

# **Towards a Dynamic Regional Innovation System**

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

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# Table of Contents

<b>1</b>	<b>Introduction.....</b>	<b>1</b>
1.1	Research Context.....	1
1.2	Defining Innovation and Regional Innovation System in China Context....	4
1.3	Aim and Research Questions .....	7
1.4	Outline .....	10
1.5	Survey Data and Evaluation .....	12
<b>2</b>	<b>Knowledge Spillovers and Technological Upgrading: The Case of the Guangdong Province, China .....</b>	<b>19</b>
2.1	Introduction.....	19
2.2	Technological Upgrading: Impact of knowledge spillover on the Local and Global Scales .....	22
2.3	Technological Upgrading in Guangdong Province, China: .....	29
2.4	Econometrical Model and Data .....	33
2.5	Report of Empirical Test.....	40
2.6	Discussion and Conclusion .....	43
<b>3</b>	<b>Interactive Learning and Systemic Innovation in the Pearl River Delta, China: Firm-level Evidence from the Electronics Industry.....</b>	<b>46</b>
3.1	Introduction.....	46
3.2	Innovation as an Interactive Process .....	48
3.3	Survey Data and Indicators .....	55
3.4	Empirical Results .....	57
3.5	Discussion and Conclusion .....	67
<b>4</b>	<b>Absorptive Capacity, Proximity and Innovation: Insights from an Electronics Firm Survey in the Pearl River Delta, China .....</b>	<b>70</b>
4.1	Introduction.....	70
4.2	Use of Proximity in Interactive Learning .....	73
4.3	Absorptive Capacity in the Firm Level as Precondition of Interactive learning .....	89
4.4	Operationalization of Analysis.....	97
4.5	Empirical Evidence.....	99
4.6	Discussion and Conclusion .....	126

<b>5 From Globalized Production Systems to Regional Innovation Systems: Governance and Innovation in Shenzhen and Dongguan, China.....</b>	<b>129</b>
5.1 Introduction.....	129
5.2 Evolutionary Regional Innovation System and Governance Infrastructure .	131
5.3 Survey Design of a Comparative Study.....	139
5.4 Governance in Shenzhen and Dongguan, China: An Evolutionary Overview .....	141
5.5 Descriptive Profile of Innovation Activities in Shenzhen and Dongguan ....	148
5.6 Empirical Results of Interactive Innovation .....	152
5.7 Discussion and Conclusion.....	157
<b>6 Conclusions.....</b>	<b>160</b>
6.1 Answers to the Research Questions .....	160
6.2 Limitations and Directions of Future Research .....	165
6.3 Policy Implications .....	168
<b>References.....</b>	<b>172</b>
<b>Appendix.....</b>	<b>184</b>
Appendix A: Firm Questionnaire.....	184
Appendix B: Test of Clustering Solution.....	197
Appendix C: Classification of Product Technology .....	199
Appendix D: Development of Shenzhen electronics industry supported by transitional institutions during 1980s and 1990s .....	203
Appendix E: Decision on modeling method and Post-estimation .....	209
<b>Curriculum Vitae .....</b>	<b>212</b>

## 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 Perflussdelta 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 Perflussdeltas 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

# 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<sup>1</sup>. 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<sup>1</sup>. 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

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<sup>1</sup> 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 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?

### **1.3 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 undertake 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	
<b>EMPIRICAL INVESTIGATION</b>	
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	