

Source: Own draft based on Cooke *et al.* (2004)

5.2.2 Evolution of Governance Infrastructure: Dynamics and Inertia

Governance can refer to two interrelated aspects: institutions and organizations. Institutions are the rules of the game and organizations are embedded in the

institutions, playing the game with different competences and capabilities (Cooke *et al.*, 1998). The interaction between institutions and organizations defines the evolutionary path of governance infrastructure. In other words, the institution defines the behavior of organizations, and organizations have a return influence upon institutions by adjusting them to meet the needs of the changing external environment.

The dynamics of the governance evolution towards becoming innovation-supported depends on the capability of the organization. In the initial industrialization phase, when the industrial base is weak, the perspective of resource endowments of related organizations becomes an important baseline for the evolving of governance towards a well-functioning innovation system. In Porter's (1998) competitive model, local endowments such as highly specialized skills and knowledge, institutions, related businesses and demanding customers are emphasized for the construction of a competitive cluster. For a grassroots globalized production system, production capital and know-how depends heavily on foreign investment. There is no skill base in the production system either from previous accumulation or assignments from the central, absorbing the spillover from the foreign technology. In contrast, the dirigiste globalized production system is able to accumulate the skill and knowledge stock from the central assignments such as relocation of large state-owned firms and knowledge-intensive institutions. Foreign investment embedded in the local environment thus differs under these two different governance modalities, which defines the capacity of localities to process, absorb and adapt the external information and technological spillover in the future (Cohen and Levinthal, 1990; Gambardella, 1992; Tripsas, 1997; Zahra and George, 2002). Engineers in these organizations are able to accumulate modern production experience thanks to the economies of scale and scope in the joint ventures between foreign investors and large state-owned firms, which provide crucial knowledge base for future development of private sectors (Kim, 1999).

Furthermore, the capability of dirigiste governance to bring new dynamics into the economy is well reflected by the technology foresight. According to the practices in some countries such as Japan, Britain, Australia and New Zealand (Martin and Johnston, 1999), technology foresight, which is mostly conducted by government agencies or advisory boards, generates concentration on long-term development of selected trajectories and develops a level of consensus on desirable futures. The successful economic growth in Korea since the mid-1960s well illustrated the strength

of dirigiste approach, under which “heavy and chemical industry” is strategically planned and took on rapid development in export market (for a detailed review on this refer to Eshag, 1991).

Technology foresight includes the practice of selecting technology priorities, identifying new strategic industries, creating partnership between sciences, industry and government, as well as providing incentives for multidisciplinary research. More extremely, crisis construction can be applied to force the firms to undertake challenging tasks (Kim, 1999). Therefore, the dirigiste approach, which is mostly initiated and governed by national level agencies with more power, is more able to draw on technology foresight to inject new dynamics into development than the grassroots approach. Especially in the time of rapid technology updating and regeneration, a grasp of future trends and timely reactions are important for the region to keep a dynamic growth path.

Although the dirigiste globalized production system possesses more knowledge and skill endowment and is more able to draw on technological foresight than the grassroots approach, it is still insecure to leave the future of development in the hands of central authorities. Firstly, there might be misinvestment in the selection of key industries when little information is collected from the market, generating opportunity costs for the locality. Secondly, soft budget-constraints are mostly likely to occur in state-owned firms, which play an important role in the dirigiste approach, causing lower efficiency and poorer performance than in private sectors (Qian and Roland, 1998). Therefore, there is an urgent need for dirigiste modalities to evolve towards network governance, involving more market mechanism of competition. In addition, the participation of market power would incentivize the exploitation of entrepreneurial activities on the stock of technological knowledge in dirigiste production systems with a wide range of applications, enabling the firms to undertake interactive learning to gain innovation ideas and support.

On the other hand, the evolution of grassroots governance from a production system to an innovation system carries more inertia than the dirigiste one. As argued by Easterly (2008), the grassroots approach evolves gradually within the constraint of previous institutions, while the dirigiste approach is able to start with a blank sheet or tear up the old institutional setup. This argument has two implications. Firstly, while the dirigiste governance is able to draw on technology foresight, a “competency trap” might arise in grassroots governance, as being too good at something constrains the

capacity of grassroots organizations to absorb new ideas and develop new trajectories (Levitt and March, 1988). In the light of this, a mixed level of organizations should be in place to ensure breaking through the "sticky knowledge" and forming new competencies. Secondly, vested interests in organizations tend to emerge in the evolving process of grassroots governance, which might oppose the changes that undermines their current gains and positions (Boschma, 2004). This aspect is demonstrated by the restructuring problems that are faced by previously heavily industrialized areas in Britain and Germany. Altogether, it constitutes "cognitively sunk cost", which creates a negative reinforcing cycle, impeding new development dynamics and trajectories (Leonard-Barton, 1992).

Therefore, grassroots governance in a production system with a weak industrial base tends to encounter competency traps and complex vested interests, leading to the risk of negative lock-in and sticky inertia. When governance evolution towards the one supporting innovation systems encounters inertia in the face of restructuring and upgrading, it would create systemic market and policy barriers to interactive business innovation as new development alternatives (Könnölä *et al.*, 2006).

The theoretical overview of the governance infrastructure discussed above provides the starting point for investigating its impact on business innovation activities. The comparison of the Shenzhen and Dongguan cases should reveal a different pattern of interactive learning and systemic innovation, providing a divergent evolving path of governance infrastructure as shown by Figure 5.1. Before addressing the innovation pattern based on empirical results, the research design will be presented, followed by the review of the evolving governance infrastructure in Shenzhen and Dongguan since the opening policy in 1978 and the presently overall innovative performance in the two cities.

5.3 Survey Design of a Comparative Study

The comparative study has been identified by many scholars, for example Staber (2001), Doloreux (2002), Dolereux (2004) and Asheim and Coenen (2005), as the most important means of fully understanding the function of RIS and capturing hidden variables that are of interest to the construction of RIS. Therefore, comparing the evolution of the regional innovation systems in Shenzhen and Dongguan offers a unique perspective for understanding the specific contents of governance

infrastructure that influence the systemic innovation in the region.

The empirical data were collected from an electronics firm questionnaire survey in Shenzhen and Dongguan, Guangdong Province, China. The investigation focuses on the electronics industry because of its great dominance and development history in the research area, which enables the inquiry into its evolutionary path. As shown in Figure 5.2, the output value of the electronics industry in Shenzhen and Dongguan kept growing during the period between 1994 and 2009. Dongguan, which is known as the world factory of electronics, experienced a much lower level of output value growth than Shenzhen due to the concentration of low value processing.

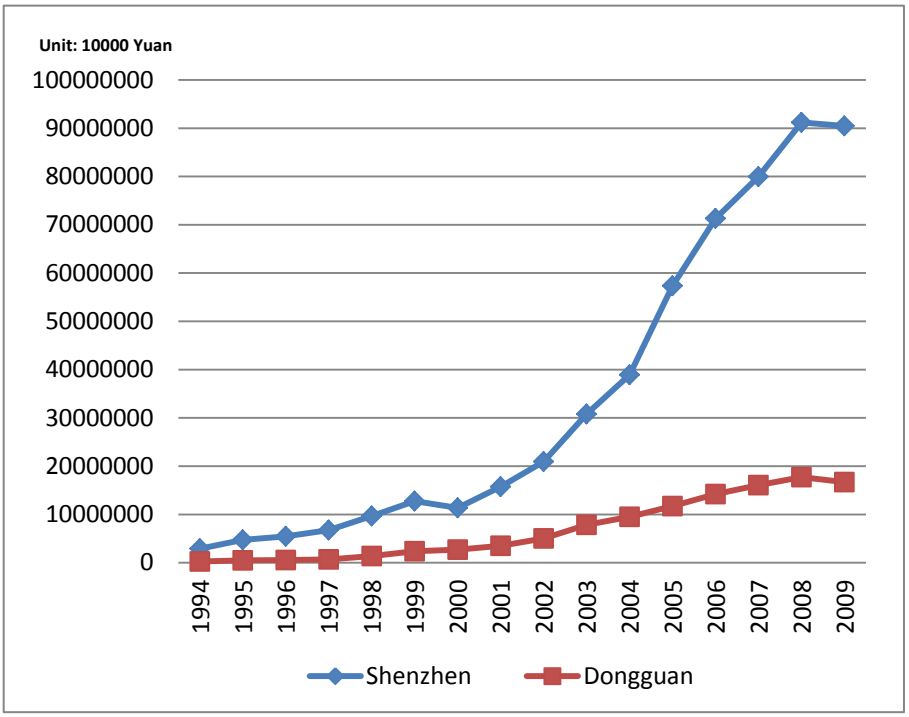


Figure 5.2 Output Value of Electronics Industry during 1994-2009

Sources: Shenzhen Statistical Yearbook (1995-2010) and Dongguan Statistical Yearbook (1995-2010)

The questionnaire survey was conducted via telephone and mail in order to ensure the feasibility of the survey and validity of the data, and was strengthened by following-up that aimed to persuade the firms to fill out and send back the questionnaires, as well as to fill out unanswered questions after the questionnaires were returned. Additionally, in order to establish contact with more firms, a second approach was applied, namely visiting fairs. The fairs and firms were randomly selected. Moreover, the fairs visited have a large number of firm exhibitors, ensuring

the unbiased nature of the fair-visiting result. In total, 312 Shenzhen firms and 281 Dongguan firms were contacted. In total, 167 Shenzhen firms and 177 Dongguan firms filled out the questionnaires, with the response rate in Shenzhen and Dongguan being 54% and 63%, respectively.

In the sample, there are 140 innovative Shenzhen firms and 161 Dongguan firms. In the questionnaire, the constructed variables regarding the innovation activities of electronics firms cover the internal efforts and external interaction during the innovation process, i.e. acquiring new innovative ideas, acquiring codified knowledge and tacit knowledge. The scope of external interaction covers various business partners, such as parent companies, foreign customers, domestic customers, universities and research institutions, as well as sales agents. In addition, the informality of interaction with the partners is identified, i.e. interacting with the partners through active search strategy such as the Internet, exhibitions or sales agents, or interacting with the partners through the introduction and recommendation of long-term business partners, relatives and friends. Surveyed firms were asked as to the importance of each aspect in product innovation activities.

5.4 Governance in Shenzhen and Dongguan, China: An Evolutionary Overview

The institutional setups in Shenzhen and Dongguan, which have evolved since the open door policy to meet the needs of rapid industrialization, correspond to the dirigiste and grassroots governance modalities respectively. In the following analysis, the evolution process of governance will be summarized by the thorough review of the "Shenzhen Electronics Yearbook" (SECC, 2004, most of the information is systematically summarized in Appendix D) and the "Guangdong Electronics Yearbook" (GECC, 2002). In these two yearbooks, descriptive facts are provided for the developmental path of the electronics industry in Shenzhen and Dongguan. Moreover, an in-depth interview was conducted in late 2007 with the former chair of Guangdong Electronic Chamber of Commerce (GECC) to gain insight into the industrial development history and changing interests of governments at various levels.

5.4.1 Governance Evolution in Shenzhen since opening

(1) Governance in the initial phase of industrialization

Shenzhen was a small, peripheral town before 1978. In 1979, it was selected by the central government as one of the special economic zones where the opening policy could be best brought into play. The role of the electronics industry was in focus from the very beginning of the special zone development in Shenzhen (GECC, 2002; SECC, 2004). Due to its geographical proximity to Hongkong, which made Shenzhen quite different from other special zones, the electronics industry has been developing rapidly relying on processing operation.

Governance to initiate industrial development is based on the strategy of embedding large-scale foreign investment with large state-owned firms that possess good resources endowments. Favorable policy for attracting foreign investment is designed to encourage large-scale programs with longer fund turnover periods, aiming to control short-term opportunist behavior of foreign firms.

Special financial formulas, such as joint ventures between large state-owned companies and foreign investors, are applied. These large firms were originally an important part of the national innovation system in the planned economy. They stemmed from large state-owned companies directly under the jurisdiction of state ministries and provinces, renowned universities and research institutes, as well as military-related plants that were highly specialized in heavy industry. Right from the opening in 1979, many divisions of ministry- and province-subordinated firms and institutes have been agglomerating in Shenzhen rapidly due to order from central government to develop the special zone (SECC, 2004).

These state-owned firms played an important role in organizing and nurturing the industrial cluster in the very beginning of development. On one hand, they were heavily embedded with highly qualified human capital and technology that were leading among Chinese counterparts at that time. On the other hand, they struggled with the low profit due to irrational ownership incentive and were therefore thirsty for external capital and global leading technology. At that time, they were then able to introduce high-scale production lines due to the disposal of state-owned assets and scale economies of production. Moreover, the high endowment of human capital in state-owned companies enables the better absorption of imported technology. After taking advantage of foreign capital and technology, the growth of these domestic

firms took a considerable rate (SECC, 2004).

Besides joint venture with foreign companies, there were also joint ventures between domestic state-owned firms, mainly between the firms under jurisdiction of state ministry and firms under the jurisdiction of Guangdong province. Peng and Heath (1996) points out further the state-owned companies in transition economy such as in China, while applying the conventional acquisition and expansion strategy, settle as well on network-based strategy of growth drawing upon personal trust and informal agreement among managers. Moreover, the alliances among these state-own companies was always accompanied by tasks of developing a specific leading product technology such as color kinescope, LCD, small-volume exchange equipment and multi-layer printed circuit in 1984 as well as optical fiber in 1997 (SECC, 2004). In addition, Shenzhen City Government also initiated the direct investment in high-tech companies to nurture new growth opportunity and attract high-end foreign investment (SECC, 2004).

The inter-firm linkages of production, information and technology have been built with the growth of these Chinese firms allying between each other under the state order as well as with the foreign firms. In 1986, the Shenzhen Electronics Group Company (later as Saige Group), which unifies 117 companies among all the 178 companies in Shenzhen on voluntary basis, was established under the approval of the Shenzhen City Government. It was then one of the four experimental sites of enterprise group of electronics industry in China. In 1988, the Shenzhen Electronics Group Company arranged the construction of the first specialized electronic parts supply market in China, “Saige Electronics Supply Market”, which is a remarkable milestone in organizing the supply chain of the electronics industry in Shenzhen (SECC, 2004). Within this organizational arrangement, information and production opportunities are more frequently shared among member companies.

Gradually, network governance has been formed in multi-level organizations, encompassing China Central Ministries, the Guangdong Province and the Shenzhen City Government and industrial park authorities in the aspects of initiating technology transfer, facilitating technological absorption of domestic firms and assisting the business sector in training, quality control and customer searching (SECC, 2004).

With the support of the dirigiste governance and geographical proximity to Hongkong, the electronics industry in Shenzhen has been developing rapidly relying on simple processing operation in this period. Nevertheless, the industrial structure in

electronics was concentrated in the standard consumer electronics industry (mainly telephone, TV, calculator and radio), which was faced with a saturated market and limited space of technological upgrading (SECC, 2004).

(2) Governance in the transitional phase

After 1990, the electronics industry in Shenzhen faced the rising factor price and gradually lost the technological advantage in consumer electronics compared to the other regions in China. In order to achieve successful upgrading towards high-tech electronics, the Shenzhen city government has also strategically drawn on the technological foresight in five industries: PC and software, telecommunication, microelectronics, optical-electro-mechanical integration and new materials. Under the guidance of the selected industries, foreign investment was supported around the five industry fields (SECC, 2004).

Other than adjusting the institutional competence to initiate the upgrading, the Shenzhen Government implemented two primary measures in terms of financing programs. Firstly, firms were offered the accessibility to capital markets, with the first capital market being opened in Shenzhen in 1982. Secondly, the city government supported the small and medium-sized high-tech private firms, such as Huawei, with specific funding intermediaries (SECC, 2004).

In 2002, half of the state-level 909 projects on integrated circuit design have located in Shenzhen and a cluster of integrated circuit design companies already took shape, which covers the operation of encapsulation, testing, plate making, device providing, scribing and thick film integrating. Among these firms, most of them are domestic firms such as Guowei, Huawei, Zhongxing, Aisikewei, etc. By the end of 2002, Intel and STMicroelectronics all followed and established research and design center of integrated circuit in Shenzhen. *(SECC, 2004)*

The foreign investment in Shenzhen was only experimental at first and does not constitute the pulling motor of development in Shenzhen. However, it did bring new management concepts to Shenzhen aside from the advanced equipment. Owing to Shenzhen’s special background as the experimental field for opening policies in China, private firms and privatization reform of state-owned firms were encouraged and supported by various levels of government. In 1993, Shenzhen’s National People's

Congress adopted the “Stock Limited Corporations Ordinance of Shenzhen Special Zone” and “Limited Liability Company Ordinance of Shenzhen Special Zone” with legislative power of special zones. Even in small and medium sized state-owned companies, employee stock ownership was gradually allowed. Under this circumstance, the human capital endowment was able to be released from the old national innovation system embedded in state-owned companies, central ministries (Shenzhen Division) and research institutes (Shenzhen Division), which alltogether enables the exploitation of market opportunities in technology. Entrepreneurship prospered in Shenzhen and the young migrants were eager to explore the huge market opportunities in a time of transition, reform and rapid growth. As a result, many private firms flourished in the 1990s, establishing the base for a wide scope of interactive learning and systemic innovation in the interactive regional innovation system.

5.4.2 Governance Evolution in Dongguan since opening

(1) Governance in the initial phase of industrialization

With the devolution of partial power of fiscal arrangements and foreign investment policies from the central government to town and village governments, the Dongguan local government has been enthusiastically devoted to economic growth.

The industrialization process in Dongguan started in the garment and shoe industries during 1980s. Compensation trade, i.e. processing raw materials on clients' demands, assembling parts for the clients and process according to the clients' samples, expanded quickly in many villages and towns. The source of orders was mostly Hong Kong due to the cultural proximity. At that time, there were about 650 thousand Dongguanese settled in Hong Kong. They worked or opened their own factories in Hong Kong and thereby were the mostly reliable communicators of business between Hong Kong and their hometown (Interview in Dongguan, September 2007).

The Dongguan local government put great focus on encouraging the Hong Kong-Dongguanese to invest in their hometown. In 1981, the office of outward processing and assembly was established to organize this important task. Moreover, the village and town governments also greatly supported the development of compensation trade by offering cheap land, favorable policies and flexible standards.

The distribution of the processing earnings is negotiated between the town and village governments and foreign investors, mostly under informal frameworks such as oral agreements (Interview in Dongguan, September 2007). In this way, vested interests are taking shape among foreign firms, township and village governments and peasants who live on the rent of the collectively owned land.

In the process of industrial development based on grassroots foreign investment attraction, infrastructure supply is directed to industry-specific and hands-on service mainly from the township and village governments, deploying the fiscal income into construction, such as factory buildings, roads, electricity and telecommunications, to improve the investment environment. This bottom-up industrialization process matched simultaneously with small-scale Hong Kong investment that feared institutional uncertainty. This leads to the scattered land use pattern and low agglomeration economy. Nevertheless, the demonstration effect of "successful small Hong Kong bosses" and the shaping of vested interests have further strengthened the governance focus on compensation trade in Dongguan.

(2) Governance in the transitional phase

By 1995, the profit space of garment industries was greatly shrinking. Electronics firms, mainly led by Taiwanese firms, along with some of the Shenzhen firms, were gradually relocating to Dongguan in the middle of the 1990s. The shift, attracted by low-cost factors in Dongguan, was systematically carried out through the clustering of Taiwanese firms with complex supplier linkages. Take Delta Electronics for an example, it has brought 22 small and medium sized upstream and downstream Taiwanese firms when investing in Dongguan. Relying on the networked production bought by Taiwanese firms, the electronics industrial chain is now complete and integrated in Dongguan with a kitting rate more than 95%. At the beginning of the 21st century, the compensation trade in electronics in Dongguan reached its peak. However, even before its accelerating phase in the mid 1990s, the policy focus at the provincial level on electronics development was specifically placed on Shenzhen, Guangzhou and Foshan, rather than on Dongguan (GECC, 2002).

In order to attract large-scale high-tech investment in the face of industrial upgrading, the Dongguan City Government established the first city-level industrial park with high entry standards in 2001. Furthermore, the Dongguan City Government responded to the call from the central and provincial governments to "empty the cage

for new bird", i.e. to evacuate the old low-end processing industries and attract new high-tech ones. However, this led to great resistance from the township and village governments. On the one hand, the township and village governments and the peasants rely heavily on processing firms for their major income (Yang, 2010). Therefore, vested interest has been firmly configuratd from the bottom up, thus creating the inertia for structural change. On the other hand, the village and town governments not only lack the incentive, but also the experience to undertake far-sighted ex ante developmental arrangements and provide necessary infrastructure support in order to secure upgrading towards high value-added activities (Interview in Dongguan, September 2007).

"The profit of garment industry has been shrinking after 1995, and the development of electronics industry took pace. At that time, the bosses of medium-sized firms in Taiwan saw the huge profit made by the bosses of small-sized firms investing in Dongguan, and decided to follow in and establish plants here. However, the industry is without planning at all because Dongguan government, especially the town government, would offer land whenever the foreign firms are willing to invest. I remember that many surrounding towns and cities laughed at us on that, calling it 'there are so many stars in the sky in Dongguan but without a moon'."

——Own Interview with Dongguan Electronics Association President Ye in 2007

Due to the weak industrial base before the rapid development, the local skilled labor market and related industrial institutions remained underdeveloped, especially in face of great profit made too rapidly by compensation trade. Statistics in the year 2009 show that the domestic sector was much weaker in Dongguan than in Shenzhen (Table 5.2). This less endogenous development path is expected to impact on the development of the regional innovation system in Dongguan.

Table 5.2 Statistics of the Domestic Sector in Shenzhen and Dongguan (2009)

Firm above designated size*	Shenzhen	Dongguan
Share of domestic firm units	53%	25%
Share of domestic firms' output value	37%	16%
Share of domestic firms' added value	47%	15%

* firms above designated size include all state-owned firms and firm with no less than five million sales

Source: Shenzhen Statistical Yearbook 2010 and Dongguan Statistical Yearbook 2010

5.4.3 Summary of Governance in Shenzhen and Dongguan

From the above discussion, it can be concluded that the development of the electronics industry in Shenzhen is strongly supported by ex-ante involvement of state authorities and institutes that simultaneously echoed with the trend of the global industrial shift of the electronics industry to low-cost regions in the 1980s (Luthje, 2004). On the other hand, the institutional setup in Dongguan has repeatedly been strengthened for the aim of processing trade development with the symbiotic gain of the village and town level governments, overseas Chinese investors (mainly Hong Kong and Taiwan) and local peasants. Moreover, the support of institutional organizations is ex-post to enhance the comparative advantage of the existing developmental mode of mass low-end production.

Before the discussion on the innovation pattern based on empirical result from the electronics industry survey, the overall innovative performance in Shenzhen and Dongguan would be displayed to gain a first insight into the development of regional innovation system.

5.5 Descriptive Profile of Innovation Activities in Shenzhen and Dongguan

Table 5.3 depicts the major statistics from each of the two cities. The population size in Shenzhen and Dongguan does not deviate a lot, and the employment opportunities in both cities are also quite high. However, the industrial output value as well as the gross domestic product (calculated as the value added) in Shenzhen is more than two times larger than that in Dongguan, which indicate a much higher productivity in Shenzhen than in Dongguan. Moreover, the pattern of specialization in high-tech sector in Shenzhen outstands from that in Dongguan in terms of industrial output value and employment.

As for the innovation indicators, Shenzhen's total R&D expenditure is more than six times higher than that in Dongguan, and the intensity of R&D investment is 3.4% for Shenzhen, which is comparable even to that in developed countries (OECD 2.3% in 2009, USA 2.9% in 2009, Japan 3.4% in 2009, Korea 3.3% in 2009[4]). While in

[4] Sources: OECD, Main Science and Technology Indicators database, January 2011.

Dongguan, the intensity of R&D investment (1.1%) is still in a low level, which is even lower than the national average level of 1.7% in 2009. Not only that, the R&D personnel in Shenzhen outperforms that in Dongguan both in absolute and relative term, which all point to a higher level of human capital that enables the functioning of regional innovation system.

Table 5.3 Major Indicators in Shenzhen and Dongguan (2009)

	Shenzhen	Dongguan
Population	8912,300	6350,000
Gross Domestic Product (billion Yuan)	820	376
Industrial Output Value (billion Yuan)	1582	676
% of High-tech manufacturing sector[1]	69%	39%
Employment	6924,853	5381,981
% of High-tech manufacturing and service sector[2]	33%	19%
Total R&D expenditures (billion Yuan)	27.97	4.14
% of GDP	3.4%	1.1%
R&D personnel	123687	18524
share of R&D personnel per 1000 employees	17.9	3.4

2. High-tech manufacturing sector refers to ordinary equipment, special purpose equipment, transport equipment, electric equipment and machinery, telecommunications, computer and other electronic equipment (only above designated sized firms that include all state-owned firms and firm with over five million sales are calculated).
3. High-tech manufacturing and service sector include the high-tech manufacturing sector above and service sector, i.e. information transfer, computer and software services, scientific research, technical services and geographical prospecting.

Sources: Shenzhen Statistical Yearbook 2010, Dongguan Statistical Yearbook 2010 and 2nd Investigation Report of Guangdong R&D Resources

Because the high-tech manufacturing sector defined in Table 5.3 is very broad, firms in this sector might produce the same kind of products while possess different levels of technological capabilities. As a result, the performance of high-level high-tech companies in both cities is further investigated. For Shenzhen firms, high-tech firms with intellectual property are defined as high-level high-tech firms. For Dongguan firms, it refers to provincial-level high-tech firms because firms earn this qualification only if they participate intensively in R&D activities or acquire scale economy in high-tech product applying high-tech achievements. Thereby, these two measures are comparable in some way. Notwithstanding the Shenzhen definition is stricter than the Dongguan definition, the high-level high-tech companies in Shenzhen develop at a much higher rate than that in Dongguan during the period of 1999 and 2008. In 2008, the industrial output value produced by high-level high-tech companies in Shenzhen reached over Yuan, which is almost 3.5 times higher than the

output value in Dongguan. This comparing pattern demonstrates the stronger innovation capabilities for Shenzhen firms that that for Dongguan.

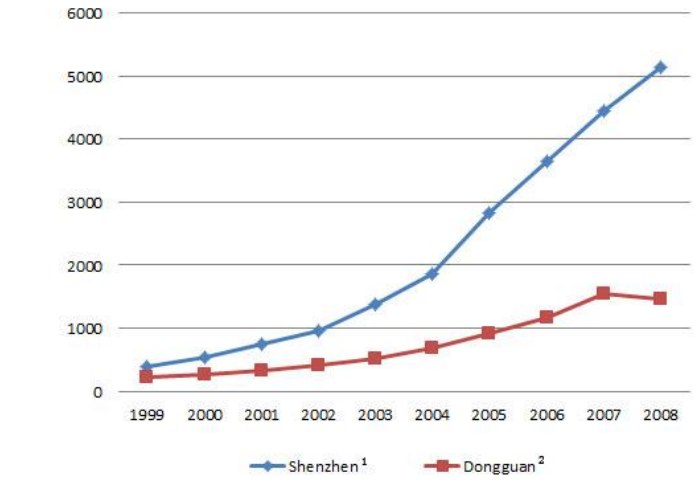


Figure 5.3 Industrial Output Value of High-Level High-tech companies (1999-2008)

Source: Shenzhen Statistical Yearbook 2010, Dongguan Society and Technology 2009

The patenting activities further reveal the innovation capabilities of the business superstructure in both cities. Table 5.4 shows that the absolute number of patent application and patent grant in Shenzhen exceeds that in Dongguan to a large extent in the year 1995, 2000, 2005 and 2008. Although the passing rate of patent application is lower in Shenzhen than that in Dongguan in the year 1995 and 2000 (which might be also attributed to the low number of patent application in Dongguan), the passing rate overtakes that in Dongguan in spite of the much larger denominator (absolute number of patent application) for Shenzhen.

Table 5.4 Patent Application and Grant in Shenzhen and Dongguan

		Shenzhen	Dongguan
1995	Patent application	1104	325
	Patent grant	721 (65%)	262 (80%)
2000	Patent application	4431	1653
	Patent grant	2401 (54%)	1051 (63%)
2005	Patent application	20940	6694
	Patent grant	8983 (43%)	1974 (29%)
2008	Patent application	36249	14406
	Patent grant	18805 (52%)	4362 (30%)

* numbers in the parentheses are the share

Source: Shenzhen Statistical Yearbook 2010, Dongguan Society and Technology 2009

Among the grated patent in both cities, it is shown by Table 5.5 that the grated patenting concentrating more on higher level of category such as utility model patent and invent patent in Shenzhen firms than that in Dongguan, Moreover, Shenzhen's concentration towards higher category compared to Dongguan is gradually strengthened from 1995 to 2008.

Table 5.5 Distribution of Granted Patent Category in Shenzhen and Dongguan

		Shenzhen	Dongguan
1995	Invent patent	7 (1%)	8 (3%)
	Utility model patent	280 (39%)	41 (16%)
	Design patent	434 (60%)	213 (81%)
2000	Invent patent	1 (—)	4 (—)
	Utility model patent	750 (31%)	344 (25%)
	Design patent	1650 (69%)	1051 (75%)
2005	Invent patent	917 (10%)	24 (1%)
	Utility model patent	3458 (38%)	1116 (36%)
	Design patent	4608 (51%)	1974 (63%)
2008	Invent patent	5409 (29%)	115 (1%)
	Utility model patent	7971 (42%)	3616 (45%)
	Design patent	5425 (29%)	4362 (54%)

* numbers in the parentheses are the share

Source: Shenzhen Statistical Yearbook 2010, Dongguan Society and Technology 2009

For the patenting activities in private sector, Table 5.6 shows that the number of patent application of medium and large enterprises in Shenzhen is well over that in Dongguan to a great extent. In addition, the share of invention patents among the whole patent application is much higher for Shenzhen than that for Dongguan.

Table 5.6 Patent Application of Medium and Large Enterprises (2007-2008)

		Shenzhen	Dongguan
2007	Patent application	20668	1243
	Among which: Inventions	15322 (74%)	337 (27%)
2008	Patent application	22391	1486
	Among which: Inventions	15053 (67%)	300 (20%)

* numbers in the parentheses are the share

Source: Shenzhen Statistical Yearbook 2010, Dongguan Society and Technology 2009

Overall, the comparison of the general innovation capabilities between Shenzhen and Dongguan suggests a much better developed pattern of innovation capabilities in Shenzhen that would permit a well-functioning regional innovation system in which the interactive reciprocal innovation synergies is taking shape.

5.6 Empirical Results of Interactive Innovation

After comparing the divergent evolutionary paths of governance since the opening up and current innovation capabilities in Shenzhen and Dongguan, an empirical investigation into the scope and extent of interactive learning and systemic innovation in their primary industries, the electronics industry, was conducted in order to gain insights into the development of respective regional innovation systems. In the analysis, tobit regression was applied to examine the impact of external interaction with other business partners on firms' innovation outcomes.

Factor analysis was firstly applied to reduce the dimensions of independent variables in order to simplify the following regression. The derived factors are able to explain over 60% of the variance of the original sample. In order to avoid multicollinearity, seven variables were finally selected as the independent variables. Table 5.7 shows the independent variables, including the innovation behavior mainly investigated and other control variables such as firm characteristics and firm absorptive capacity.

The dependent variable in the regression is the average score of evaluation of the degree of improvement (ranging from 0 to 5 with increasing significance of change) on function expansion and categories upgrading. Appendix E (See Figure E.1-E.3) shows the censoring pattern of the dependent variables of the tobit regression models. Long (1997) demonstrates that OLS regression provides inconsistent estimates of the parameters when the dependent variable displays a censoring pattern. In this case, tobit regression was run in order to derive reliable estimation.

Table 5.7 Independent variables in Product Innovation outcome Regressions

	Indicators	Description
Innovation Behavior	NPI_external partners	Interacting with *domestic customers, universities, research institutions and sales agents* to gain innovation ideas
	NPI_internal efforts	Making *internal learning efforts* such as own ideas, license purchasing and reverse engineering
	NPI_parent comp. & foreign	Relying on parent companies or foreign customers to gain innovation ideas
	NPTK_active learning	Sending staff *to business partners* for training
	NPTK_passive from customer	Receiving training and know-how from people sent *by domestic and foreign customers*
	NPTK_passive from parent comp.	Receiving training and know-how from people sent *by parent company*
	NPInteraction _informal	Interacting with innovation partners *within Guanxi networks*
Firm Characteristics	Size	Defined according to Chinese firm size standard, 1 as large firms with no less 300 million Yuan sales and no less than 2000 employee, otherwise as small and medium-sized with the value of 0
	Ownership	1 as firms with foreign participation (wholly owned or joint venture), 0 as firms with 100% domestic participation
	Age	Years since establishment of the firm
Absorptive Capacity	Educational level of technical staff	Proportion of technical staff with bachelor degree and above
	Initial technological level of main product	Defined according to International Standard Industrial Classification of all Economic Activities, Rev 3[1], 1 as producing low-tech products when starting business, 2 as producing medium-tech products when starting business; 3 as producing high-tech products when starting business

1. Specific classification of products into the different levels could be referred to Appendix C.

Source: Own Survey Questionnaire (See Appendix A)

Table 5.8 gives the descriptive statistics for the variables and tests the variation level between Shenzhen and Dongguan. In the surveyed sample, most of the firms are small and medium sized (94% and 89% in Shenzhen and Dongguan, respectively). The share of domestic firms in Dongguan is less than that in Shenzhen to a significant degree. Technical staff possesses significantly higher absorptive capacity in Shenzhen than that in Dongguan according to the share of above bachelor degree technicians, and Shenzhen firms also start with higher production technology than Dongguan. In terms of innovation behavior, Shenzhen firms turn more to external partners in

triggering innovative ideas than Dongguan firms, but not at a significant level. On the other hand, Dongguan firms rely more on the transfer of tacit knowledge from parent companies and foreign customers, and more frequently use informal relations with friends and business partners.

Table 5.8 Descriptive Statistics in Shenzhen and Dongguan

	Shenzhen				**Dongguan**				***ANOVA***	
	Mean	S.D.	Min.	Max.	Mean	S.D.	Min.	Max.	*F*	*Sig.*
Firm Size (% of large firms)	0.06	0.23	0	1	0.11	0.31	0	1	2.255	0.134
Firm Ownership (% of foreign firms)	0.28	0.45	0	1	0.47	0.50	0	1	11.95	0.001
Firm Age (years)	10.4	7.6	1	57	12.2	7.1	2	51	4.30	0.039
Educational level of technical staff (%)	0.43	0.36	0	1	0.33	0.30	0	1	5.72	0.017
Initial technological level of main product	1.99	0.63	1	3	1.78	0.64	1	3	7.93	0.005
NPI_external partners	0.10	1.05	-2.05	2.53	-0.07	0.96	-2.78	1.69	2.24	0.135
NPI_internal efforts	0.02	0.89	-2.67	1.68	0.11	1.06	-2.61	7.43	0.63	0.427
NPI_parent comp. & foreign	-0.22	0.87	-1.81	2.22	0.27	1.04	-2.89	2.90	19.19	0.000
NPTK_active learning	-0.03	1.01	-2.10	2.57	0.06	0.95	-2.19	2.10	0.68	0.409
NPTK_passive from customer	-0.02	0.94	-1.95	2.08	0.10	1.04	-2.13	2.27	1.03	0.31
NPTK_passive from parent comp.	-0.04	0.98	-1.38	3.28	0.10	1.02	-1.38	3.21	1.40	0.238
NPInteraction informal	-0.14	0.95	-2.52	1.60	0.14	1.03	-2.53	1.60	6.13	0.014

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

Table 5.9 shows the result of the tobit regression on product innovation outcome. Three models are run as a comparison: whole model pooling of the Shenzhen and Dongguan data, the Shenzhen model and the Dongguan model. All the models fit significantly better than an empty model, which is indicated by the significant level of the chi-square likelihood ratio. The whole model serves as an intermediate between the Shenzhen model and the Dongguan model, which reflects the difference between Shenzhen and Dongguan in a clearer way.

Table 5.9 Tobit Regression on innovation outcome

Independent variables		*Product Innovation outcome*		
		Whole Model	**Shenzhen Model**	**Dongguan Model**
Constant		3.56***	3.38***	3.70***
		(0.192)[1]	(0.289)	(0.239)
Educational Level of Technical Staff		0.004*	0.005	0.002
		(0.002)	(0.003)	(0.003)
Ownership		-0.30*	-0.53*	-0.05
		(0.153)	(0.268)	(0.206)
Firm Size		0.23	0.32	0.15
		(0.276)	(0.522)	(0.305)
Firm Age		0.008	0.03*	-0.008
		(0.010)	(0.015)	(0.013)
Initial Product Type according to technology	Medium tech vs. low tech[2]	0.15	0.08	0.16
		(0.168)	(0.282)	(0.191)
	High tech vs. low tech[2]	0.37	0.14	0.60**
		(0.237)	(0.357)	(0.302)
NPI_external partners		0.31***	0.53***	0.12
		(0.091)	(0.158)	(0.105)
NPI_internal efforts		0.20**	0.39***	0.05
		(0.081)	(0.135)	(0.093)
NPI_parent comp. & foreign		0.25***	0.21	0.25**
		(0.089)	(0.155)	(0.102)
NPTK_active learning		-0.05	-0.28*	0.08
		(0.094)	(0.147)	(0.118)
NPTK_passive from customer		-0.07	-0.43***	0.16
		(0.087)	(0.135)	(0.103)
NPTK_passive from parent comp.		-0.08	-0.11	-0.12
		(0.082)	(0.133)	(0.098)
NPInteraction_informal		-0.04	0.04	-0.07
		(0.083)	(0.140)	(0.098)
Prob > chi2		0.0005	0.0006	0.0291
Pseudo R square		0.05	0.11	0.07
Number of Observations		240	109	130

1. Standard errors in parentheses; *p<0.10, **p<0.05, ***p<0.01.
2. Initial product as low tech as the default group, which means low tech as 0, the others as 1.

Source: Calculation based on own survey conducted in DFG SPP 1233 [2009]

Observing firstly the variables indicating the behavior in the various stages of the product innovation process, Shenzhen firms combine their internal absorptive capacity with external interaction with other partners to trigger innovation ideas, which eventually boosts the innovation outcomes. In a regional innovation system, the interactive learning not only contributes to effective knowledge transfer, but also triggers the innovation, enabling capitalization on new creative resources from the

complementary knowledge of various players in the cluster (Capello, 1999). This indicates the strategy and capacity of Shenzhen electronics firms to capitalize on wider sources of knowledge spillover, including domestic customers, sales agents, universities and research institutes, which signify the maturing of the interactive regional innovation system in Shenzhen.

On the other hand, innovation ideas originating within strict hierarchical organizations, i.e. instructions from parent companies and foreign customers, boosts innovation outcome for Dongguan firms. Interactive learning in Dongguan is exclusively oriented to a fairly passive pattern of receiving orders to expand product functions and upgrade product categories from the organizationally proximate partners. Compared to the innovation activities in Shenzhen firms, the limited capacity for drawing upon a wider scope of external sources to foster innovation reflects the bottleneck of upgrading in Dongguan, where the internal absorptive capacity and external business environment do not permit the strategic use of interactive learning in the innovation process.

What is worth mentioning here is the significantly negative effect of either actively sending employees to gain technical experience or passively having engineers sent by other partners to pass on technical experience for Shenzhen firms. This might be related to the loss of technical staff in the process of gaining tacit knowledge. The higher absorptive capacity of the technical staff in Shenzhen firms than those in Dongguan enables them to absorb the knowledge from other organizations more effectively and identify the opportunities with higher salaries and positions. However, it should be cautiously interpreted because the labor mobility among local firms should contribute to effective interactive learning processes over the whole economy (Arrow, 1962, Almeida and Kogut, 1999). It is possible that firms gain the spilling-in human capital while losing others in the process of tacit knowledge transfer.

Moreover, the difference in the significance level of control variables confirms the hypotheses from another point. For Shenzhen firms in the sample, older firms tend to have higher performance in product innovation. This variable demonstrates the long history of capability accumulation related to innovation activities, such as in technological development, management optimization and market research, contributes to higher absorptive capacity and higher effectiveness in bringing out better innovation results. In contrast, the small insignificant impact of firm age on innovation outcome for Dongguan firms indicates the firm strategy for accumulating

technological and managerial capabilities around innovation activities is not conscious and systematic. However, Dongguan firms producing high-tech electronics products at the beginning, which indicates higher absorptive capacity, perform better than firms producing low tech electronics products at the beginning in a significant level of 90%. In short, firms in Dongguan rely more than Shenzhen firms on the routine accumulated gradually within the firm boundary, rather than on complementary knowledge outside the firm, leading to the lack of dynamism and incentive to trigger innovation. The innovation activities in Dongguan are rather passively led by globalized players such as parent companies and foreign firms.

Post-estimation was made to ensure the robustness of the results. In Appendix E, the distribution of the residuals in the whole model, Shenzhen model and Dongguan model were displayed (See Figure E.4, Figure E.5, Figure E.6). They all obey the normal rule, which indicates that heterokedastic issue, that might tortures the results of Tobit model, does not exist.

5.7 Discussion and Conclusion

Governance perspective towards regional development and innovation is characterized by supply-side support, which aims to provide supportive resources, secure collective actions and establish the strategic goals (Hausner, 1995). By comparing two cities from an evolutionary perspective, this chapter finds that dirigiste governance modality in Shenzhen in the initial industrialization phase leads to a more mature and developed regional innovation system than the grassroots governance modality in Dongguan, though they both started the industrialization process in the wake of the opening policy in the late 1970s.

Insights from the empirical results show that dirigiste governance in the initial industrialization phase is more competent in providing innovation-related resources and adjusting the developmental path with strategic intervention than the grassroots governance, widening the scope of interactive learning and shaping the behavioral rationalities of firms to resort more to external complementary knowledge. While the newly recognized strand of grassroots governance supports its competency to mobilize the local resources and interdependencies (Amin, 2002), the result suggests a rather contrasting pattern, indicating that this approach in the initial phase of

industrialization might lead to a negative lock-in effect in the face of restructuring and upgrading by restricting the firms within the repeated and narrow path of knowledge accumulation and generation.

As evolutionary investigation is subject to context, it should be remembered that the two cities in this study started the rapid industrialization out of nothing, that is to say, with a barren endowment of local skills and industrial base. In this case, the grassroots approach tends to restrain the scope of development within the disposal of less competent local authorities. On the other hand, the empirical findings on the success of dirigiste governance in shaping innovative synergies among the firms and knowledge-intensive organizations should not be viewed as arguments favoring the central planning method of development in Keynesian legacy. In fact, this institutional advantage is combined within the market opportunity brought about the reorganization of global production networks, boosting a plurality of autonomous decision agents with respective strategic goals in the transition economy.

Grassroots governance in China has been widely applied since it was cost efficient for the central government and has actually mobilized the initiative of local governments to develop the economy. For clusters that developed out of grassroots governance in the early phase of industrialization, two lessons can be learned to boost the development of the regional innovation system. Firstly, strategic planning of industrial development should be carried out to avoid negative lock-in, adjusting the developmental path to meet the changing market environment in time and identifying related new industries. Most importantly, levels of governance should be accordingly regulated and balanced to unfasten the vested interests aiming for contrasting development goals. Secondly, policy focus should be put upon enhancing the absorptive capacity of firms and related organizations, such as attracting high quality human capital and encouraging the conscious accumulation and development of technological capabilities within firms.

As for the more developed case in Shenzhen, experiences of building a sustainable regional innovation system can be further borrowed from Europe and the USA where innovation governance models are mature. In Europe, economic agents depend to a significant degree on public institutions for fostering innovation activities, while in the USA, the role of private institutions such as banks and venture capitals is prominent in organizing systematic learning and innovation. Ultimately, if the supporting governance is competent in performing inclusive, monitoring, consultative

and networking features, it is more likely to allow high potential regional innovation systems.

The comparative study between Shenzhen and Dongguan, China captures the governance modality in the initial industrialization phase and its evolution with market change as an important factor that leads to different degrees of regional innovation system development. As indicated by Cooke (2004:17), "regional innovation systems are evolving as their contextualization elements shift with globalization, the rise of knowledge-intensive industry and the hollowing-out of 'Industrial Age' industries". Therefore, it would be useful to identify the elements of governance in relation to the business needs under the new market trends. Furthermore, more thought should be put into the question of how to keep the dynamics and prevent the inertia of governance modality in the face of necessary changes.

6 Conclusions

6.1 Answers to the Research Questions

The term ‘regional innovation system’ has a different meaning in China, since innovation here is characterized mainly as an exploiting process of externally sourced knowledge, rather than knowledge generation. In the preceding chapters, the pattern of interactive learning and systemic innovation, which is closely related to the formation of a regional innovation system, has been investigated among the electronics firms in the Pearl River Delta, China. Furthermore, the spatial differences in this region have been uncovered with an evolutionary observation of the governance infrastructure that incentivizes and supports the innovation activities in the business sector. To summarize the insights from the empirical investigation in the Pearl River Delta, China, answers will be provided to the key research questions formulated in Chapter 1 in the following three blocks, i.e. sections 6.1.1-6.1.3.

6.1.1 The shaping of interactive learning behavior and systemic innovation activities

In the third wave of globalization in 1980s, the bulk of foreign capital flowed to developing countries in the form of direct investment in manufacturing (Dollar, 2001). During this process, the Pearl River Delta was integrated into the global economy following the introduction of the opening policy in 1978. However, the production systems in these regions are strongly governed by the global lead firms and global buyers (Yeung, 2009; Humphrey and Schmitz, 2008). The FDI-dependent mode has provided great impetus for the rapid industrialization in these regions.

The central question for the innovation and upgrading in China is: how and under what circumstances do knowledge spillovers sourced externally trigger knowledge spillovers on the local scale, enabling the formation of regional innovation systems in latecomer export-oriented regions (T1)? This theoretical question relates to the first empirical question E1 “Have local-scale knowledge spillovers come into being to sustain long-term development in the face of a changing and fragile post-crisis global market in the export-oriented Guangdong Province, China? As demonstrated by the

analysis and empirical evidence in Chapter 2, external knowledge spillover has triggered the knowledge spillover within industries mainly through the channel of FDI in the Guangdong Province. The results show that the impact of industrial specialization on new product development relies on the value of FDI stock. That is to say, knowledge spillover within the same industry, which promotes the learning by doing and knowledge exploitation processes, only comes into play when the FDI stock in the region is high. This is potent evidence of the triggering effect of FDI on the formation of local interactive learning processes within the same industry. FDI facilitates the function of local knowledge spillover channels by enabling inter-firm collaboration and cooperation, enhancing human capital and accelerating spin-off activities.

The knowledge spillover effects produced through interactive learning either with global partners or domestic partners are further supported by the firm-level investigation in Chapter 3 and Chapter 4. In Chapter 3, the motive of interactive learning is firstly theoretically discussed, which is elaborated upon by the T2 question "Why do firms undertake interactive learning with external partners in the decision-making and implementing process of innovation activities?" Following the argument of organization routine proposed by Nelson and Winter (1982), the bounded rationality and competence of firms necessitates the complementary use of interactive learning with other organizations in the aspect of searching for relevant information in order to make innovation-related decisions, as well as of seeking the support of codified and tacit knowledge in the innovation process. From the empirical results in Chapter 3, it is concluded that a wider scope and higher intensity of interactive learning promotes the innovation outcomes for the electronics firms in the Pearl River Delta, which provides the answer to the first part of E4 "What is the effect of interactive learning in general on innovation outcomes?" In addition, the empirical investigation in Chapter 4 further discovers that socially active innovators outperform lame innovators.

In Chapter 4, an attempt is made to relate firms' internal absorptive capacity to their innovating behavior. The empirical question E2 - "Which aspects of absorptive capacity enable the electronics firms to undertake interactive learning with external partners through strategies of using organizational proximity and social proximity in product innovation processes?" - is then addressed. It is shown that the production experiences in high-tech fields prepare the firms with more capability and resources to

undertake interactive learning using either social proximity or organizational proximity. Nevertheless, parameters for R&D activities, including the presence of technology centers as well as the possession of design capability and development capability, do not differ significantly for interactive learning groups from the lame innovators. This result does not support Cohen and Levinthal's (1990) finding on R&D's function in creating and exploiting new knowledge. However, it should be pointed out that in their research, R&D refers to more basic research that is able to prepare the firms with general background knowledge to exploit new scientific knowledge rapidly. The concentration of test and development activities in the R&D function among the electronics firms in the Pearl River Delta might be able to explain the incapability of R&D to boost the absorptive capacity of firms to undertake interactive learning for new knowledge exploitation. In any case, the results on the effect of R&D should be interpreted consciously, and this issue will be addressed in the discussion of the limitations of the thesis.

6.1.2 The informal aspect of innovation activities in China

Under the proximity concept of investigating interactive learning in the Pearl River Delta, China, the informal aspect of innovation activities has been covered in the analysis in Chapter 3 and Chapter 4. In the context of China, informal and continual interaction among various economic players and the embeddedness in "Guanxi" networks are important factors for doing business. In the first phase of the research project, on which this thesis is based, the informal aspect of economic life in China has been investigated with an analytical focus on production activities. Meyer (2011) has conducted a thorough investigation into the informal interaction mode of customer-producer relations with regard to achieving a high level of flexible production, concluding that informality contributes to finding a new customer or producer quickly, increasing speed to market and saving time when conflict emerges in contractual enforcement. This thesis further develops the understanding of the informal aspect of economic life in China with respect to innovation activities, which is of great relevance to the upgrading issue in the face of rising factor prices, intensifying competition from other regions and shrinking foreign markets.

Empirical results in Chapter 3 verify that informal relationships with business partners, relatives and friends are a widely applied practice in interactive learning during the product innovation process. The firms that undertake the widest scope and

highest intensity of interactive learning activities tend to apply informal Guanxi networks to assist in searching and contacting with the related business partners, from whom reliable information and knowledge can be sourced from in the product innovation process.

In Chapter 4, the insights into the informal aspects of interactive learning are further elaborated upon explicitly under the concept of social proximity. It firstly probes into the question T3: "What is the role of social proximity and organizational proximity in interactive learning activities in latecomer export-oriented regions?" Based on the review of the global production network literature, it hypothesizes that organizational proximity with foreign parent companies and foreign customers is helpful in transferring tacit knowledge for firms in latecomer countries in the early phase of development, and enables firms to foster innovation further with a more sophisticated supply chain and sufficient absorptive capacity. On the other hand, social proximity, embodied by the informal Guanxi asset in China, is able to play a role in trust building by shaping local dynamic innovative synergy with the precondition of mature internal absorptive capacity. Through the comparative analysis of the extent to which social proximity with local partners and organizational proximity with global partners foster product innovation, it is shown that electronics firms in the Pearl River Delta, China, resort more to social proximity than to organizational proximity in interactive learning processes (answer to E3: "How is interactive learning organized in the burgeoning regional innovation system? To be more specific, does interactive learning embed more in socially proximate networks or organizationally proximate networks?"). Nevertheless, socially active firms do not outperform organizationally dependent firms in terms of transforming the proximity assets into better innovation outcomes (answer to the second part of E4: "And what is the effect of interactive learning embedded within socially proximate networks and organizationally proximate networks on innovation outcomes respectively?").

This result suggests an unstable role of social proximity, embodied by the Guanxi network, in sustaining trust with regard to innovation activities with high levels of uncertainty and risk. As pointed out by Chesbrough and Teece (1996), information sharing can be reduced or biased as each seeks to get the most at the other's expense. Therefore, the effect of informal methods, such as Guanxi networks in the Chinese business mode on promoting systemic innovation among firms needs to be assured by a durable and time-consuming relationship construction under the market

circumstances, where the interests of the interacting and cooperating firms are kept in correspondence and harmony. Moreover, supported institutions and related organizations that shaped common norms and rules should be shaped to sustain stable interactive learning processes.

6.1.3 The spatial difference in interactive learning activities under divergent patterns of governance infrastructure evolution

Regional innovation systems stress the role of governance infrastructure in supporting the business superstructure of innovation activities. A trend towards the evolutionary perspective on regional innovation systems has been testified to by the republication of the seminal book "Regional innovation systems: the role of governance in a globalized world" in 2004 (Cooke *et al.*, 2004). Compared to the first edition (Braczyk *et al.*, 1998), this book analyzes the evolutionary path of regional innovation systems with changing contextualization elements such as globalization, the rise of the knowledge economy and the deindustrialization process. Chapter 5 adjusts the evolutionary lens according to the context of China, where the regional innovation system is being incubated from the production system relying heavily on integration into the lower end of global production networks facing rising factor prices and upgrading pressure, and focuses the investigation on the transition from governance that supports initial industrialization to governance that supports the innovation activities.

By means of a thorough theoretical discussion of governance infrastructure, both in production systems and innovation systems as well as their relationships, Chapter 5 depicts the evolutionary path of the globalized grassroots production system and the globalized dirigiste production system towards the regional innovation system, providing an answer to question T4: "What leads to the dynamics and inertia of regional innovation system under different governance infrastructures?". It is concluded that globalized grassroots production systems with a weak industrial base tend to encounter competency traps and complex vested interests, leading to the risk of negative lock-in and sticky inertia along the evolutionary path towards the one supporting innovation systems. Compared with the globalized grassroots production system, the globalized dirigiste production system, which is mostly initiated and governed by national level agencies with more power, is more capable of injecting new dynamics into development and accumulating the skill stock from the central

assignments, for example through relocation of large state-owned firms and knowledge-intensive institutions. Moreover, the awakening of market mechanisms to facilitate the transition of dirigiste governance to network governance is also strengthened as one of the most important determinants in the dynamics of the dirigiste approach.

The inter-city comparative study between Shenzhen and Dongguan electronics firms yields the answer to question E5: "How do regional innovation systems in Shenzhen and Dongguan, China differ from each other in the scope and effect of interactive learning, considering that the two cities are evolving towards regional innovation systems under different governance infrastructures in the initial industrialization phase?". It demonstrates that electronics firms in Shenzhen are able to capitalize on a wider scope of interactive learning activities to foster innovation, while Dongguan electronics firms have restricted the scope of learning to within the hierarchical boundary with parent companies and foreign customers, leading to the reliance on the transfer of tacit knowledge from a limited number of players to foster innovation. Combined with the answer to question T4, it can be concluded that the dirigiste approach in globalized production systems without a previous industrial base is more competent in providing innovation-related resources and adjusting the developmental path with strategic intervention than grassroots governance, widening the scope of interactive learning and shaping the behavioral rationalities of firms to resort more to external complementary knowledge.

6.2 Limitations and Directions of Future Research

This section reflects on the limitations of the study and provides directions for future research accordingly. Limitations and the corresponding research directions can be summarized under the following three aspects.

6.2.1 The mechanism of distributive system on the regional level

This chapter analyzes the distributive power of China's regional innovation system with the focus on inter-organizational interactive learning. Nevertheless, distributive channel of information and knowledge in the regional innovation system are not only sustained through inter-firm vertical collaboration and horizontal cooperation, but also through labor mobility and spin-off activities.

It is commonly emphasized that regional innovation systems depend on the density and quality of the network among firms, knowledge-related organizations and institutions. However, the issue of how labor and its related governance contribute to the systems of innovation processes is still neglected in the literature of RIS. In small firm district, the short and turbulent life of small firms results in a high turnover of qualified workers. According to the firm interviews in the pre-test phase of the survey in this study, many firms rely on talent poaching to ensure the success of innovation projects. Further research on the learning by hiring effect within the regional innovation system in China could go in to two directions. Firstly, the factors that lead to firms' reliance on interaction with individuals instead of organizations as a way to gain complementary knowledge can be explored, as unbalanced absorptive capacity among the latecomer firms further disturb the sustainability of inter-organizational interaction. Secondly, the role of labor-related governance, such as training agencies, employment agencies, labor unions and supported laws, and practice in promoting the innovation activities should be explored further.

Another factor that contributes to the distributive power of innovation systems is namely spin-off activities. Parhankangas and Arenius (2003) define three types of spin-offs as spin-offs developing new technologies, spin-offs serving new markets and restructuring spin-offs. Although these spin-offs differ from each other in the intensity of resource sharing linkages and knowledge transfer with the parent companies, the effect of interactive learning among them is assumed to be higher due to the sharing of experience and routines. Asheim and Coenen (2005) also point out that spin-off activities are key methods of knowledge application and exploitation, especially in scientific knowledge-based clusters. Therefore, further research should investigate the sustained relationship and interaction between spin-offs and the incubators and parent firms, as well as their role in exploiting and commercializing the new combination of knowledge.

6.2.2 The negative effect of informal Guanxi network in innovation

In the theoretical discussion on the role of Guanxi networks in innovation in Chapter 4, the downside of Guanxi networks in fostering innovation has been touched upon. However, this thesis does not undertake an empirical investigation into the negative effect of informal Guanxi networks in innovation due the limits of the firm survey resources.

The disadvantage of Guanxi lies in two aspects. Firstly, it can damage the development of firm internal capability due to limits of time and resources. It is an intricately woven interpersonal network that requires constant monitoring, investment and subtle utilization. Gains in terms of Guanxi network improvement must result in lack of investment in other aspects such as managerial capability and technological capability. Secondly, the rent-seeking kind of Guanxi network can harm the overall efficiency of economies. Resources are distributed according to Guanxi with government officials, rather than according to capability and efficiency of the firms. This actually suppresses the firms' incentives to invest in long-term technological capability accumulation, leading to underdevelopment of absorptive capacity that hampers the effect of interactive learning in innovation activities.

Therefore, absorptive capacity constitutes the primary leveraging tool in the capacity to capitalize on informal Guanxi networks with regard to innovation outcomes. Only when the firms develop enough capacity to absorb, adapt and exploit the information and new knowledge, can Guanxi networks contribute to the innovation outcome of the system at the regional level. Future research should further collect the empirical evidence of the negative effect of informal practices on the innovation activities and compare them to their positive role in shaping trust and reducing risk in the interaction process.

6.2.3 Methodological Issues in the Survey Design

The empirical investigations of this thesis are all based on an electronics firm questionnaire survey conducted at the end 2009. Following the empirical investigation into the questions concerned with innovation activities, there are two primary aspects in which improvement can be made in future firm survey investigations in regions such as the Pearl River Delta, China.

Firstly, a small sample size of serious R&D undertakers in the Pearl River Delta hinders the systematic investigation of the effect of R&D intensity on boosting the absorptive capacity and shaping interactive learning behavior. Especially in the questionnaire survey, it was very difficult to obtain comparable and accurate data on R&D activities. Many firms tended to overrate the presence of the R&D function and the intensity of R&D expenditures, since R&D is still a trendy word in China and firms are not informed as to the exact meaning of it. Sometimes even minor adaptation activities are viewed as R&D, which leads to incomparability with firms

that undertake true R&D functions. Therefore, improvements to future firm surveys should be made in the following respects: firstly, a detailed investigation should be conducted to differentiate between basic research, applied research and test & development activities among the general R&D functions. Most importantly, efforts should be devoted during the survey to explaining the true meaning of each element of R&D activities to the surveyed firms, attempting to gather a more comparable dataset out of it. In short, the thesis raises a call for a more thorough investigation of R&D activities in the Chinese context with regard to the composition and quality of R&D activities.

Secondly, the interaction mode with each business partner in each specific innovation process has not been identified under this survey design. The matrix of questionnaires would otherwise have been too complex for the firms to answer. In order to ensure the success of the survey, only general information on interaction methods with business partners could be identified. As this thesis only constitutes experimental exploration with regard to the role of informal Guanxi networks in innovation activities, future empirical research design should select the focus according to the respective research interests and investigate further in which process of innovation (e.g. collecting information and gaining support of equipment and technical experience) and with which partners (e.g. parent companies, foreign customers, domestic customers, suppliers, universities and other related organizations) firms apply informal networks to foster the innovation outcomes.

6.3 Policy Implications

The systemic innovation approach leads to different policy focus compared to the linear innovation approach (Smith, 2000). The linear innovation approach points out the market failures in the knowledge generation process, in which the policy should intervene in order to reach an optimal production of knowledge stock. Taking this into consideration, policy intervention should focus on encouraging the indigenous knowledge production process, such as R&D activities, through the channel of subsidies and intellectual property rights protection (Arrow, 1962). On the other hand, the systemic innovation approach does not necessarily exclude actions of this kind, and further underlines the systematically weak performance of market-based systems. In short, policy intervention following the logic of the system approach aims to encourage the sharing and joint exploitation of knowledge stocks in the process of

new knowledge commercialization.

This thesis adopts a systemic approach towards the innovation issue in China and highlights the role of interactive learning in the formation and development of the regional innovation system in the Pearl River Delta, China. Based on the findings in the previous chapters, the following suggestions on policy intervention can be made for enhancing the innovation capability of firms and strengthening the distributive power of the innovation system at the regional level. These three aspects of policy recommendation provide illuminating answers to question P1: "What policy implication can be drawn from the previous answers from the theoretical and empirical perspectives to enhance further the innovation capability of firms and regions in China?"

6.3.1 Enhancing and Balancing the Firm Absorptive Capacity

Absorptive Capacity is the prerequisite for undertaking interactive learning. Moreover, an equivalent stock of knowledge and capabilities between firms ensures the sustainable innovative synergies based on reciprocal exchange. Otherwise, firms tend to restrict the knowledge flow within the firm boundary in order to avoid opportunist behavior from other firms.

In order to shape the reciprocal regional innovative synergies, policy actions can intervene in the following three respects. Firstly, the government - especially municipal governments - should devote resources to city image management and create high-quality living environments, attracting highly qualified technical and managerial talents. According to the results in Chapter 4, the focus in talent introduction can be put on the educated managerial talents as well as entrepreneurs with an overseas background to strengthen the strategic coupling with global partners in promoting upgrading and innovation. Measures such as setting up business incubators for returned personnel can be strategically implemented. Moreover, related labor agencies should cooperate closely with the firms to identify the firms' demand for skill and should organize corresponding recruitment activities. Secondly, government at the various levels should focus on the attraction of high-tech operations and encourage firms to upgrade to high-tech fields. As demonstrated by the results in Chapter 4, production experience and current practices in high-tech fields of the electronics industry are able to boost the absorptive capacity and eventually promote interactive learning among the firms. Last but not least, government should provide

incentive for firms to keep sequential records of technological programs and exchanges, initiating the accumulation of technological capability at the firm level. This aim can be achieved through measures of tax reduction and subsidies.

6.3.2 Identifying and Supporting the Capacity of Interactive Learning

The results derived from the empirical investigation in Chapter 3 and Chapter 4 affirm the positive role of interactive learning in fostering innovation for electronics firms in the Pearl River Delta, China. However, the empirical results also reveal that only a limited number of firms are capable of capitalizing on interactive learning in product innovation processes. The underdevelopment of interactive learning activities can be attributed not only to the underdevelopment of internal absorptive capacity to understand and adapt the external knowledge, but also to the limited resources for identifying related knowledge and searching for appropriate partners. In Chapter 4, it is shown that firms can use proximity to identify the interacting partners in product innovation processes. However, the dynamic proximity building process should be matched with certain relatedness and complementation of knowledge to share and inspired with both sides.

As interactive learning is a process of approaching externalities without firm boundaries, public policy can play a role in assisting the firms to establish proximity with related partners in the interactive learning activities. Smith (2000) suggests that the identification of the large externalities should be central to policy formation and operation. Policy actions in this respect include:

- Firstly, identify the direct and indirect knowledge inputs for a sector in order to enhance the understanding of both the depth and complexity of knowledge bases that are relevant in the regional innovation system (Smith, 2000).
- Provide sources of generic scientific technological information and knowledge through the financial support of universities and research institutes. Also, pay attention to the industrial orientation of the research conducted by universities and research institutes.
- Provide incentive and support the effective establishment of proximity between firms oriented towards fruitful interactive learning and systemic innovation processes. Actions of this kind can be made through providing catalogs of related firms with related and complementary activities, making trade literature available, organizing fairs, attracting skilled personnel and

encouraging co-operative programs.

6.3.3 Timely Assessment of Inertia for Innovation-supported Governance Infrastructure

In Chapter 5, the inter-city comparison between Shenzhen and Dongguan, China indicates that governance differences indeed shape the innovation pattern of the respective regional innovation systems. Therefore, there is a need for monitoring and assessing the performance of governance infrastructure, and more importantly, adjusting the governance modality to meet the changes in the market, industrial organization and technology.

According to the analysis of the globalized grassroots production system in Dongguan, it is important to escape from the inertia caused by the competence trap and vested interests if evolution towards an interactive innovation system is to be achieved. In this respect, there is a call for the formation of network governance to unfasten the vested interests among the original developmental agencies, in which external agencies that have different interests from the original development agencies should be involved in generating incentives, developing technological alternatives and nurturing the required systems. Specifically speaking, a strategic plan of industrial development can be carried out with the identification and assessment of emerging changes in technological regimes, technological opportunities and patterns of demand that push the market into new technological areas (Smith, 2000). There is clearly policy failure in the identification process due to the limited competency of public players to follow industrial dynamics. As a result, network governance should actively involve firms and industrial associations. Furthermore, dialogue between the public and private institutions should be encouraged. In summary, assessing the inertia of governance infrastructure is an important part of systems-oriented policies.

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Appendix

Appendix A: Firm Questionnaire

Fact Sheet

1. **Please name your most important product in terms of sales (e.g. notebooks, DVD player).**

   _____

2. **What percentage of sales did your company generate with its most important product category in 2008?**_____%

3. **In what year did your company start its operation in the PRD? _____**

4. **With which product did your company start its operation in the PRD (e.g. notebooks, DVD player)**

   _____

5. **What share of sales did your company generate with markets in the following regions in 2008?**

   Sum of shares = 100%

   ___% Chinese mainland

   ___% HK

   ___% Taiwan

   ___% Rest of the World

6. **Please indicate share of your company's sales in 2008 according to the following categories in domestic (D) and international (I) respectively.**

D	**I**	
__%	**__%**	**Original equipment manufacturing (OEM):** products manufactured by your company according to design specifications provided by buyers or parent company
__%	**__%**	**Original design manufacturing (ODM):** products developed and designed by your company according to performance requirements of buyers or parent company
__%	**__%**	**Original brand manufacturing (OBM):** products developed and designed by your company and sold under own brand

7. **How is your company registered in the PRD?**

☐State-owned ☐Collectively-owned ☐Private

☐Wholly foreign-owned enterprise (incl. HK, MA, TW)

☐Chinese-foreign equity joint venture (incl. HK, MA, TW)

☐ Chinese-foreign cooperative joint venture (incl. HK, MA, TW)

8. **If foreign owned (incl. HK, MA, TW): where does the main foreign investment come from?**

_____

9. **If privately owned: Has your company been founded as a private company or has it been privatized in the past?**

☐ Privately founded ☐ Privatized

10. **Does your company belong to an enterprise group?**

☐Private group ☐ state-owned group

☐ does not belong to an enterprise group

11. **Is your firm located in an industrial park?**

☐ Yes ☐ No

If yes, please name the industrial park: _____

12. **Please give information about the supplier of your core parts and components (high-tech inputs such as CPU).**

a) Where is this supplier located?

_____ (city/province/country)

b) What kind of firm is this supplier?

☐ Foreign customer ☐Domestic customer

☐ Other foreign firms in the same industry

☐ Other domestic firms in the same industry

c) How long has your company been working with this supplier? _____ years

13. Where does your company perform the following activities? (Multiple answers possible)

	Location of activities
Production	
Management	
Finance	
Sales/Marketing	
R & D	
Training activities	

14. Are the heads of the following units of your firm members of the main owner`s family or the Chinese Communist Party (CCP)? Member of …

Owners'Family	CCP	
☐	☐	CEO
☐	☐	Finance department
☐	☐	Production department
☐	☐	Marketing / Sales department
☐	☐	Technical department
☐	☐	Human resource department

15. Is there an official office of the Chinese Communist party (CCP) in your firm?

☐ Yes ☐No

If **yes**, how many persons are working in that office? _____

16. Does your company has work union? ☐ Yes ☐ No

17. What is the educational background of your workers in management and technical activities?

Management staff	Technical staff	
___%	___%	Senior High or below
___%	___%	Vocational degree
___%	___%	Bachelor degree
___%	___%	Master degree
___%	___%	PhD

18. How many sales in RMB has your company realized in 2008?____ millions of Yuan

19. What is your company's average annual growth rate?

Sales

2007: _____% First half 2009: _____%

Net Profit

2007: _____% First half 2009: _____%

A. Market and Strategy

1. **This Unit of your company can be described as:**

☐ Individual enterprise

☐ Headquarter of a multi-firm company

☐ Regional Headquarter

☐ Affiliated of multi-firm company

2. **Which statement is most suitable to describe the strategic orientation of your firm? Your firm.....**

☐ is oriented towards business opportunities in established markets
☐ just responds to incoming orders
☐ focus on upgrading its capabilities and position in the value chain
☐ follows emerging trends
☐ is introducing new brands or products to set new market trends
☐ tries to enter specialized markets with low degree of competition

3. **Which sources of finance did your firm use 2008?** (Share of financial sources in %, 100% in total) **Please, assess the accessibility of these sources** (1- not accessible , 5 – easy accessible)

____% Chinese Bank 1 2 3 4 5
____% HK Bank 1 2 3 4 5
____% Foreign Bank 1 2 3 4 5
____% Stock market 1 2 3 4 5
____% Parent / Affiliated company 1 2 3 4 5
____% Family members & friends 1 2 3 4 5

4. **Does your working capital primarily rely on bank loans?** ☐ Yes ☐ No

5. **Does your investment capital primarily rely on bank loans?** ☐Yes ☐No

6. **Does your firm feel the pressure of upgrading from following factors?** (1 – not important , 5 – very important)

The rising cost of production 1 2 3 4 5
Market competition 1 2 3 4 5
The reducing number of foreign orders 1 2 3 4 5
Government policies 1 2 3 4 5

The Pearl River Delta (PRD) region, including Hong Kong and Macao, will be built into *"a globally competitive"* and *"vigorous area in Asia Pacific"* by 2020, says the National Development and Reform Commission (NDRC).

7. **How does the outline of the NDRC affect your business strategy?** (Multiple answers possible)

☐ New Investments in production
☐ Development of own brands
☐ More Research and Development
☐ No Change of business strategy
☐ I don't know the outline / plan of the NDRC

8. **Does your firm have special activities to improve the business activities?** ☐ Yes ☐ No

If **yes**, please specify the activities. (Multiple answers possible)

☐ Work organization ☐ Training programs

☐ Supply Chain Management ☐ R&D

☐ Brand development ☐ other Marketing activities

9. **In terms of upgrading, which statement is most suitable for your company? Upgrading is...**

☐ to stay in this business and increase the value added significantly.

☐ to diversify products and production.

☐ to switch completely to different products.

B. Organisation and Marketing

10. **How many persons on average have been employed in your firm?**

2007___ first half of 2009 on average___

11. **How many persons on average have been employed in your firm in the following departments?**

2007	first half of 2009 on average	
___	___	Production workers
___	___	Technical staff
___	___	Marketing/ Sales
___	___	Management staff

Outsourcing *is subcontracting a process, such as product design, manufacturing or other business functions to a third-party company.* ***Insourcing*** *is the opposite; it is defined as the delegation of operations within a business to an internal (but 'stand-alone') entity that specializes in that operation.*

12. a) Did your firm has any new business activities since 2007? ☐ Yes → continue ☐ No → Jump to Q.13

12.b) if **yes**, which are new activities?

☐ Marketing/Sales (market research, consumer advertisement)

☐ Finance (Accounting/Bookkeeping)

☐ Production

☐ Research and Development

☐ Human Resources (Training/Recruitment)

12.c) Where does the new activity come from?

_____ (City/Province/Country)

12.d) What is the relationship between you and the firm that gave you this activity?

☐Parent company or affiliated companies
☐ Foreign customers
☐ Foreign firms within the same sector
☐ Domestic customers
☐ Domestic firms within the same sector

13. a) Did your firm give any activities to other companies since 2007? ☐ Yes → continue ☐ No → Jumpt to Q.14

13. b) if **yes**, which are new activities?

☐ Marketing/Sales (market research, consumer advertisement)
☐ Finance (Accounting/Bookkeeping)
☐ Production
☐ Research and Development
☐ Human Resources (Training/Recruitment)

13. c) Where does the new activity come from?

_____ (City/Province/Country)

13. d) What is the relationship between you and the firm that gave you this activity?

☐Parent company or affiliated companies
☐ Foreign customers
☐ Foreign firms within the same sector
☐ Domestic customers
☐ Domestic firms within the same sector

*Relocations activities cover the shift of a business unit or selective departments **within** the firm to a new location.*

14. How important are the following factors for your relocation activities? (1 - not important, 5 - very important)

If no relocation, please jump to the next question.

Lower production costs 1 2 3 4 5
Availability of skilled workers 1 2 3 4 5
Better infrastructure 1 2 3 4 5
Preferential Policy 1 2 3 4 5

15. Does your firm undertake marketing activities?

☐ Yes → continue ☐ No → Jumpt to Q.17

16. a) Since when does your firm performs the following marketing activities?

Branding _____
Market Research _____
Advertising _____

16. b) If your firm perform marketing activities: What are the goals of these? (Multiple answers possible)

☐Increase or maintain market share
☐ Enter new markets
☐ Increase visibility or exposure for products
☐ Response to Government Incentives for branding
☐ Increase the ability to adapt different client demands
☐ Develop stronger relationships with customers

17. If your firm doesn't perform marketing activities: What are the reasons? (Multiple answers possible)

☐ No need for marketing activities
☐ Outsourced
☐ Lack of qualified personal
☐ Parent Company is doing marketing activities
☐ack of funds within the Enterprise
☐ Lack of finance from sources outside the company (venture capital, public sources of funding)

C. Product & Process Development

18. Since when does your firm design products by yourself? _____
(If not any, please leave it blank)
Since when does your firm develop products by yourself? _____
(If not any, please leave it blank)

19. How important are the following activities for your company in the last 3 years? (1- not important, 5 - very important)

Introduce whole set producing lines	1 2 3 4 5
Self installing producing lines	1 2 3 4 5
Process engineering	1 2 3 4 5
Reverse engineering	1 2 3 4 5
Industrial design	1 2 3 4 5
Research and development	1 2 3 4 5

20. a) How old are your machines and equipment on average?

☐ earlier than 1980 ☐ 1980s ☐ 1990s
☐ 2000-2005 ☐ newer than 2005

b) Please roughly indicate the expenditure-to-sales ratio in upgrading machines and equipment in ….

2007 _____% first half 2009 _____%

21. Has your company set up technological center? ☐ Yes ☐No

If **yes**, what kind of level:

☐ state-level TDC ☐ province-level TDC

☐ municipal-level TDC ☐ others

22. Please tick the following patent that your company own. *(multiple choice)*

If not own any patens, please leave blank.

☐ Invention patent ☐Utility model patent

☐ Design patent ☐International patent

23. Please evaluate the change of the following performance in your company in the past 3 years due to technological and innovation inputs. (1-no change, 5- significantly change)

Cost reduction	1 2 3 4 5
Better product quality	1 2 3 4 5
More product function	1 2 3 4 5
More attractive product design	1 2 3 4 5
More flexible Production	1 2 3 4 5
New market expansion	1 2 3 4 5

24. Does your firm introduce any new products in the past 3 years?

☐ Yes → continue ☐ No → Jumpt to Q.17

25. Please roughly indicate the expenditure-to-sales ratio in product development in….

2007 _____% first half 2009 _____%

26. What share of total sales in the past 3 years is realized with new or significantly improved products? … _____%

27. How important are the following ways in new product idea generation for your firms? (1 - not important, 5 - very important)

1) Own idea generation and development	1 2 3 4 5
2) Reverse Engineering	1 2 3 4 5
3) Purchase product licenses	1 2 3 4 5
4) Orders from Parent company	1 2 3 4 5
5) Orders from Foreign customers	1 2 3 4 5
6) Orders from Domestic customers	1 2 3 4 5
7) Market report of sales agent	1 2 3 4 5
8) Market report of universities or research institutions	1 2 3 4 5

28. How important are the following ways in acquiring necessary equipment or software in the process of new product development and production? (1 - not important, 5 - very important)

1) Acquisition from parent company 1 2 3 4 5
2) Acquisition from foreign customers 1 2 3 4 5
3) Acquisition from domestic customers 1 2 3 4 5
4) Others_____ 1 2 3 4 5

29. How important are the following ways in acquiring technical experience and know-how in the process of new product development and production? (1 - not important, 5 - very important)

1) Engineers sent by parent company 1 2 3 4 5
2) Engineers sent by foreign customer 1 2 3 4 5
3) Engineers sent by domestic customer 1 2 3 4 5
4) Engineers sent to foreign lead firms or customers 1 2 3 4 5
5) Engineers sent to domestic lead firms or customers 1 2 3 4 5
6) Engineers sent to universities 1 2 3 4 5

30. How important are the following ways in getting into contact with your partners for new product development ? (1- not important, 5 – very important)

1) Active searching (e.g. exhibitions, internet) 1 2 3 4 5
2) Business contacts (e.g. recommendation from partners) 1 2 3 4 5
3) Personal contacts (recommendation from family members and friends) 1 2 3 4 5

31. a) Does your company obtain technological upgrading related knowledge from universities or research institutions?

☐ no jump to Q.32 ☐ yes, name of UNI/RI:_____

b) Please assess the importance of the following criteria considered for selecting universities as sources. (1 - not important, 5 - very important)

Reputation 1 2 3 4 5
Expertise/ Research quality 1 2 3 4 5
Propensity for industrial co-operation 1 2 3 4 5
Uni is in the same city as your company 1 2 3 4 5
Uni is in Guangdong 1 2 3 4 5
Uni is in other provinces in China 1 2 3 4 5
Personal relationships 1 2 3 4 5

c) Please mark the channels obtain knowledge and technologies from universities or research institutes.

Informal exchange 1 2 3 4 5
Technical services/ testing 1 2 3 4 5

Technical consulting	1 2 3 4 5
Managerial consulting	1 2 3 4 5
Joint research/publication/patenting	1 2 3 4 5
Licensing of univ. technology	1 2 3 4 5
Buying of univ. technology	1 2 3 4 5
Staff mobility/training/internships	1 2 3 4 5

D. Human Resources

Recruitment practices

32. Does your firm choose the following channels to recruit technical (T) and managerial (M) staff? (Multiple answers possible)

	T	M
Vacancy advertisement in newspaper		
Company website, job-listing websites		
Government affiliated agency		
List of cold callers		
Personal networking / Recommendation		
Job fairs		

33. When you employ technical (T) and managerial (M) staff, which candidate will you hire?

(one answer per column)	**T**	**M**
A candidate with at least 3 years' experience working experience	☐	☐
A less experienced, but cheaper candidate	☐	☐

34. On which contractual basis do you hire technical (T) and managerial (M) staff? (Multiple answers possible)

	a) Without contract	**b) Short-term contract**	**c) Long-term contract**
T	**_____ %**	**_____ %**	**_____ %**
M	**_____ %**	**_____ %**	**_____ %**

Short term indicates less than one year

35. For which staff does your company use a recruitment agency? (multiple answers possible)

☐temporary ☐ fixed term ☐permanent

36. If you hire staff temporarily and/or fixed term, why? (multiple answers possible)

☐ To adjust the size of the workforce. ☐ To avoid Labour Law regulation.

☐ The company does not hire anybody permanently.

☐ Temporary and/or fixed term staff costs less.

Professional development and skills training

37. To whom does your company offer job skills training and/or professional development? (Multiple answers possible)

☐No staff → Jump to Q43

☐ Management staff ☐Technical staff ☐Other staff

38. When does the staff receive training and/or professional development? (Only one answer)

	T	M
One time (e. g. when entering the company)	☐	☐
More often, but on an irregular basis.	☐	☐
On a regular basis	___days/year	___days/year

39. How much did your company spend on training and/or professional development in…?

2007:___Yuan first half 2009:___Yuan

40. How important are the following ways to organize training? (1 - not important, 5 - very important)

In-house training	1 2 3 4 5
Training through related agents or agencies	1 2 3 4 5
Training through parent company or affiliated company	1 2 3 4 5
Training through foreign customers	1 2 3 4 5
Training through domestic customers	1 2 3 4 5
Training through suppliers	1 2 3 4 5
Training through universities and research institutions	1 2 3 4 5

41. Does your firm use the following ways to organize the trainning (multiple answers possible)

☐ Coaching or mentoring

☐ Instructor-led workshops or courses

☐ Online tutorials and guided programs

☐ On-the-job training

☐ Printed materials (manuals, booklets)

42. How important are the following aims in training the technical staff? (1-not important, 5-very important)

Learn to use the equipment	1 2 3 4 5
Learn to maintain the equipment	1 2 3 4 5
Learn to repair the equipment	1 2 3 4 5
Learn to improve the equipment	1 2 3 4 5
Learn to develop new products/equipments	1 2 3 4 5

Staff retention

43. How often do the following problems occur with your highly qualified staff? (1 - never, 5 – very often)

High wage claims	1 2 3 4 5
Staff leaving after training	1 2 3 4 5
High absenteeism rate	1 2 3 4 5
Lack of practical skills	1 2 3 4 5
Insufficient quantitiy	1 2 3 4 5

44. How does your company prevent highly qualified staff from leaving? (Multiple answers possible)

☐ paid leave ☐ materials (e.g. cellphone)
☐ housing ☐personal professional development
☐ health or accident insurance ☐ higher salaries
☐ holidays or occasions

E. **Concluding Part:** *Personal Networks*

45. How important are personal network to public officials for fulfilling the following tasks? (1 - not important, 5 - very important)

Access to technology	1 2 3 4 5
Access to bank loans	1 2 3 4 5
Access to government funds	1 2 3 4 5
Access to reliable policy information	1 2 3 4 5
Recruitment of skilled personal	1 2 3 4 5
Access to export license	1 2 3 4 5
Access to domestic market license	1 2 3 4 5

46. How often per week do you or key personal of your firm have formal contact with representatives of the government?

___ times per week with representatives of the Local People`s Congress (PC) or the local People's Political Consultative Conference (PPCC)
___ times per week with representatives of the Provincial / National People`s Congress (PC) or the Provincial / National People's Political Consultative Conference (PPCC)
___ times per week with representatives of communist party

47. Did your firm participate in the following supporting policy programs in the last 3 years?

If **yes**, please specify the yearly value of received funds in Yuan or if your firm received tax incentives.

Supporting Policies	Yuan	Tax incentives
High-tech enterprise identification program		Y/N
Innovation or upgrading funds from the local government		Y/N
Innovation or upgrading funds from the provincial government		Y/N
IPR advantage firms nurturing project		Y/N
Difficult firms certification and subsidies		Y/N

48. What is the educational background of the CEO / Managing director? (Multiple answers possible)

☐ Bachelor degree
☐ Master degree
☐ Doctor degree
☐ Overseas Study experience
☐ Attended courses at Central Party School (CPS)
☐ None of the Above

49. What is the work experience of the CEO / Managing director? (Multiple answers possible)

☐ Worked in a private-owned company
☐ Worked in a state-owned company
☐ Worked as a government official
☐ Overseas work experience
☐ None of the above

Scale Standards:

1) Accessibility

1	2	3	4	5
Not access.	A little access.	Normal access.	Easily access.	Very easily access.

2) Importance

1	2	3	4	5
Not important	A little important	Of normal importance	Important	Very important

3) Significance

1	2	3	4	5
Not significant	A little significant	Of normal significance	Significant	Very significant

4) Frequency

1	2	3	4	5
Never	Seldom	Sometimes	Often	Very often

Appendix B: Test of Clustering Solution

The choice of the clustering number is determined by two fitness criteria in the statistical sense: their BIC (Bayesian information criteria) and the AIC (Akaike information criteria). Most importantly, the interpretability of the model should be taken account of in order to ensure the theoretical soundness.

In Table B.1, it can be concluded that the 3-cluster solution fits best according to BIC criteria, while the 4-cluster solution fits best according to the AIC criteria. In the latent class model, the BIC criteria decide the number of clustering in a more conservative way than the AIC criteria. In this way, the interpretability should be applied to make a choice for the mixed pattern.

Table B.1 Selection Criteria (BIC) by Class

Classes	BIC	AIC
2	13198.8	12868.7
3	13075.1	12578.1
4	13137.5	12473.4

In Table B.2, I show the 4-cluster solution. In this solution, it is possible to identify the intensive interactive learning cluster (cluster 1) and the weak interactive learning cluster (cluster 4). However, cluster 2 and cluster 3 are quite similar in the scope and intensity of interactive learning and therefore do not differ from each other in a significant way. In order to derive a parsimonious and well interpreted result, I finally used the 3-cluster solution as the basis for the empirical analysis.

Table B.2 The 4-cluster Solution

	Probability of high evaluation[1]	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Origins of Innovation ideas	Own idea collection	0.81	0.61	0.47	0.44
	Reverse engineering	0.82	0.56	0.48	0.37
	Licensing	0.60	0.28	0.21	0.08
	Demand from parent company	0.54	0.32	0.20	0.06
	Demand from foreign customers	0.88	0.69	0.46	0.19
	Demand from domestic customers	0.91	0.63	0.50	0.41
	Market reports of sales agents	0.70	0.40	0.39	0.13
	Market reports of universities or research institutes	0.50	0.13	0.18	0.02
Support of Equipment and Software	Support from parent company	0.38	0.18	0.08	0.02
	Support from foreign customers	0.90	0.58	0.25	0.03
	Support from domestic customers	0.94	0.42	0.42	0.41
	Own purchase	0.29	0.14	0.06	0.22
Support of Related Technical know-how and experience	Engineers sent by parent company	0.34	0.17	0.03	0.03
	Engineers sent by foreign customers	0.87	0.42	0.23	0.00
	Engineers sent by domestic customers	0.85	0.41	0.39	0.16
	Engineers sent to foreign lead firms or customers	0.85	0.44	0.33	0.05
	Engineers sent to domestic lead firms or customers	0.81	0.49	0.53	0.29
	Engineers sent to universities	0.55	0.18	0.32	0.05
Interacting mode in the innovation process	Active searching	0.95	0.90	0.71	0.63
	Business contacts	0.98	0.81	0.66	0.55
	Personal contacts	0.71	0.27	0.35	0.25
Share of each cluster		17%	28%	25%	30%

Appendix C: Classification of Product Technology

Note: This table is made jointly with the project member Daniel Schiller based on International Standard Industrial Classification of all Economic Activities, Rev 3. Products not included in the table are classified as low tech.

Category	Description
high	Internal combustion piston engines for aircraft, and parts thereof
high	Reaction engines
high	Turbopropellers
high	Parts for turbojets or turbopropellers
high	Power-generating machinery
high	Automatic data-processing machines; magnetic or optical readers, machines for transcribing data and machines for processing such data
high	Electrical apparatus for line telephony or line telegraphy
high	Transmission apparatus for radio-telephony, radio-telegraphy, radio-broadcasting or television
high	Telecommunications equipment, n.e.s.
high	Parts and accessories suitable for use solely or principally with the apparatus of division 76
high	Electrodiagnostic apparatus for medical, surgical, dental or veterinary purposes, and radiological apparatus
high	Diodes, transistors and similar semiconductor devices; photosensitive semiconductor devices (including photovoltaic cells); light-emitting diodes
high	Electronic integrated circuits and microassemblies
high	Piezoelectric crystals, mounted; parts, n.e.s., of the electronic components of group 776
high	Optical instruments and apparatus, n.e.s.
high	Compasses; other navigational instruments and appliances; surveying, hydrographic, oceanographic, hydrological, meteorological or geophysical instruments and appliances; rangefinders
high	Instruments and apparatus for physical or chemical analysis (e.g., polarimeters, spectrometers)
high	Oscilloscopes, spectrum analyzers and other instruments for measuring or checking electrical quantities instruments and apparatus for measuring or detecting alpha, beta, gamma, X-ray, cosmic or other ion radiations
high	Arms and ammunition

high	Hearing-aids (excluding parts and accessories)
high	Pacemakers for stimulating heart muscles (excluding parts and accessories)
medium-high	Steam turbines and other vapour turbines, and parts thereof, n.e.s.
medium-high	Internal combustion piston engines for propelling vehicles
medium-high	Internal combustion piston engines, marine propulsion
medium-high	Parts, n.e.s, for the internal combustion piston engines of subgroups 713.2, 713.3 and 713.8
medium-high	Other gas turbines
medium-high	Parts for the gas turbines of heading 714.89
medium-high	Rotating electric plant, and parts thereof, n.e.s.
medium-high	Gas generators, distilling or rectifying plant, heat-exchange units and machinery for liquefying air or other gases
medium-high	Agricultural machinery (excluding tractors), and parts thereof
medium-high	Wheeled tractors
medium-high	Coal or rock cutters and tunnelling machinery
medium-high	Other boring or sinking machinery
medium-high	Coal or rock cutters and tunnelling machinery, not self-propelled
medium-high	Other boring or sinking machinery, not self-propelled
medium-high	Scrapers, not self-propelled
medium-high	Parts for boring or sinking machinery of heading 723.37 or 723.44
medium-high	Textile and leather machinery, and parts thereof, n.e.s.
medium-high	Paper and pulp mill machinery, paper-cutting machines and other machinery for the manufacture of paper articles; parts thereof
medium-high	Printing and bookbinding machinery, and parts thereof
medium-high	Food-processing machines (excluding domestic); parts thereof
medium-high	Other machinery and equipment specialized for particular industries; parts thereof, n.e.s.
medium-high	Machine tools working by removing metal or other material
medium-high	Machine tools for working metal, sintered metal carbides or cermets, without removing material
medium-high	Medical, surgical or laboratory sterilizers
medium-high	Driers for agricultural products
medium-high	Driers for wood, paper pulp, paper or paperboard
medium-high	Driers, n.e.s.
medium-high	Vacuum pumps
medium-high	Compressors of a kind used in refrigerating equipment
medium-high	Air compressors mounted on a wheeled chassis for towing
medium-high	Centrifuges (including centrifugal driers), n.e.s.
medium-high	Filtering or purifying machinery and apparatus, for liquids or gases
medium-high	Parts for the pumps, compressors, fans and hoods
medium-high	Parts of the machines and apparatus
medium-high	Ball- or roller bearings
medium-high	Taps, cocks, valves and similar appliances for pipes, boiler shells, tanks, vats or the like

medium-high	Gears and gearing; ball screws; gearboxes and other speed changers
medium-high	Clutches and shaft couplings (including universal joints)
medium-high	Calculating machines; accounting machines, ticket-issuing machines, incorporating a calculating device; cash registers
medium-high	Photocopying apparatus incorporating an optical system or of the contact type, and thermocopying apparatus
medium-high	Other office machines (e.g., addressing machines, automatic banknote dispensers)
medium-high	Television receivers
medium-high	Turntables (record-decks) and record-players
medium-high	Sound-recording and other sound-reproducing apparatus; video-recording or reproducing apparatus
medium-high	Microphones and stands therefor; loudspeakers; headphones, earphones and combined microphone/ speaker sets; audio-frequency electric amplifiers; electric sound amplifier sets
medium-high	Boards, panels (including numerical control panels), consoles for electrical control or the distribution of electricity
medium-high	Optical fibre cables
medium-high	Electrical insulators of ceramics
medium-high	Television picture tubes, cathode-ray (including video monitor cathode-ray tubes)
medium-high	Other electronic valves and tubes (including television camera tubes)
medium-high	Batteries and electric accumulators, and parts thereof
medium-high	Electric filament or discharge lamps; arc lamps; parts thereof
medium-high	Electromechanical tools for working in the hand, with self-contained electric motor; parts thereof
medium-high	Electrical capacitors, fixed, variable or adjustable (pre-set)
medium-high	Electromagnets; permanent magnets
medium-high	Electrical signalling, safety or traffic control equipment
medium-high	Electric sound or visual signalling apparatus (e.g., bells, sirens, burglar and fire-alarms)
medium-high	Carbon electrodes, carbon brushes, lamp carbons, battery carbons and other carbon articles used for electrical purposes
medium-high	Motor cars and other motor vehicles principally designed for the transport of persons
medium-high	Motor vehicles for the transport of goods and special-purpose motor vehicles
medium-high	Road motor vehicles, n.e.s.
medium-high	Parts and accessories of motor vehicles
medium-high	Motor cycles (including mopeds) and cycles, motorized and non-motorized; invalid carriages
medium-high	Trailers and semi-trailers; other vehicles, not mechanically-propelled; specially designed and equipped transport containers
medium-high	Railway vehicles (including hovertrains) and associated equipment
medium-high	Lamps and lighting fittings (including searchlights and spotlights), n.e.s.
medium-high	Illuminated signs, illuminated name-plates and the like

medium-high	Parts of the portable electric lamps (excluding storage batteries)
medium-high	Instruments and appliances, n.e.s., for medical, surgical, dental or veterinary purposes
medium-high	Meters and counters, n.e.s.
medium-high	Instruments and apparatus for measuring or checking the flow, level, pressure or other variables of liquids or gases
medium-high	Measuring, controlling and scientific instruments, n.e.s.
medium-high	Automatic regulating or controlling instruments and apparatus
medium-high	Parts and accessories for machines, appliances, instruments and apparatus, n.e.s.
medium-high	Photographic (other than cinematographic) cameras
medium-high	Photographic flashlight apparatus
medium-high	Cinematographic cameras and projectors; parts and accessories thereof
medium-high	Microfilm, microfiche or other microform readers
medium-high	Image projectors, n.e.s.
medium-high	Photographic (other than cinematographic) enlargers and reducers
medium-high	Spectacle lenses of other materials

Appendix D: Development of Shenzhen electronics industry supported by transitional institutions during 1980s and 1990s

1979 In March, *Guangdong oversees Chinese farm management Bureau* signed with Hongkong Ganghua Electronics Corporation in Beijing to establish Guangming oversees Chineses electricity firm that undertakes product processing.

In July, *Guangdong Electronics Industry Bureau* decided to establish out-oriented processing base in Shenzhen Special Zone and three state-operated factories in North Guangdong were relocated to Shenzhen.

In September, *Guangdong Planning Committee* approved the establishment of Guangdong Electronics Assembly Plant in Shenzhen (now as the Huaqiang Electronics Industry Company) which subordinated to the leadership of *Guangdong Electronics Industry Bureau*.

Later, *Communication Army Division in the General Staff Headquarter* invested and established Hongling Electric Appliance Processing Plant (now as Shenzhen Electric Appliance Corporation) in Shenzhen.

In December, ***Fourth Ministry of Machine Building*** transferred a group of technical backbone staff in Guangzhou 750 Factory to Shenzhen in order to establish Shenzhen Electronics Assembly Plant (now as Shenzhen Aihua Electronics Corporation). Meanwhile, *Third Ministry of Machine Building* established Shenzhen Office of China Aeronautical Technology Important Company (now as Avic Shenzhen Company).

Later, China Foreign Investment Management Committee approved that *Oversees Chinese Town Economic Development Parent Company* joint venture with Hongkong Ganggua Electronic Corporation, establishing the first industrial joint venture in Shenzhen "Guangdong Guangming oversees Chineses Electronics Industry Company" (now as Shenzhen Konka Group Company Ltd.) that produces recorders and televisions.

1980 In April, Shenzhen Revolutionary Committee approved the establishment of joint venture Xinhua Electronics Plant which *Shenzhen Industry Bureau* provided land and Hongkong Xinyou Trade Corporation provided capital and equipment.

In May, *China Electronics Technology Important & Export Company (Shenzhen Division)* was established.

1981 In January, *Guangzhou Electronics Industry Bureau* decided to establish Guangdong South-China Radio Factory in Shenzhen based on 8571 Factory.

In March, *Guangdong Electronics Industry Bureau* signed the joint venture contract with China Electronic Device Parent Company in Beijing to establish Shenzhen Huaqiang Electronic Device Company (now as Shenzhen Yuehua Electronic Device

Company).

In September, *Shenzhen Industry Bureau* established Shenzhen Kangle Electronics Corporation jointly with Haerbing Fourth Radio Factory.

In October, *Shenzhen Industry Bureau*, China Zhenhua Electronics Company (earlier as the 837 Factory) and Hongkong Luks Group Co. LTD. jointly established Shenzhen Huafa Electronics Corporation and introduced the 14"－22" production line of color TV with annual output of 100 thousand.

Later, *Fourth Ministry of Machine Building* (now as Zhenhua Electronics Group) invested in Shenzhen and established Shenzhen Huayun Electronics Co., Shenzhen Shenyun Electronics Co. and Shenzhen Huafa Electronics Co.

1982 In January, Shenzhen Electronics Industry Company (earlier under the same system with Shezhen Industry Bureau) was established, which was in charge of municipal electronics companies and new self-invested electronics companies.

In July, wholly Hongkong invested company "Hongkong Luks Industry Corporation was approved by Shenzhen City Government. Later on, it introduced 14"－18" production line of color TV with annual output of 100 thousand.

In December, Guangdong Guangming oversees Chineses Electronics Industry Company (now as Shenzhen Konka Group Company Ltd.) introduced 4"－20" production line of color TV with annual output of 300 thousand.

1983 In April, wholly Japan invested Sanyo Electric Machinery Corporation was registered.

In June, *state-owned and operated 8571 factory* jointly established Shenzhen Yuebao Electronics Joint Company with Baoan Industrial and Transportation Bureau under the approval of Guangdong Province Economic Development Committee.

In Octorber, 70% of the color TV produced by Shenzhen Huafa Electronics Corporation after introducing the production line was exported and the output was expanded to annually 450 thousand.

In November, China Aeronautical Technology Important Company (now as Avic Shenzhen Company) and Beijing Computer Parent Company jointly invested and established China's first LCD and LCD model design and manufacturing specialized company "Shenzhen Tianma Micro-electronics Corporation". In 1984, the first TN-LCD production line went into operation in Tianma Corporation.

In December, *Shenzhen Electronics Industry Development Coordination Committee* was established jointly by related management departments of state ministry-related companies, Guangdong Electronics Industry Bureau and Shenzhen City Government.

1984 In January, Shenzhen Office of Ministry of Electronics was approved and established in order to manage the ministry-related companies and public institutions

in Shenzhen.

Later, Guangdong Guangming oversees Chineses Electronics Industry Company (now as Shenzhen Konka Group Company Ltd.) introduced new color TV production line and began the production of 14”color TV.

In January, *Guangdong Electronics Industry Bureau* transferred a group of technical staff that produces audio-head in Guangdong South-China Electronics Company to Shenzhen and jointly invested with Baoan Industrial Development Company to establish Yuebao Electronics Joint Company.

In April, Shenzhen Huaqiang Electronics Industry Company and Japan Sanyo Electric Device Co. Ltd. established the joint venture Huaqiang-Sanyo Electronics Co. Ltd with the contract period of 15 years.

In May, Shenzhen Electronics Industry Parent Company (now as Saige Group) and China Electronic Device Parent Company established the joint venture “Color Kinescope Company”. In July, Shenzhen development project of color kinescope was established to take charge of the plan, application and negotiation of joint ventures.

In July, Shenzhen Division of Avic Technology, Industrial and Trade Company and Southern Aerodyne Mechinery Company established Shenzhen Shennan Electric Circuit Corporation. In 1985, double and multi-layer printed circuit production line was introduced from USA and was then able to produce printed circuits no more than 6 layers.

In August, China Shenzhen Color TV Parent Company was jointly invested and established by Ministry of Electronics Industry, China Electronic Device Parent Company and Shenzhen City.

In October, Shenzhen Futian Industrial Development Company and Sixth Experimental Factory of Post and Telecommunications Institutes of Changchun jointly invested 900 thousand Yuan to establish Shenzhen Changhong communication equipment company limited, which undertakes the research and production of small-volume exchange equipment.

In December, Shenzhen City Government approved the establishment of Shenzhen Xianke Laser Television (SAST) Co. Ltd., which includes Laser Sender Company, Laser CD Company and Laser Technology Research Institute. The total investment was 300 million Yuan.

In December, China Academy of Sciences established China Kejian Co. Ltd. in Shenzhen.

1985 In January, Esopn invested 10 million Hongkong dollar and established wholly owned Yexin Technology (Shenzhen) Co. Ltd. It introduced the ESOPN printer production line with annual output of 300 thousand and the export rate is 100%. In

1987, this production line went into operation.

In February, Shenzhen Zhongxing Semiconductor Co. Ltd was established, which investment reached 2.8 million Yuan and came jointly from aerospace system 691 Factory, Great Wall Industrial Company (Shenzhen) and Hongkong Yunxing Electronic Trade Company.

In April, Shenzhen Xianke Laser Television (SAST) Co. Ltd. signed a technology cooperation contract on Laser singing and sight system with Holland Phillip Company.

In July, Technology Development (Shekou) Co. Ltd. invested 2 million dollar introduced American hard disc magnet head production line with annual output of 1 million.

In September, Shenzhen Electronics Group Company (later as Saige Group) was established under the approval of Shenzhen City Government, which unifies 117 companies among 178 companies on voluntary basis. It was then one of the four experimental sites of enterprise group of electronics industry in China.

1986 In March, Shenzhen Electronics Industry Association was established based on *Shenzhen Electronics Industry Development Coordination Committee.*

Wholly American Owned Company Flextronics was established in Shenzhen and a mainframe production line with annual output of 1 million was introduced.

1987 In May, China Computer Development Company relocated the production base to the South and established China Great Wall Computer Development Company (Shenzhen) and starts the production of Great Wall series of PC.

In July, Shenzhen Computer Industrial Association was established.

In July, Japanese owned company "Topresearch Circuit Board Co. Ltd." was established in Shenzhen and mainly produced double and multi-layer circuit boards.

In September, Modern Electronics Industry Co. Ltd. (also called MAC, co-established by China Electronic Device Company and Hongkong Kangmao Development Co. Ltd.) was established with the investment of 128 million dollar and purchased 3 production line of big-screen color kinescope and technology from American General Electric. The annual production was 1.5 million.

In September, Shenzhen Huawei Technology Co. Ltd was established and was one of the earliest private-owned technological enterprises at that time.

In October, Shenzhen Electronics Products Quality Control Center was opened.

In November, Shenzhen Sanda Electronic Industry Company was established based on Shenzhen Office of Ministry of Electronics.

Hongkong invested company "Nantai Electronics (Shenzhen) Co. Ltd." was established in Shenzhen with the operation of processing with supply material.

1988 In March, The first specialized electronic parts supply market in China "Saige

Electronics Supply Market" was opened which is build by Shenzhen Saige Group.

Later on, Shenzhen Zhongxing Semiconductor Co. Ltd cooperated with Beijing College of Post and Telecommunication to jointly research the company's first generation digital customer exchange machine ZX500.

In June, China Tongguan Telecommunication Co. Ltd. jointly invested 13.5 million Dollar with Canada Northern Telecommunication Co. Ltd. and established joint venture Tongguang-Northern Co. Ltd. Meanwhile, Meridian ISDN digital customer exchange machine production line was introduced with an annual output of 100 thousand.

In July, Shenzhen Telecommunication Industry Co. Ltd. established cooperative enterprise "Shenzhen Guangtong Development Co. Ltd." Meanwhile, 8.5 million dollar was invested and a leading optical fiber production line was introduced with an annual output of 25000 chip km.

In August, Shenzhen Software Industrial Association was established.

1989 In January, Shenzhen Saige Group and Janpa Hitachi established joint venture "Shenzhen Saige-Hitachi color Monitor Co. Ltd.", and produced the leading 21'' color kinescope with an annual output of 1.6 million.

In August, China Electronics & Information Industry Group, Shenzhen Saige Group and Hongkong Kangmao Development Co. Ltd established the joint venture "Shenzhen Zhongkang Glass Co. Ltd." and introduced the technology and equipment from America and Japan with an annual output of 4.3 million sets.

In September, Shenzhen Lenovo Computer Co. Ltd was established with an annual output of 1 million computer mainframe.

1992 In March, Shenzhen Konka Electronics Stock Limited Corporation and Shenzhen Huafa Electronics Stock Limited Corporation went into stock market.

Shenzhen Foxconn Precision Parts Plant was established.

Skyworth Group was established with the headquarter in Hongkong and produced color TV, VCD, DVD and satellite receiver.

In December, Shenkou Development and Technology Co. Ltd and American Conner Company established the joint venture "Shenzhen Kangnuo External Equipment Co. Ltd." which was the first in China that produces Hard Disk Driver with an annual output of 2 million HDD. All the products were then exported.

In December, Shenzhen Zhongxing-Weixiantong Equipment Co. Ltd. was established under the support of shareholder units of aerospace system. A proportion of technical backbone staff and managerial backbone staff in Shenzhen Zhongxing Semiconductor Co. Ltd. were transferred.

1993 In March, Shenzhen Zhongxing New Telecommunication Equipment Co. Ltd. was established which was jointly invested by 691 factory under aerospace system,

	Shenzhen Guangyu (Group) Company and Zhongxing-Weixingtong Equipment Co. Ltd. The company first applied in China the operation system of “state-own and private-operated”.
	Shenzhen Jindie Software Technology Co. Ltd. was established.
1997	Shenzhen City Government conducted assets reorganization between Shenzhen Liming Electronics Industry Co. Ltd., Shenzhen Guangtong Development Co. Ltd. and Xingsuo Optical Cable Telecommunication Industry Company (the last two subordinated under Shenzhen Telecommunication Industry Co. Ltd.) and put them under centralized management of Shenzhen Special Zone Development Group Co. Ltd. Meanwhile, Shenzhen City Government established Shenzhen Tefa-Liming Photoelectric Co. Ltd. and Shenzhen Tefa Information Stock Limited Company, where the latter one was divided into Shenzhen Tefa Optical Fiber Co. Ltd. and Shenzhen Tefa-Xingsuo Optical Cable Telecommunication Industry Company.
2003	In January, Shenzhen Electronic Chamber of Commerce was established.
	Shenzhen City Government decided that auto electronics is the main orientation for development in the process of industry structural adjustment.
	In July, Shenzhen Electronic Chamber of Commerce signed the “Memo of Cooperation” with Hongkong Electronic Chamber of Commerce.

Source: Shenzhen ElectronicsYearbook

Appendix E: Decision on modeling method and Post-estimation

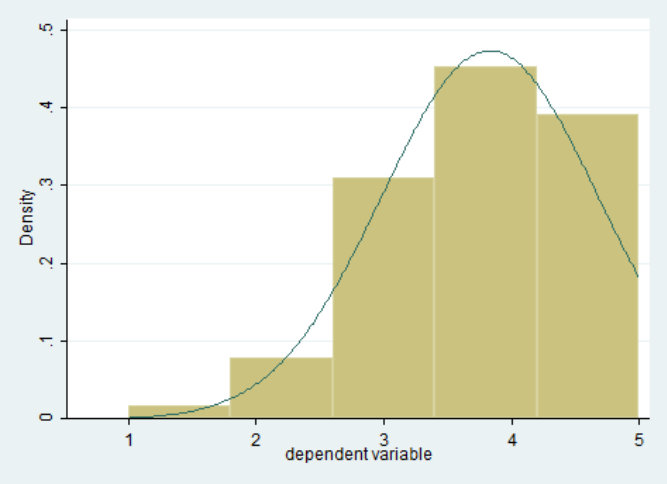

Figure E.1 Histogram distribution of product innovation outcome (Whole Model)

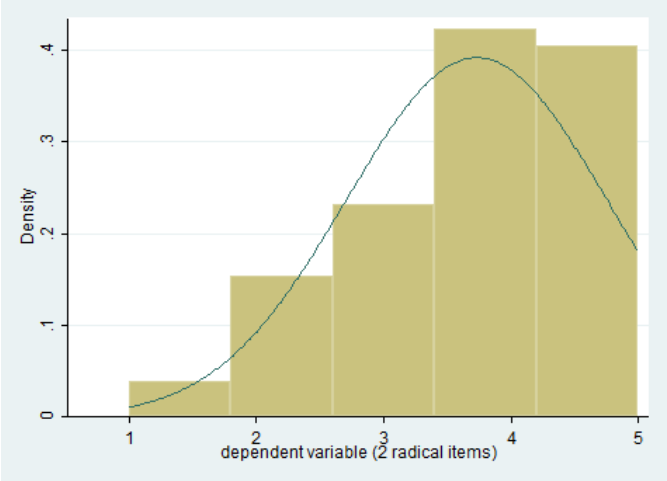

Figure E.2 Histogram distribution of product innovation outcome (Shenzhen Model)

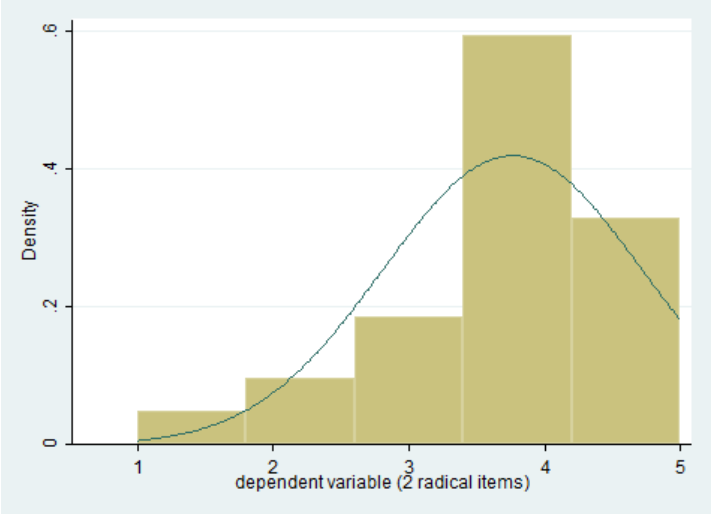

Figure E.3 Histogram distribution of product innovation outcome (Dongguan Model)

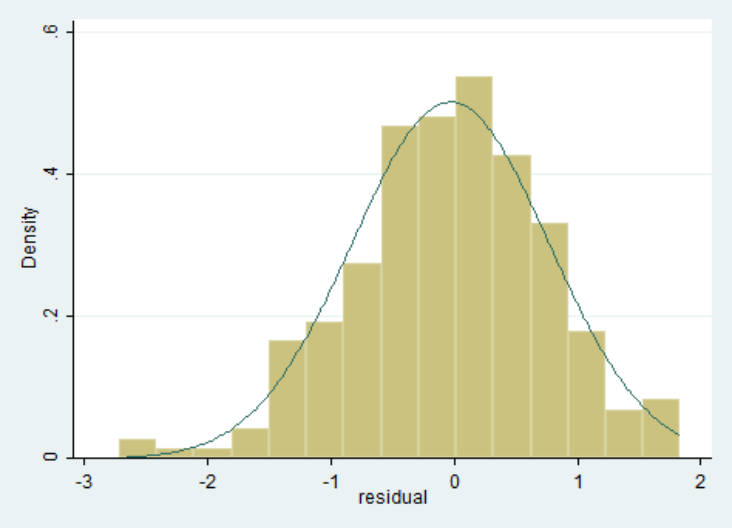

Figure E.4 Histogram distribution of model residuals (Whole Model)

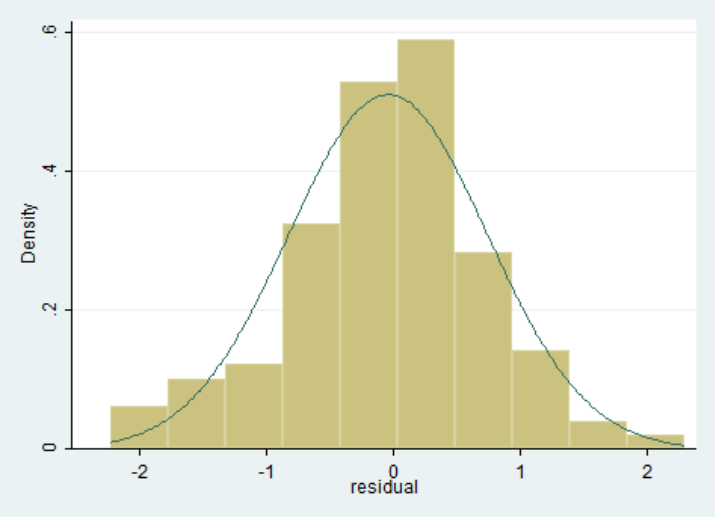

Figure E.5 Histogram distribution of model residuals (Shenzhen Model)

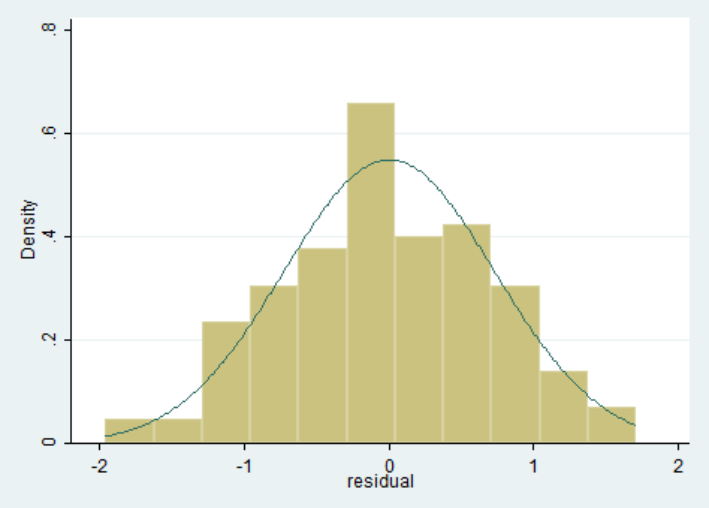

Figure E.6 Histogram distribution of model residuals (Dongguan Model)

Erklärung zur Dissertation

Hierdurch erkläre ich, dass die Dissertation

"Towards a dynamic Regional Innovation System: Investigation into the Electronics Industry in the Pearl River Delta, China"

selbstständig verfasst und alle benutzten Hilfsmittel sowie evtl. zur Hilfeleistung herangezogene Institutionen vollständig angegeben wurden.

Die Dissertation wurde nicht schon als Diplom- order ähnliche Prüfungsarbeit verwendet.

Hannover, den 24.08.2011

Wenying Fu

Curriculum Vitae

Wenying Fu

Address:	Wenying Fu Dorotheen str. 5A 30419 Hannover, Germany email: fuwenying84@gmail.com
Dat of Birth:	31.07.1984
Place of Birth:	Hainan, People's Republic of China

EDUCATION

Ph. D Candidate	Economic Geography (11/2008-present), Institute of Economic and Cultural Geography, Leibniz University Hanover, Germany (With Chinese Government Scholarships for Postgraduates)
M.S.	Human Geography (09/2006-06/2008), School of Geography and Planning, Sun Yat-sen University, Guangzhou, China
B.S. (Major)	Economic Geography (09/2002-06/2006), School of Geography and Planning, Sun Yat-sen University, Guangzhou, China
B.S. (Minor)	English (09/2004-06/2006), School of Foreign Languages, Sun Yat-sen University, Guangzhou, China

ACADEMIC TRAINING AND PRESENTATION

1 2010 SPP Theory Workshop (supported by German Research Foundation). Presentation "Regional Agility and Upgrading in the Pearl River Delta (PRD) and in Hong Kong". TU Berlin, Berlin, Germany. 01.02-02. 02.2010.

2 2010 Summer School for PhDs and Post-docs: Nonparametric Efficiency and Productivity Analysis, Wageningen, Holland. 05.07-09.07.2010.

3 2011 DRUID-DIME Academy Winter Conference. Presentation "An Emerging Innovative Milieu in the Pearl River Delta, China? The Role of Social and Organizational Proximity for Product Innovation". Aalborg, Denmark. 20.01-22.01.2011

4 2011 PhD workshop "Getting my Research into Journals" given by Prof. Peter Maskell and Prof. Keld Laursen. School in Economics and Business Administration, Copenhagen Business School, Copenhagen, Denmark. 18.01-19.01.2011.