

## THE ROLE OF FOREIGN AND DOMESTIC FIRMS IN REGIONAL INNOVATION SYSTEMS OF LATECOMER COUNTRIES: EMPIRICAL EVIDENCE FROM THE ELECTRONICS INDUSTRY IN THE PEARL RIVER DELTA

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With 1 figure and 9 tables

Received 31. March 2010 · Accepted 08. December 2010

**Summary:** The literature on technological change and regional development in latecomer countries has argued that foreign and domestic firms differ markedly with regard to their innovation and upgrading efforts. Foreign firms tend to possess greater initial technological capabilities and better access to advanced technologies, but often retain advanced production and innovation activities at their home bases. Some domestic firms, on the other hand, enter the market with fewer resources and lower technological capabilities, but make great efforts to learn. It thus remains a matter of debate as to whether foreign or domestic firms are contributing to the formation and upgrading of regional innovation systems in late-comer countries. This paper provides empirical evidence for the innovation activities of foreign and domestic Chinese firms by testing theoretically-based hypotheses with company survey data from 222 electronics firms in the Pearl River Delta in South China. The major findings are that non-domestic firms carry out innovation activities with greater intensity and more external collaboration than domestic firms. The potential for the emergence of a more coherent regional innovation system and a technological catch-up to the standard of the non-domestic incumbents on the part of domestic electronics firms is rather limited.

**Zusammenfassung:** Die Literatur zu technologischem Wandel und Regionalentwicklung in Schwellenländern argumentiert, dass sich ausländische und einheimische Unternehmen hinsichtlich ihrer Innovationspotenziale und Aufwertungsstrategien unterscheiden. Ausländische Unternehmen besitzen zunächst größere technologische Fähigkeiten und besseren Zugang zu fortgeschrittenen Technologien, lokalisieren allerdings viele dieser Aktivitäten nicht in den Schwellenländern selbst. Einheimischen Unternehmen kann es trotz ihres geringeren Bestands an Kompetenzen gelingen, durch intensive Lern- und Kooperationsaktivitäten technologisch und organisatorisch schnell aufzuholen. Es wird nach wie vor debattiert, ob ausländische oder einheimische Unternehmen einen größeren Beitrag beim Aufbau lokaler Innovationssysteme leisten. In diesem Papier werden dazu theoriebasierte Hypothesen zu Innovationsaktivitäten ausländischer und chinesischer Unternehmen auf Basis einer Unternehmensbefragung von 222 Elektronikunternehmen im südchinesischen Perlfussdelta geprüft. Die wesentlichen Ergebnisse sind, dass ausländische Unternehmen mit größerer Intensität Innovationsaktivitäten durchführen und ein umfassenderes Portfolio an externen Kooperationspartnern besitzen. Dies verringert das Potenzial für die Entstehung eines kohärenteren regionalen Innovationssystems und ein technologisches Aufholen der einheimischen Unternehmen.

**Keywords:** Regional innovation systems, technological upgrading, foreign and domestic firms, China

### 1 Introduction

Since the introduction of the Chinese reform policy in 1978, the Pearl River Delta (PRD) in South China has become a global centre of export-oriented manufacturing. The electronics industry is now the dominant sector of the so-called “world factory” in terms of production and exports. Since electronics firms in the region mainly operate at the low-tech end of the value chain, the industry has recently been facing increasing pressure to upgrade and innovate due to rising production costs and new government regulations (HKITDC 2006, 2007). Within China, com-

parative studies have revealed that the Yangtze River Delta (YRD) is better equipped to provide a suitable environment for the upgrading and strategic coupling of global production networks and regional development (YANG 2009). LU and WEI (2007) concluded that the understanding of the PRD as an externally driven regional economy and an assembling base might be incomplete, since the region is now becoming a knowledge economy. Its integrated economic development will thus depend on its inclusion in global networks for innovation and creativity.

The promotion of more advanced innovation systems was initiated rather late in the PRD as well

as in the economically advanced city of Hong Kong. Despite its impressive export performance in high-tech sectors, the regional innovation system of the PRD is less well endowed with R&D capacities and human capital than Beijing and Shanghai (KROLL and TAGSCHERER 2009). Despite the fact that private expenditures for R&D are higher than in other Chinese provinces, the PRD still lacks important players in this regard, such as a large number of top universities or national research centres (KROLL and SCHILLER 2010; ARVANITIS and JASTRABSKY 2006). For a long time, the economic development of Hong Kong was based on the transformation of the industrial economy into the so-called 'front shop, back factory' model, i.e., the relocation of production activities to the PRD while higher value-added functions remained in the city (MEYER et al. 2009; SIT 1998). Innovation was not seen as an important strategy for firms in Hong Kong, since they escaped the limits of low-cost production by tapping into cheap labour and land resources in the adjacent PRD. The focus on innovation thus did not emerge until the late 1990s, with the innovation system still being underdeveloped today (SHARIF 2006). The structural weaknesses of the PRD model, i.e., overdependence on export markets, shortfalls in education and slow progress in technological upgrading, became evident during the economic crisis. Nevertheless, not all firms were affected similarly. Initial evidence provided by HUANG and CHEN (2009) suggests that labour-intensive SMEs without proprietary products or patented core technologies suffered the most, while companies with more advance business models and a strategic focus on upgrading and innovation actually achieved higher growth rates in 2008. The electronics industry in the PRD, which involves some of the more substantial high-value-added and high-tech activities of the PRD economy, was still able to perform comparatively well in early 2008 (GDSTATS 2008).

Against this background, it is the aim of this paper to provide empirical evidence for the innovation activities of foreign and domestic Chinese firms by testing theoretically-based hypotheses using company survey data from 222 electronics firms in the Pearl River Delta in South China. Results will be presented separately for domestic and foreign firms. Among foreign firms, three sub-groups, namely Hong Kong, Taiwan, and other foreign firms, will be analysed separately.

The electronics industry in the PRD is rather heterogeneous in terms of ownership. Hong Kong and Taiwan-based companies set up factories in the early phase of the reform process. Other foreign investors followed, with state-owned and collective enterpris-

es being transformed subsequently and a domestic private sector emerging more recently (LU and WEI 2007; YANG 2007).

Existing studies on technological capability building in developing countries have revealed that ownership is an important proxy for differences in the intensity of upgrading and innovation. Foreign firms often possess better access to advanced technological capabilities than domestic firms, meaning that their potential to upgrade and innovate might thus be higher (BELL and PAVITT 1997). However, whether technology transfer occurs from foreign to domestic firms depends on the openness of foreign firms towards cooperation and the ability of domestic firms to absorb external knowledge and technology (COHEN and LEVINTHAL 1990); both are often limited (ALMEIDA and FERNANDES 2008). Empirical studies using firm-level data in different regions of China have confirmed the greater intensity of innovation activities in foreign firms (e.g., UREM et al. 2008 for firms in Jiangsu) and the importance of foreign firms as cooperation partners during the innovation process (e.g., LIEFNER 2006 for Shanghai and LIEFNER et al. 2006 for Beijing).

This paper is structured in five main parts. Firstly, existing theoretical concepts and the results of previous studies on the role of foreign and domestic firms in regional innovation systems of latecomer countries will be reviewed. Hypotheses for the empirical analysis are derived at the end of this section. Secondly, the data and methods used for the empirical analysis are introduced and their limitations are discussed. Thirdly, background information about the electronics industry in the Guangdong province based on secondary data is provided in order to justify the selection of the sector (electronics industry) and ownership types (foreign and domestic private, but not state-owned enterprises). Fourthly, survey results about the innovation activities of foreign and domestic electronics firms in the PRD are presented with a comparison of the two cities of Guangzhou and Dongguan. Finally, a discussion and conclusion will summarise the main arguments, while also providing policy recommendations as well as identifying areas in which further research is required.

## 2 Conceptual considerations on the upgrading of technological capabilities and innovation in developing countries

In this section, differences in innovation activities and technological capability building between foreign and domestic firms in developing countries will be highlighted. The discussion will then be re-

lated to the regional perspective on innovation systems in developing countries, before hypotheses for the empirical analysis are formulated in connection with the conceptual considerations.

Innovation is defined as the introduction of a new or significantly improved product, process, marketing method, or organisational method in business practices, workplace organisation or external relations. The minimum requirement is that it is new or significantly improved to the firm. This includes both innovations developed by the firm itself and those that have been adopted from external partners (OECD 2005). The distinction between innovation and non-innovation depends on the existing level of capabilities. In other words, the same product might be significantly improved for a latecomer firm in China and thus counted as an innovation, but not new at all for a foreign affiliate located in China. In that sense, the indication of innovation activities does not show the actual technological level of a firm, but simply its efforts in upgrading its own capabilities.

## 2.1 Technological capabilities of latecomer firms and incumbents

The analysis of technological capabilities and innovation in developing countries usually distinguishes between firms from developed countries, i.e., foreign firms in the developing region, and latecomer firms, i.e., domestic firms. In general, the technological capabilities of latecomer firms are expected to be lower than those of multinational incumbents (Mathews 2002). Typical differences discussed in the relevant literature (HOBDAV 1995; KIM 1997) include:

- Access to the latest technologies developed in the centres of scientific and technological knowledge production
- Access to highly-skilled employees, generally in short supply in developing countries.
- Access to finance, which is often limited due to the shallow financial markets of developing countries, while foreign firms can tap into the financial resources of their home country.
- Access to global consumer markets, which is limited for latecomer firms because of less well-known brands and marketing channels dominated by the multinational incumbents.

These initial differences in resources and technological capabilities form an important basis for the assumption that it is more likely for foreign firms to carry out innovation activities than for domestic

firms in developing countries. However, latecomer firms also possess specific competitive advantages (MATHEWS 2002) which result from the fact that they can potentially (i) use the most advanced technologies from the first day on, (ii) collaborate intensively with more advanced partners, (iii) bypass the organisational inertia of more established companies, while (iv) being able to operate with lower costs. In the case of Hong Kong's SMEs, LOH (2002) coined the term 'nimble and nifty' to describe these advantages.

Another factor that may contribute to a low intensity of innovation activities of foreign firms in developing regions is the concentration of these activities in the home country. While critical innovation activities are carried out in the scientific and technological core regions, the resulting innovations are only implemented at the affiliates in developing countries, for example in the case of home-base augmenting (KUEMMERLE 1997). However, if adaptations to local conditions are necessary, they are often carried out locally and are a first step towards developing more advanced technological capabilities there.

Even taking these qualifications into account, it is still expected that the advantageous resource endowment of foreign firms and the complexity of the electronics industry will result in the greatest innovation efforts being made by foreign electronics firms in the Pearl River Delta.

*H1: Innovation activities of non-domestic electronics firms in the PRD are more intensive than those of domestic firms.*

## 2.2 External orientation of latecomer firms

This static view of the recent level of innovation and capabilities must be complemented by a dynamic perspective on strategies for upgrading and learning in latecomer firms. As shown above, the initial resource endowment, market position, and business model is advantageous for foreign firms entering developing countries. These advantages are incorporated into DUNNING's (1988) OLI paradigm for incumbent firms. However, this framework does not offer an explanation for the success of several latecomer firms from developing countries in entering global markets and innovative networks. As an extension of the OLI paradigm, MATHEWS (2002, 2006) introduced his so-called LLL framework which focuses on the upgrading and internationalisation strategies of latecomer firms. The three L's stand for linking, leveraging, and learning.

The starting point for the upgrading - and thus also for the innovation - of latecomer firms is a purposeful external orientation in order to overcome the weak internal resource endowment (MATHEWS 2006). Critical strategic linkages with non-domestic firms and global markets must be developed. Firm strategies are at the core of this concept as well as approaches related to it (e.g., LALL 1992, 2000; BELL and PAVITT 1997). Therefore, an analysis will be undertaken of the external orientation and strategic focus of domestic and non-domestic firms.

The Asian electronics industry provides an example of how firms in developing countries have managed to increase their technological capabilities, learn new technologies, and move successively upwards in the value chain to higher value-added products. This development of single firms began with OEM production arrangements, which were then gradually replaced by ODM and OIM/OBM (HOBDA 2000): under the OEM (original equipment manufacturing) system, subcontracting firms produce to the precise specification of a particular buyer. ODM (own design and manufacturing), in contrast, allows subcontracting firms to carry out at least some product design and production tasks. The general design layout, however, is still provided by the buyer. Under OBM (own brand manufacturing) and OIM (original idea manufacturing), the subcontracting firms conduct R&D and invent products for the use of the buyer. Whereas OEM offers possibilities for technological learning to subcontractors with limited capabilities, ODM and OBM prove the subcontractor's ability to produce higher value-added goods (HOBDA 2000, 134–140). Universities may help to acquire the knowledge necessary for making this transition. Using company-level data from Thailand, Singapore, and Penang (Malaysia), BERGER and REVILLA DIEZ (2006) apply the OEM–ODM–OBM terminology to analysing the effects of technical progress and learning. What can be observed on the level of single firms is also true of the regional and national economies of some successful Asian countries (see below; LALL 2000, 21–24).

*H2: Domestic firms in the PRD cooperate more often with other partners when carrying out innovation activities than non-domestic firms. The major reasons are limited in-house capabilities and cultural proximity to other domestic players in the innovation system.*

*H3: Domestic firms have consciously formulated long-term strategies towards innovation and upgrading in order to overcome their weak initial resource endowments and to catch up with foreign incumbents.*

## 2.3 The regional innovation perspective

External linkages have been identified as the critical component of the upgrading efforts of latecomer firms. Innovation systems (LUNDVALL 1992; NELSON 1993) are used to conceptualise the external environment for innovation. The regional innovation system (RIS) approach (e.g., BRACZYK et al. 1998) applies the elements of a national system, such as firms, government, universities, institutions, etc., to the regional level. It is argued that region-specific conditions and cooperation relationships between different organisations and individuals influence the regional innovation potential either positively or negatively. However, these regional systems are closely interdependent with national and global innovation and knowledge networks (REVILLA DIEZ and BERGER 2005). Since the case study in this paper is focused on the Pearl River Delta, its regional innovation system is expected to have an influence on the innovation activities of firms.

When analysing RIS in developing countries, certain specificities have to be taken into account (REVILLA DIEZ and BERGER 2005). Among them are (i) human resource development, which is of major importance for the development of absorptive capacities, learning and technological capability building, (ii) linkages to extra-regional players, which are important in offering critical learning opportunities for firms in developing countries and thus for developing strong regional innovation systems in the long run, since local players are weak in terms of innovation potential (ERNST 2000), and (iii) the fact that the concept of innovation systems is an ex-ante concept in developing countries (AROCENA and SUTZ 2002) and provides a policy agenda for system building and promotion.

The analysis will take into account the regional innovation perspective by looking at the intensity of the external linkages of domestic and non-domestic firms. Furthermore, selected results will be presented separately for two major industrial clusters in the PRD (BELLANDI and DI TOMMASO 2005; ENRIGHT et al. 2005; LI and FUNG RESEARCH CENTRE 2006), namely the cities of Guangzhou and Dongguan.

## 3 Data and methods

The hypotheses were tested mainly by using primary data from a company survey of electronics firms in the PRD. The data is described in detail in this section. Specific indicators which were constructed



based on the data are introduced in the respective result sections. Secondary data from the Guangdong Statistical Yearbook 2008 (GDSTATS 2008) were used to prove the relevance of the sample selection regarding its sectoral scope, i.e., the electronics industry, and its scope in terms of ownership form, i.e., mainly private firms with Chinese ownership and foreign firms, with a special focus on those with Hong Kong and Taiwanese investment.

The set of primary data covers 222 electronics firms in the PRD. The survey was focused on the cities of Dongguan (89 firms or 40% of the sample) and Guangzhou (116 firms or 52%). The remaining 17 firms or 8% are located in other cities of the delta. Guangzhou was selected as one of the cities in which a high portion of Guangdong's electronics industry is located (7% of the provincial gross value added in electronics). It is the provincial capital with a diversified industrial structure, a strong service sector, and is home to the major universities of the province. Firms in Guangzhou are markedly focused on the domestic market. In contrast, Dongguan was initially industrialised using investments from Hong Kong and Taiwan (YANG 2007). Its economic structure is almost completely focused on the manufacturing sector, and in particular on the electronics industry. 12% of the gross value added of the electronics industry in Guangdong is produced in Dongguan. The export

orientation is very high; service industries are weak; there are no universities. The location of the two cities is shown in figure 1, which also documents the dominant role of the electronics industry other cities of the PRD.

The sampling of firms for Dongguan was based on the Guangdong Electronics Company Catalogue 2007 and for Guangzhou on a list provided by the Statistical Bureau of Guangzhou. The survey was focused on districts with a high density of electronics companies. In Guangzhou, the Tianhe, Panyu and Huadu districts were selected as relevant clusters of the electronics industry. In Dongguan, the three main districts of the survey were Changan, Dongcheng, and Houjie. 300 questionnaires were distributed to randomly selected firms in these districts. In Dongguan, 89 of 150 questionnaires, or 59%, were returned. The response rate in Guangzhou was 77%, or 116 of the 150 distributed questionnaires. All questionnaires could be used for the analysis, as missing or contradictory answers were redressed in telephone follow-ups. The survey was completed in early 2008. General characteristics of the sample and structural differences between Dongguan and Guangzhou are shown in table 1.

The telephone follow-up resulted in a high quality and consistency of the information provided by the participating companies. However, tests for repre-

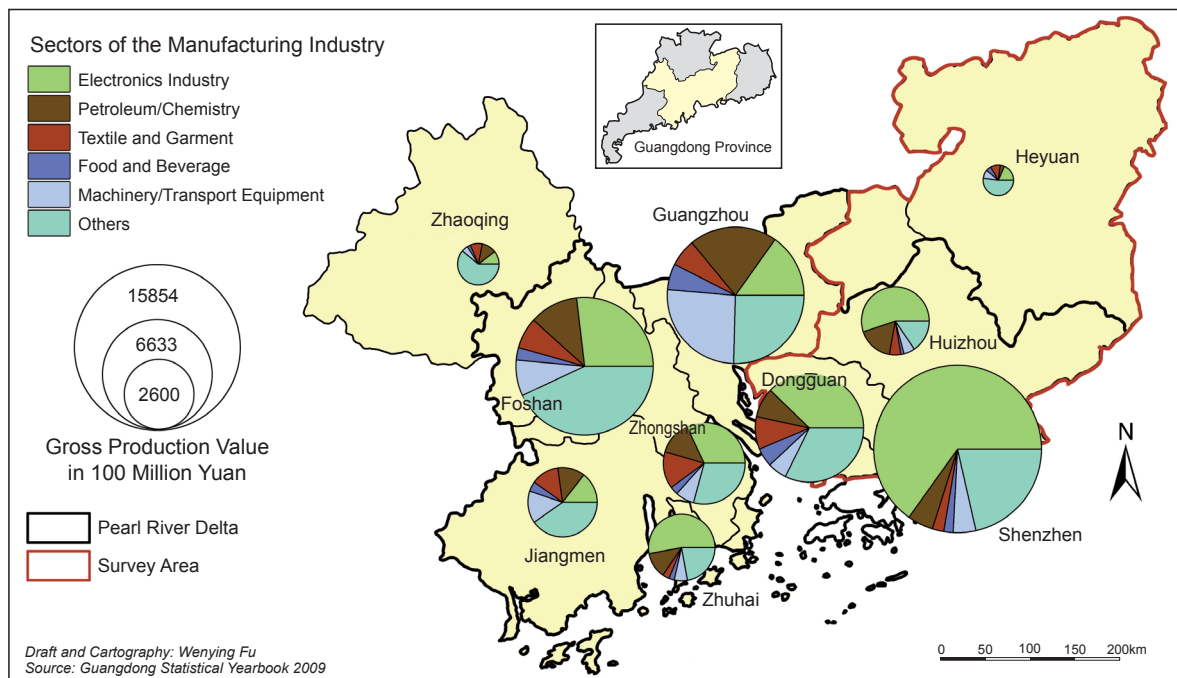


Fig. 1: Sectoral composition of the manufacturing industry in the Pearl River Delta, China.

Tab. 1: General characteristics of the surveyed firms in HK and the PRD

		Dongguan	Guangzhou			Dongguan	Guangzhou
<b>Number of firms</b>		91	116				
<b>Owner- ship in %</b>	Chinese	40%	61%	<b>Employees in PRD [%]</b>	1 – 99	27%	43%
	HK	15%	21%		100 – 499	45%	34%
	Taiwan	22%	5%		500 and above	29%	23%
	Other	23%	13%		China	51%	59%
<b>Found- ation in PRD in %</b>	2000 and earlier	60%	56%	<b>Main final market [%]</b>	Emerging Asia	19%	15%
	2001-2007	40%	44%		Western Countries, Japan	30%	26%

**Dongguan and Guangzhou differ highly significantly ( $X^2$ -test below 1%) in terms of ownership and employees. Source: own survey**

sentativeness were impossible due to inaccessible information on the structural characteristics of the total population or the sampling frame, although since the response rate was rather high, this is expected to be a minor problem. Furthermore, the analysis is exploratory. It aims to identify significant influencing factors and patterns; it does not attempt to estimate results for the total population.

The questionnaire consisted of five sections and addressed the following topics: (i) industry and market conditions, (ii) production system, (iii) employment, (iv) innovation activities, and (v) a fact sheet on structural characteristics. The companies were asked to answer the questions only for the operating site at the specific location. In the remainder of the paper, the terms firm and company are used interchangeably and are related to the site surveyed.

Innovation activities were mainly measured using input and process indicators, for example the importance of certain types of innovation, the organisation of innovation activities, and the importance of different innovation-related sources of information. The collection of quantitative data on innovation expenditures or on sales with new products as a ratio of total sales did not produce useful results, since the interviewees could not explicitly attribute expenditures and sales to specific innovation activities. The difficulties experienced when measuring innovation outputs are in line with observations from innovation surveys in several developing countries reported by the Oslo Manual (OECD 2005).

Ownership of firms is defined by the nationality of the main owner, which was included as a question in the survey. The information was double-checked by examining the firm registration. 115 firms were classified as domestic firms without any major foreign ownership. 111 of them were private enterprises (only

seven of these had been privatised), two were state-owned and two were collectively owned. 102 firms were identified as non-domestically owned. 73 were wholly foreign-owned and 19 were joint ventures. Ten firms were registered as domestic enterprises, but had a major foreign owner. They were also included in the group of foreign enterprises. Five companies did not provide any information about their ownership or registration and had to be excluded from analyses which differentiated according to ownership.

#### 4 Overview of the electronics industry in the Guangdong province

This section provides basic information about the relevance of the electronics industry in the Guangdong province, its spatial distribution, ownership structure, and export orientation based on the gross value added of the three industry sub-sectors: (i) electrical machinery and equipment; (ii) communication equipment, computers and other electronic equipment; and (iii) manufacture of instruments, meters and machinery for cultural and office use. Furthermore, it will be demonstrated that the electronics industry is the strongest sector in terms of technological activities. The data used in this section is based on the Guangdong Statistical Yearbook 2008 (GDSTATS 2008).

##### 4.1 Relevance of the electronics industry and ownership patterns

Both the Guangdong province and the PRD, which consists of nine core cities of the province, are highly specialised in the electronics in-

dustry. The industry's share of gross value added in manufacturing was 39% in 2007. Within the Guangdong province, the electronics industry is spatially concentrated in the PRD (96% of the provincial total). Some cities in the PRD are almost completely focused on electronics, for example Shenzhen with a share of 67% or Dongguan with 42% of the total manufacturing value added. Guangzhou, the provincial capital, has a diversified industrial structure. Its core manufacturing industries are transport equipment (27%), chemicals (21%), and electronics (13%).

Besides industry structure, the two regions covered in the survey, Dongguan and Guangzhou, differ in terms of firm ownership and export orientation. State-owned and state-controlled firms are responsible for 27% of gross value added in manufacturing in Guangzhou, in contrast to 10% in Dongguan. Dongguan has a higher share of foreign-invested activities (77%) than Guangzhou (56%). Within the group of foreign-invested firms, Hong Kong, Macau, and Taiwan firms are especially dominant in Dongguan (44%), while constituting only 19% in Guangzhou.

These ownership patterns have an influence on the export orientation of the two cities: Dongguan is much more export-oriented than Guangzhou. While Guangzhou's share of the provincial gross value added in industry is 18%, its share of exports is only 10%. In Dongguan, the respective figures are 10% for value added and 16% for exports. All in all, the patterns revealed represent important background information for the interpretation of the survey results. Furthermore, the sampling of firms in both cities ensured that the data did not represent only one facet of the electronics industry in the PRD, but rather covered its diversity in terms of ownership and export orientation.

Within the electronics industry of the Guangdong province, the share of state-owned and state-controlled firms is much lower than in other manufacturing sectors (4% in electronics compared to 24% in the remaining manufacturing sectors). As a result, the share of private domestic firms (33% for electronics compared to 25% for the other manufacturing sectors) and foreign-funded firms (62% compared to 49%) is much higher. For the foreign-funded sector, the statistical yearbook further differentiates between firms with investments from Hong Kong, Macau, and Taiwan (HMT), and other foreign-funded firms. Both sub-groups are of similar importance - 55%

of the gross value added originates from HMT firms and 45% from other foreign firms.

Based on these results, it is justified to restrict the analysis of the electronics industry to four types of ownership: (private) domestic, Hong Kong, Taiwan, and other non-domestic. The three non-domestic types of ownership are dealt with as one group in many statistical analyses.

## **4.2 Technological activities in the electronics industry**

Secondary data on technological activities was provided in the Guangdong Statistical Yearbook for input and output indicators. The input indicators available were internal expenditures for scientific and technological activities (STEXP), research and development (RDEXP), and new product development (NPEXP). Output indicators were output value (OUTVAL), sales revenue (OUTREV), and export values (OUTEXP) of new products. These data were available for all 21 cities of the Guangdong province; however, no sectoral differentiation was given. Therefore, an auxiliary measure was used to provide evidence for differences in technology intensity according to the sector. Correlation analysis is applied to the shares of each industrial sector for the individual cities and each technological indicator as a percentage of total value added. A high and positive correlation would imply a comparatively greater technological intensity of this sector.

The results of the correlation analysis in table 2 are proof of a comparatively high technology intensity of the electronics industry in the Guangdong province. Besides electronics, transport equipment and machinery are the only sectors with positive correlation coefficients for input indicators, while chemicals and pharmaceuticals have a positive coefficient for output indicators. This result justifies the focus of the following analysis on innovation activities in the electronics industry.

## **5 Innovation and upgrading activities of domestic and non-domestic electronics firms**

In this section, the hypotheses are tested using the survey data. The structure of the section corresponds with the order of the hypotheses as introduced above.

Tab. 2: Correlation coefficients for innovation indicators and value added by sector for 21 cities of the Guangdong province

Industrial sector	STEXP	RDEXP	NPEXP	OUTVAL	OUTREV	OUTEXP
electronics	0,479	0,296	0,504	0,445	0,408	0,648
transport equipment	0,162	0,178	0,121	0,152	0,128	-0,061
machinery	0,018	0,314	-0,020	-0,482	-0,493	-0,415
chemical and pharmaceutical	-0,235	-0,090	-0,250	0,445	0,474	-0,136
rubber and plastics	-0,086	-0,165	-0,087	-0,067	-0,087	0,038
textile and garment	-0,166	-0,402	-0,067	-0,034	-0,026	0,182
food and beverage	-0,164	-0,075	-0,170	-0,359	-0,343	-0,287
metal products	-0,122	-0,022	-0,162	-0,562	-0,552	-0,373
others (printing, furniture, wood processing, cultural articles)	-0,207	-0,288	-0,172	-0,302	-0,290	-0,161

Notes: Pearson product-moment correlation coefficient (two-sided), all indicators are calculated as a percentage of value-added. Source: own calculations based on GDSTATS (2008)

### 5.1 Types of innovation and innovation intensity

As a first step, a general measurement of the intensity of different types of innovation indicators for different ownership types in the manufacturing sector of the Guangdong province was calculated using a correlation analysis similar to table 2. Instead of sectors, five different types of ownership were used (see Tab. 3). The correlation coefficients for domestic companies (state-owned, collectively owned, and domestic private) are markedly lower than those for non-domestic companies. This result implies that more innovation activities are carried out in cities with more foreign firms. Within the domestic sector, private companies score slightly better than those which are state and collectively owned, but in terms of exporting new products, domestic private firms are particularly weak. In the non-domestic sector, HMT-funded firms are less focused on investing in S&T or R&D than other foreign-funded firms. However, in terms of new products (input and output), they are slightly stronger and have a strong focus on exports. To substantiate these general findings, survey data for the electronics industry were used.

The intensity of innovation in the electronics industry is measured using three different concepts in order to tackle possible misconceptions related to the term 'innovation' (Tab. 4). The existence of such a misconception is likely when looking at the very high scores for innovation activities in general. Therefore, the figures are only used for comparisons within the dataset, and not for an estimation of innovation measures that could be used for international comparisons.

Firstly, a simple measure for innovation is whether a firm carries out any innovation activity based on a broad definition of activities which includes, for example, the introduction of products and processes new to the firm, the acquisition of new machines, and training related to innovation and upgrading. The majority of firms from all groups answered this question with 'yes', although the proportion of domestic firms was significantly lower than that of non-domestic firms.

Secondly, a more detailed measurement distinguishes between different kinds of innovation (product, process, organisational, and marketing innovation). In general, activities related to techni-

Tab. 3: Correlation coefficients for innovation indicators and types of ownership for 21 cities of the Guangdong province

Ownership	STEXP	RDEXP	NPEXP	OUTVAL	OUTREV	OUTEXP
state-owned companies	-0,114	-0,078	-0,098	-0,235	-0,206	-0,184
collectively owned companies	-0,030	-0,341	0,089	0,227	0,225	0,380
domestic private companies	-0,153	0,087	-0,169	-0,143	-0,129	-0,541
companies with funds from Hong Kong, Macao and Taiwan	0,167	-0,133	0,252	0,195	0,185	0,597
other foreign-funded companies	0,211	0,233	0,105	0,196	0,169	0,197

Notes: Pearson product-moment correlation coefficient (two-sided), all indicators are calculated as a percentage of value-added. Source: own calculations based on GDSTATS (2008)



Tab. 4: Types of innovation according to ownership

		domestic	non-domestic	thereof		
				Hong Kong	Taiwan	other
<b>innovation activities</b>	yes (1)	66%	77%	74%	81%	78%
	no (0)	34%	23%	26%	19%	22%
	X <sup>2</sup> -test (sign.)		0,003	0,440	0,593	0,834
<b>product innovation</b>	very important (5)	43%	50%	46%	50%	54%
	normal importance (2-4)	13%	19%	15%	27%	16%
	not important/applicable (0-1)	44%	31%	38%	23%	30%
	X <sup>2</sup> -test (sign.)		0,029	0,257	0,225	0,721
<b>process innovation</b>	very important (5)	36%	40%	36%	50%	38%
	normal importance (2-4)	21%	31%	31%	31%	32%
	not important/applicable (0-1)	43%	28%	33%	19%	30%
	X <sup>2</sup> -test (sign.)		0,005	0,492	0,289	0,900
<b>organisational innovation</b>	very important (5)	12%	21%	21%	31%	14%
	normal importance (2-4)	34%	40%	38%	42%	41%
	not important/applicable (0-1)	54%	39%	41%	27%	46%
	X <sup>2</sup> -test (sign.)		0,005	0,922	0,104	0,221
<b>marketing innovation</b>	very important (5)	16%	23%	18%	27%	24%
	normal importance (2-4)	35%	41%	41%	50%	35%
	not important/applicable (0-1)	49%	36%	41%	23%	41%
	X <sup>2</sup> -test (sign.)		0,024	0,462	0,184	0,504
<b>innovation index</b>		43,74	56,03	52,18	64,62	54,05
	t-test (sign.)		0,017	0,410	0,171	0,686
		n=114	n=102	n=39	n=26	n=37

Source: own survey

cal innovation are more important for all firms than those related to non-technical innovation. All kinds of innovation are significantly more important for non-domestic firms than for domestic firms. The smallest differences are found in the case of product innovation.

Thirdly, a composite indicator (innovation index) was constructed using information on all four types of innovation activities. It ranges from 0 to 100, with all four types being unweighted. For example, a firm which regards all types as very important has an index value of 100, while a company with only one 'very important' type and three 'not applicable' types has an index value of 25. The analysis of the average index values according to ownership supports the observations made above. Domestic firms

have a significantly lower innovation index value than non-domestic firms.

Within the non-domestic sector, Taiwanese firms have the highest scores for all three measurements, while Hong Kong firms have slightly lower scores than other foreign firms. Even though these differences are statistically not significant due to the small size of the sub-sample, the consistency across different indicators substantiates the assumption that Taiwanese firms are the more innovative ones in the region while Hong Kong firms are the least innovative non-domestic firms. Taiwanese firms have a comparatively strong focus on non-technical innovations, i.e., organisational and marketing innovations.

It has to be mentioned that the results for domestic firms are revealing on-average innovation ca-

pabilities, but it has been shown by FAN (2006) for the telecom-equipment sector that some large domestic firms in Shenzhen like Huawei or ZTE are unique with regard to their innovation capabilities. These outstanding cases might be missed because the survey was not carried out in Shenzhen. In that sense, the coefficient of variation of the innovation index for domestic firms (87%) is much higher than for foreign firms (66%). Among domestic firms, 37% do not possess any innovation capabilities while their share is only 25% among the foreign firms.

Based on the overall results, hypothesis H1: "Innovation activities of non-domestic electronics firms in the PRD are more intensive than those of domestic firms" can be confirmed.

## 5.2 Use of external sources for innovation activities

Additional information about the use of external partners during the innovation process is gained from the comparison of the way innovation is performed

and the information sources used. In general, companies can rely on internal sources, such as their own R&D departments and other in-house innovation activities, or they can tap into external sources through cooperative R&D, acquisition of external innovations, and using external technology as the basis for their own innovation activities, i.e., reverse engineering. External information sources for innovation activities that require an interactive relationship are (i) partners within the same company or business group (head offices, affiliates, joint venture partners), (ii) customers who place original equipment manufacturing orders (OEM), (iii) other customers and suppliers, (iv) unrelated companies, and (v) universities and research institutes. Other methods which are not based on direct interaction or co-operation with a partner include the acquisition of information from fairs or technology markets and the hiring of qualified workers.

The results in tables 5 to 7 suggest that domestic firms in general rely more often on internal sources than non-domestic firms. The importance of the firms' own R&D/innovation activities is significantly greater, while the scores for cooperative R&D/innova-

Tab. 5: Types of innovation activities according to ownership, n=152 firms that perform any innovation activities

		domestic	non-domestic	thereof		
				Hong Kong	Taiwan	other
<b>own R&amp;D/innovation activities</b>	very important (5)	72%	65%	59%	52%	81%
	normal importance (2-4)	20%	30%	34%	43%	15%
	not important/applicable (0-1)	8%	5%	7%	5%	4%
	X <sup>2</sup> -test (sign.)		0,080	0,464	0,166	0,027
<b>cooperative R&amp;D/innovation activities</b>	very important (5)	13%	17%	17%	24%	11%
	normal importance (2-4)	37%	47%	45%	48%	48%
	not important/applicable (0-1)	49%	36%	38%	29%	41%
	X <sup>2</sup> -test (sign.)		0,075	0,944	0,377	0,483
<b>external innovations as a basis for own innovations<sup>1</sup></b>	very important (5)	19%	9%	14%	14%	0%
	normal importance (2-4)	45%	49%	31%	57%	63%
	not important/applicable (0-1)	36%	42%	55%	29%	37%
	X <sup>2</sup> -test (sign.)		0,095	0,004	0,177	0,032
<b>direct application of external innovations</b>	very important (5)	5%	8%	14%	10%	0%
	normal importance (2-4)	31%	30%	21%	33%	37%
	not important/applicable (0-1)	64%	62%	66%	57%	63%
	X <sup>2</sup> -test (sign.)		0,631	0,015	0,779	0,105
		n=75	n=77	n=29	n=21	n=27

<sup>1</sup> This paraphrase was chosen to avoid the negative connotation of the term 'reverse engineering'. Source: own survey

tion are lower. The second most important activity for domestic firms is reverse engineering, which is rather unimportant for non-domestic firms.

What kind of interpretation is suitable for these results? The general perception regarding a great importance of internal R&D/innovation activities is that such companies are highly committed to innovation. However, internal technological capabilities of companies from China and other latecomer countries are generally quite low (e.g., LALL 1992). If they were determined to learn and to acquire new capabilities, they would need to tap into external sources by blending them with internal capabilities (BELL and PAVITT 1997), for example in the sense of MATHEWS' (2006) linking, leveraging, and learning approach. Based on this theory-backed assumption, this internally-oriented pattern is interpreted as a weakness at early stages of technological catch-up because Chinese firms are too passive in fostering their internal capacity building by joining hands with external partners. A fact that is especially true for SMEs. Nevertheless, the initiation of in-house R&D efforts provides absorptive capacity for potential linkages in the future.

In contrast, the fact that other foreign firms rely heavily on internal R&D/innovation activities can be seen as an indication of the relative strength of their internal capabilities and their ability to tap into knowledge sources at their headquarters abroad, but also as a weakness from the perspective of the regional innovation system, because fewer options for domestic firms are available to cooperate with foreign firms in the PRD. One reason for the limited openness of foreign firms could be the weak protection of intellectual property rights (IPR) in China. Furthermore, Taiwanese firms are the most active collaborators within the group of non-domestic firms, but the differences are not significant due to the small population size of that group.

Table 6 provides more details on the importance of different information sources for innovation activities. Not surprisingly, non-domestic firms most often rely on their parent companies or other affiliates as an important knowledge source. In that respect, they differ markedly from most domestic firms who, especially in the case of private SMEs, do not have this option. However, domestic firms are often embedded in global value chains by delivering products to OEM customers, for example global brand-name owners or trading companies. But despite the fact that domestic and non-domestic firms sell a similar share of their products under OEM agreements, the OEM customers are less often used by domestic firms as an information source for innovation activities.

Only 'hiring qualified workers' is significantly more intensively used as an information source by domestic firms than by non-domestic firms. In the long-run, an improved skill base might increase the absorptive capacity of Chinese firms (COHEN and LEVINTHAL 1990) and might thus enable them to participate in cooperative and interactive R&D/innovation activities.

Universities and research institutes are the least important information source for firms of all kinds of ownership. This result confirms findings from WANG and LIN (2008) for the ICT industry in the PRD and CHEN and KENNEY (2007) for the role of universities in the regional innovation system of Shenzhen. There are no significant differences between foreign and domestic companies.

The external orientation of Chinese and foreign firms in the innovation process is summarised in table 7. Here, companies with at least one and without any very important external information source in the innovation process are compared. The sources considered are those used in table 6, but without the options "fairs/technology markets" and "hiring qualified workers" because these modes do not require interactive relationships with an external partner. The greater external orientation of non-domestic firms in contrast to domestic ones is highly significant. All sub-groups of non-domestic firms cooperate more intensively than domestic firms. Other foreign firms indicate a very important external information source significantly more often than non-domestic firms from Hong Kong and Taiwan. This underlines the advanced access and integration of foreign firms into knowledge networks, which may, of course, occur as a result of close ties with their parent companies.

In contrast to the expectations regarding a more intensive use of external knowledge sources for domestic firms with limited technological capabilities, hypothesis H2: "Domestic firms in the PRD cooperate more often with other partners when carrying out innovation activities than non-domestic firms", must be rejected. The results derived from the company survey are contrary to those found in the literature on technological capability building in developing countries which stress the importance of international knowledge transfer, for example through foreign direct investment and intensive linking, leveraging, and learning (MATHEWS 2006).

Comparable findings regarding the internal orientation of Chinese firms have been reported by SUN (2002) for large and medium-sized manufacturing enterprises. Since his study, which used data from 1999, the situation seems to have remained rather un-

Tab. 6: Information sources for innovation according to ownership

		domestic	non- domestic	Hong Kong	thereof Taiwan	other
<b>parent company, affiliate, joint venture partner</b>	very important (5)	8%	38%	31%	38%	46%
	normal importance (2-4)	21%	29%	28%	33%	27%
	not important/applicable (0-1)	71%	33%	41%	29%	27%
	X <sup>2</sup> -test (sign.)		0,000	0,232	0,779	0,405
<b>OEM customer</b>	very important (5)	10%	13%	14%	0%	23%
	normal importance (2-4)	29%	41%	41%	55%	31%
	not important/applicable (0-1)	62%	45%	45%	45%	46%
	X <sup>2</sup> -test (sign.)		0,015	0,992	0,062	0,014
<b>non-OEM customer/ supplier</b>	very important (5)	8%	11%	10%	15%	8%
	normal importance (2-4)	33%	37%	24%	45%	46%
	not important/applicable (0-1)	59%	52%	66%	40%	46%
	X <sup>2</sup> -test (sign.)		0,448	0,045	0,309	0,322
<b>unrelated company in the same sector</b>	very important (5)	7%	13%	7%	19%	15%
	normal importance (2-4)	33%	33%	21%	43%	38%
	not important/applicable (0-1)	60%	54%	72%	38%	46%
	X <sup>2</sup> -test (sign.)		0,085	0,005	0,115	0,473
<b>university, research institute</b>	very important (5)	10%	9%	14%	0%	12%
	normal importance (2-4)	19%	21%	14%	25%	27%
	not important/applicable (0-1)	71%	69%	72%	75%	62%
	X <sup>2</sup> -test (sign.)		0,894	0,126	0,226	0,386
<b>fairs, technology market</b>	very important (5)	12%	18%	21%	14%	19%
	normal importance (2-4)	32%	34%	24%	48%	35%
	not important/applicable (0-1)	56%	47%	55%	38%	46%
	X <sup>2</sup> -test (sign.)		0,173	0,200	0,174	0,979
<b>hiring qualified workers</b>	very important (5)	42%	28%	31%	29%	23%
	normal importance (2-4)	30%	37%	21%	48%	46%
	not important/applicable (0-1)	27%	36%	48%	24%	31%
	X <sup>2</sup> -test (sign.)		0,032	0,011	0,240	0,301
		n=73	n=76	n=29	n=20	n=26

Source: own survey

changed. SUN (2002) regards the focus on in-house R&D as a strength which is important for the market success of these enterprises. In contrast, the findings presented in this paper for Chinese-owned electronics firms in the PRD, which consist mainly of SMEs, are assessed as a weakness, because their potential to carry out meaningful internal innovation activities is

expected to be rather limited. In addition, the domestic technology market and government-supported R&D institutes and universities have increased their efforts significantly since the turn of the millennium, but SUN's (2002,1069) conclusion still applies to the recent data: "Industrial enterprises are not yet well linked with domestic technological development".



**Tab. 7: Share of firms with at least one very important external information source for innovation activities according to ownership**

	domestic	non-domestic	thereof		
			Hong Kong	Taiwan	other
indication of at least one very important external source	33%	55%	48%	48%	69%
no indication of any very important external sources	67%	45%	52%	52%	31%
X2-test (sign.)		0,005	0,114	0,112	0,003
	n=73	n=76	n=29	n=21	n=26

Note: The external sources correspond with those used in table 5 with the exception of fairs/technology markets and hiring qualified workers. Source: own survey

### 5.3 Strategic orientation

The previous chapter analysed the use of external sources during the innovation process related to the strategic orientation towards innovation and cooperation. The electronics companies were asked which statement comes closest to their strategic orientation. They could choose between six statements which can be found in the note of table 8. These statements were later ranked according to their innovative content. For the highest and the lowest class, two statements were combined. If a firm sets a new market trend or enters a new specialised market, this firm indicates a very conscious and specific strategy towards active innovation. A general focus on upgrading and innovation in the long term is less specific and less determined, and is thus considered to be somewhat less innovative. If a firm operates in an established market, but is, at the same time, very keen on taking advantage of short-term opportunities, a certain innovative capability is still necessary. However, if a firm simply follows whatever trend is emerging or responds to any incoming order without any specific strategy besides keeping the factory busy, it is considered to be rather passive.

The results in table 8 show significant differences between domestic and non-domestic firms. Non-domestic firms more often use the first three, more innovative strategies, while a much larger number of Chinese firms selected statements that identified them as rather passive followers. Within the group of non-domestic firms, other foreign firms could be identified as the least passive group. Their affiliates in China are rather committed to upgrading and innovation in the long-run. Despite the great importance of innovation activities for Taiwanese firms, their strategic focus is significantly more often on short-term opportunities. Their innovation activities thus seem to be of an incremental nature and rather

close to the market. This conclusion is also supported by the low share of Taiwanese firms with in-house R&D/innovation units.

In the future, the greatest impact on upgrading and innovation in the electronics industry of South China is expected to originate from foreign firms. While Taiwanese firms have, in recent times, been most intensely engaging in innovation and upgrading activities, their strategic focus remains short-term oriented. Based on the data presented above, foreign firms from outside China, Hong Kong and Taiwan are expected to carry out sophisticated activities even more frequently than now.

The self-assessment of firms regarding their strategic orientation provides evidence for the rejection of hypothesis H3: "Domestic firms have consciously formulated long-term strategies towards innovation and upgrading in order to overcome their weak initial resource endowments and to catch up with foreign incumbents". However, the results are only significant at the 10%-level and, within the foreign-owned sector, Taiwanese firms are much less long-term oriented than the two remaining groups.

### 5.4 Comparison of innovation intensities in Guangzhou and Dongguan

A comparison of innovation indicators for Guangzhou and Dongguan is possible with the data at the city level. The specialisation of Dongguan in the electronics industry is greater and localisation effects may thus result in strong collaboration between firms from the same sector. However, YANG (2009) has already highlighted the weak coupling of electronics firms from Taiwan with other important players in the innovation system in Dongguan.

Instead, Guangzhou's economy is rather diversified and the city has several strong universities and

Tab. 8: Strategic orientation according to ownership

	domestic	non-domestic	thereof		
			Hong Kong	Taiwan	other
active innovator	9%	11%	10%	12%	12%
long-term upgrader	53%	59%	62%	42%	68%
short-term opportunist	13%	16%	13%	27%	12%
passive follower	25%	14%	15%	19%	9%
X <sup>2</sup> -test (sign.)		0,093	0,801	0,058	0,337
	n=112	n=99	n=39	n=26	n=34

Notes: Phrases used in the questionnaire:

Active innovator:	sets new market trends with new brands or products
Active innovator:	enters specialised markets with weak competition
Long-term upgrader:	long-term focus on upgrading and innovation
Short-term opportunist:	aims at short-term opportunities in established markets
Passive follower:	follows emerging trends
Passive follower:	simply responds to incoming orders

Source: own survey

other local supporting organisations for innovation. Therefore, urbanisation economies and more diverse players in the city's innovation system may serve to increase innovation activities and external linkages.

The results in table 9 show that domestic firms in Guangzhou carry out innovation activities more intensively, even though the number of firms carrying out innovation activity is lower. Domestic and non-domestic firms also carry out innovation more often in collaboration with other partners. Among the external innovation sources, universities and research institutes are significantly more often chosen as partners by both domestic and non-domestic firms in Guangzhou than in Dongguan.

## 6 Discussion and conclusion

The final chapter of this paper will interpret and discuss the results presented above and conclude by deriving policy recommendations and identifying areas in which further research is needed.

The importance of innovation activities is greater for foreign than for domestic firms. Within the group of foreign firms, Taiwanese firms showed the strongest focus towards innovation, followed by other nationalities, and finally Hong Kong firms. The results are almost as expected and show that Taiwanese producers are truly at the technological cutting edge of their respective market niches of the electronics industry (YEUNG 2007), even though many major brand owners are still located in North

America, Japan, or Europe. The weakness of firms from Hong Kong in terms of innovation, which has been identified by earlier studies (DAVIES 1996; SHARIF and BAARK 2005), is confirmed by the results presented here. The results regarding the openness towards cooperation in innovation and upgrading have shown that domestic firms are rather isolated from technological inputs. If at all, innovation and upgrading activities are carried out within companies, without external inputs that are necessary in the case of limited technological capabilities. Stimuli for further upgrading are thus not expected from domestic firms in the short-term. Similar results on a low propensity to cooperate during innovation and upgrading have been reported by SUN (2002). Despite an otherwise intense involvement of Chinese firms in networks, for example family networks and business groups (WHITLEY 1992), these connections are not accessed for long-term upgrading.

Further research is needed on the role of different kinds of networks, such as formal networks with business partners or informal networks with family members, for innovation activities. The initial expectation would be that family contacts were an important safeguard in the past, when the weak institutional environment resulted in great transactional uncertainties, but that their relevance has declined over time and could even become negative, as in the case of cronyism or lock-in. A transition from relation-based to rule-based governance is expected if market development is deepened (LI et al. 2004). Besides family relations, government-enterprise re-

Tab. 9: Comparison of selected innovation indicators for Guangzhou and Dongguan

	domestic				non-domestic			
<b>Innovation activities</b>	yes	no	X <sup>2</sup> -Test		yes	no	X <sup>2</sup> -Test	
<b>Guangzhou</b>	67%	33%			78%	22%		
<b>Dongguan</b>	62%	38%	0,354		77%	23%	0,892	
<b>Innovation index</b>			t-test				t-test	
<b>Guangzhou</b>	47,64				57,89			
<b>Dongguan</b>	33,43		0,061		52,79		0,498	
<b>Cooperative R&amp;D/ innovation activities</b>	very impor- tant	normal impor- tance	not imp./ not applic.	X <sup>2</sup> -Test	very impor- tant	normal impor- tance	not imp./ not applic.	X <sup>2</sup> -Test
<b>Guangzhou</b>	15%	34%	51%		23%	49%	29%	
<b>Dongguan</b>	5%	38%	57%	0,149	11%	45%	45%	0,060
<b>Information source: university/res. inst.</b>	very impor- tant	normal impor- tance	not imp./ not applic.	X <sup>2</sup> -Test	very impor- tant	normal impor- tance	not imp./ not applic.	X <sup>2</sup> -Test
<b>Guangzhou</b>	11%	22%	67%		14%	26%	60%	
<b>Dongguan</b>	10%	10%	81%	0,012	5%	16%	78%	0,014

Note: 5 - very important, 2-4 - normal importance, 0-1 - not important/not applicable. Source: own survey

lations are expected to have an important impact on firm strategies in the transitional environment of China. HU and SHI (2009) found a positive relationship between the political resources and diversification strategies of the largest private enterprises in China.

Strategy has been identified as a significant influence on innovation. However, comparatively fewer domestic firms are pursuing a strategy that is focused on active involvement in innovation. One reason could be the inability to adjust the firms towards long-term goals due to limited managerial or financial resources. Domestic firms should, therefore, be encouraged to increase the managerial skills along with their technological capabilities. For Hong Kong firms, DAVIES and KO (2006) found a positive effect of upgrading strategies on performance in general.

Overall, the results did not provide evidence for a catch-up process on the part of domestic firms in the electronics industry of the PRD with its incumbents from abroad. If it is taken for granted that initial technological capabilities of non-domestic firms are higher than those of domestic firms, the fact

that non-domestic firms (i) carry out innovation activities more often, (ii) have more external linkages, and (iii) strategically opt for more innovation in the long-run, provides evidence for a growing capability gap between the two groups. Only the great importance of hiring qualified workers in domestic firms hints at an improvement of the human capital base and thus absorptive capacities which might lead to more intensive efforts dedicated to upgrading and innovation.

Regarding the regional innovation system of the Pearl River Delta, the results show three major weaknesses: (i) the internal orientation of domestic firms limits the inflow of external knowledge into the region, (ii) close linkages of non-domestic firms with their parent companies show that they are also detached from the regional innovation system, and (iii) the first two conclusions are assumed to be related to the weakness or absence of critical partners in the region, for example universities and research institutes were reported to be the least frequently used partners. This final result is especially relevant for Dongguan, whose firms are more weakly integrated into the innovation system.

The major policy recommendation is to extend the scope of innovation support towards strengthening the regional innovation system and linkages between the important players. Recently, a strong focus has been on so-called high-tech enterprises and technological innovation. If technological capability building is not complemented in a systemic by an upgrading of internal organisational capabilities, it is at risk of being adapted rather half-heartedly.

Requirements for further research can be identified in three fields: Firstly, improved measurements for innovation and upgrading activities should be based on a broad definition relevant to the situation of developing countries. Future surveys on the topic should thus attempt to produce data on the process of innovation, its barriers and motivations, and on sensible measurements for innovation outputs. Secondly, factors that influence the intensity of upgrading and innovation activities should be analysed in greater depth. The quality of corporate governance, for example, is still a rather neglected topic in innovation research. Thirdly, the firm perspective used in this paper should be further developed into a regional perspective that takes into account global and local interactions in innovation and upgrading.

### Acknowledgements

Earlier versions of this paper were presented at the workshop on “The Impact of Transnational Corporations on Innovation and Regional Development in China” in Shanghai, August 2009, organised by East China Normal University and the Alexander-von-Humboldt-Foundation, and at the DIME workshop on “Industrial Dynamics and Sectoral Systems in Developing Countries” in Milan, December 2009, organised by Bocconi University. The author would like to thank the participants for their useful input. The research underlying these results received funding from the German Research Foundation (DFG) under grant RE 1720/8-1 within the priority programme SPP 1233 “Megacities – Megachallenge: Informal Dynamics of Global Change”.

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